

## WATER SECURITY GUIDANCE DOCUMENT

## PART 2 SECTION 4 WATER SECURITY STATUS INDICATORS (WSSI)

Program on Water Governance University of British Columbia

Gemma Dunn Emma Norman Karen Bakker

**Earth Sciences**Simon Fraser University

Diana Allen Rafael Cavalcanti de Alburqurque

## **ABSTRACT**

A step-by-step guide for communities to assess the *current status* of water security, in terms of water quality and water quantity in relation to aquatic ecosystem health and human health. The methodology is tested within the Township of Langley, British Columbia. The approach can be adapted to use site specific indicators of water quality and quantity for aquatic ecosystem and human health.

## **RELATED JOURNAL ARTICLE:**

Norman, E., Dunn, G., Bakker, K. Allen, D. and Rafael Cavalcanti de Alburqurque (in review). **Integrating Governance in Water Indicator Assessment:**Developing a Water Security Indicator Method. Submitted to Water Resource Management (August 2011).

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### **BACKGROUND: KEY ISSUES AND CONTEXT**

The Water Security Status Indicator (WSSI) addresses three gaps in water assessment methods for local communities in Canada:

- Whilst many water-related indicators are being developed to measure and assess water, few are user-friendly at the local scale (watershed or sub-watershed).
- 2. There are a large number of indicators focusing on a small range of issues (e.g., solely on drinking water), which do not consider the broader balance of aquatic ecosystem health and human health.
- Narrowly-focused indices are of limited utility to water managers and communities grappling with competing users and integrated water systems, where balancing trade-offs can be a significant management challenge.

## **PURPOSE OF THE ASSESSMENT METHOD**

Assessing 'current status' is a challenging task, but a key component of the broader assessment of water security. This section concentrates on assessing current status of water quality and quantity in relation to human health and aquatic ecosystem health. Approaches to mapping some of this information are detailed in *Part II*, *Section 5: Mapping Groundwater Contaminants*, and are also presented in this case study on page 16.

The WSSI should be viewed as the starting point since it does not include future risk. This assessment method can either be used as a stand-alone tool, or in conjunction with the *Water Security Risk Assessment (WSRA)* method outlined in *Part II, Section 2.* A combined approach, assessing current status and future risk, would give a community a more comprehensive understanding of its overall water security.

Indicators are commonly used in assessments, as they can facilitate the synthesis of large amounts of complex information into a simplified, accessible format that can be easily understood. Indicators can help identify progress (or lack thereof) as the results can be used to create baselines against which water-related variables can be measured over time. The WSSI is not a new indicator; rather, it is an assessment method designed for community use, using available indicators. The purpose of the WSSI is to assess the current status of freshwater, in terms of water quantity and quality, in relation to aquatic ecosystem health and human health.

The WSSI assessment method provides a framework to guide:

- i. the selection of indicators:
- ii. the simultaneous analysis of indicators; and
- iii. the incorporation of the assessment results into water management decisions.

Communities are engaged in the indicator selection process, making participation by end-users central to its method. A key contribution of the WSSI is

this process of choosing and implementing indicators, strengthening the utility and applicability of the results, in turn resulting in improved water management outcomes.

## **INTENDED USERS**

This method is primarily aimed at community watershed groups, citizen environmental committees, water managers, and municipal water policy and decision-makers.

## **DESCRIPTION OF METHOD**

The WSSI assessment method is an integrated framework for selecting and simultaneously analyzing multiple indicators for water quality and water quantity, relating to aquatic ecosystem health and human health. Rarely do indicators cover all of these key criteria, which we argue are instrumental for communities in their efforts to assess water security status effectively.

## A STEP-BY-STEP GUIDE TO APPLYING WATER SECURITY STATUS INDICATORS

Since the WSSI is a *process* by which indicators are selected to assess water security, in this section we present only a general guide to applying the WSSI assessment method. We do not recommend specific indicators, as these should be chosen by a given community specific to their needs and resources (including data availability). At the end of this document, we present an illustrative example of the application of the WSSI (including the rationale for the indicators selected), in our case study community, the Township of Langley, British Columbia.

Table 1: Summary table outlining the fundamental steps to apply the WSSI assessment framework

Step	
1	Define Scope and Scale of Assessment
2	Identify Stakeholders and Assemble the Assessment Team
3	a) Visioning and Goals
	b) Water Security Objectives and Targets
4	Prepare Information Required to Assess Water Security Status
a) Decide the Time-Frame of the Assessment	
	b) Identify Key Water Issues (which parameters need to be measured)
	c) Identify Data Availability and Accessibility
	d) Identify Prior (Water Related) Studies and Access to Information
	e) Identify Existing Indicators
5	Analyzing and Reporting Results

Step	
6	Risk Assessment and Back-Casting: Status in Relation to Water Security Goals
7	Governance Mechanisms to Move Towards Water Security

## STEP 1 - DEFINE THE SCOPE AND SCALE OF ASSESSMENT

Define the scope and scale of the water security assessment, identifying the physical (geographic boundaries) of the area that will be assessed. Identify the water sources (e.g., river or aquifer). Ideally, the assessment area should consider both surface water and groundwater interactions. Transboundary watersheds may have water managers with different legal and administrative systems. Assess whether information from other parties can be accessed, and whether additional stakeholders can be brought to the discussion table (Refer to step 2). Consider vulnerability of the water source, and threats to the water source (Refer to Part III, Section 7 Boil Water Advisory Protocol – Part 1, Step 1 & Part 2 Step 1).

## STEP 2 - IDENTIFY STAKEHOLDERS AND ASSEMBLE THE ASSESS-MENT TEAM

Identify the stakeholders within the project boundaries. These should include those involved in monitoring water related issues and land-use planning; decision-makers (for example watershed groups, municipal sectors, provincial representatives, as well as private and public sectors); and stakeholders (industry, agriculture, medical, commercial, residential, first nations and so on). It is important that *all* decision makers be identified and included at the outset of the process, in order to successfully identify information needs and facilitate well-informed decisions. Note: the inclusion of a broad cross-section of stakeholders will likely aid in identifying data sources and parameters, as well as target setting.

## STEP 3A - VISIONING AND GOALS

Discuss what water security would look like in your community. Scenario-building is a collaborative exercise whereby stakeholders collectively create 'desired futures' of water security in the region. The visioning is a 'qualitative exercise' where stakeholders articulate their desired futures. For example, in the Grand River Conservation Authority (GRCA) in Ontario, stakeholders articulated their needs and desires around what they want the river system to be (e.g., the ability to swim in the river or canoe in the river free of algae or odours). This is also an opportunity to identify potential risks to water security, which is discussed in more detail in *Part II*, *Sections 2 and 3*.

## STEP 3B - OBJECTIVES AND TARGETS

Objectives tend to be more quantitative, and targets are usually specific to a particular variable. Ideally, objectives and targets should be based on sound science (enshrined in legislation or technical standards that are science based). It is helpful that people with technical and scientific expertise partici-

pate in objective and target setting to translate community goals into meaningful measures. As an example, the GRCA first identified a preliminary set of objectives to take to the community. This list was then discussed with various stakeholder groups and the broader public to ascertain whether these objectives were still current, or if modifications and/or additions were necessary.

Once the parameters of water security have been identified, and likely ways to achieve these objectives identified (e.g., targets to reach, and a timescale to achieve this by), identify potential governance barriers (and if feasible future risks – see *Part II*, *Section 2 and 3*) that could inhibit achieving these goals. (See also step 6).

## STEP 4 -PREPARE INFORMATION NEEDED FOR ASSESSMENT

- **a. Time frame**: Define the time frame for the water security status assessment i.e., whether it will be ongoing (which is recommended) or whether it will be conducted as a one-off.
- **b. Key Issues**: Identify key water-related issues for your area, and compile a list of the parameters that need to be monitored and assessed. This could be further broken down to key issues in specific areas (e.g., a particular stretch of river, or aquifer). The issues should include *human health* and aquatic ecosystem health in terms of quality and quantity.
- c. Data Availability: Data form the foundation upon which indicators are built, and consequently play a fundamental role in assessment. Data will most likely be dispersed across a number of organizations ranging from academics, consultants, industry, commercial, agriculture, NGOs, to municipal, provincial and federal agencies, each with varying degrees of quality, comprehensiveness and access. Identify organizations and/or departments that may have the data required for the assessment of water quality, quantity, aquatic ecosystem and human health. Find out whether staff are available and willing to provide advice and guidance; identify key contacts. Are there data for surface water and groundwater? Are the data accessible? Which parameters are monitored and recorded? Over what time periods are data collected (ongoing or ad hoc)? It is important to ascertain data gaps during the initial assessment, as this understanding can also inform future planning. If using data from a variety of sources, identify the methods used to collect data. Are the reporting units and collection methods the same or different between data sets? Once the parameters you want to measure have been identified, assess the datasets to see if these variables have been monitored consistently. Assess whether any of the data sets are compatible enough to be amalgamated (ensuring that the reporting units are consistent).

Suggestion: If possible, arrange a meeting whereby representatives from all the agencies that collect data are brought together. Discussions should include why they collect data (what their drivers are); the relative comprehensiveness and gaps of their data (in terms of time periods or parameters measured); accessibility (data sharing); and the standards and methods used to collect and record data. This meeting could serve to establish stronger pathways to facilitate data exchange. In addition, this meeting

could be a good opportunity to explain your group's vision to develop the WSSI, and the participants could also help decide which indicators to use (see below).

Prior Studies: Identify any water related studies that have already been conducted. These could be used as part of the foundation for the assessment. In addition, consider if lessons can be learned from previous experience(s).

d. Available Indicators: Determine which indicators are already available to assess water status in your defined region in terms of water quality, water quantity, aquatic ecosystem and human health. (Refer to the indicator inventory conducted in 2009: http://www.watergovernance.ca/projects/ water-security/program/ for a comprehensive list of fresh water-related indicators that have been developed at the federal, regional (large-scale watershed), and provincial levels. The list also includes some examples of local (small-scale watershed) indicators). Indicator selection should involve a critical analysis of whether or not existing indicators developed at various scales are appropriate and address community needs. If possible, technical and scientific input and advice are advised. It is also worth noting that if data are not available to comprehensively calculate an indicator of choice, the identification of such data gaps is itself useful. In the short term, data gaps could be filled by use of proxies. Over the longer term the identification of data gaps can help build a case toward developing a monitoring framework that will yield relevant data over time.

The following section of this Guidance Document presents an illustrative example to organise data as part of the WSSI assessment method. This approach was also utilized when testing the WSSI assessment in our case study community (see Example of Assessment Method, page 14). Part II, Section 5 Mapping the Likelihood of Groundwater Contamination is a further example demonstrating how to map data.

Table 2 shows the general framing of the WSSI assessment matrix, which would be populated by indicators identified by the community, specific to their needs. Assess whether there are sufficient data available to calculate the indicators selected.

Table 2: WSSI Assessment Matrix

Indicators that define safe water for	Water Quality	Water Quantity
Human Health		
Aquatic Ecosystem Health		

## **SELECTING INDICATORS: GENERAL TIPS AND SUGGESTIONS**

Here are some general considerations when selecting indicators to assess the key criteria of water status—water quality and water quantity (in terms of aquatic ecosystem and human health):

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## • WSSI Indicators should be easy to understand, timely, relevant, reliable, consistent, credible, transparent and accurate.

- WSSI indicators should be comprehensive, integrative and accessible.
- Consider the water source (groundwater, surface water, or integrated), and whether the choice of WSSI indicators reflects this.
- Consider land use activities and intensity, which may impact water quality and quantity.
- A number of agencies develop indicators for multiple scales (international, national, regional, provincial and local). Consider how accessible relevant, existing indicators are (e.g., will the developer share the index formula or calculator?), and whether the indicators can be adapted to suit your needs.
- Once the variables (i.e. parameters) to be assessed have been selected, the standards against which they are to be compared also need to be chosen (local, provincial, pan-Canadian, or international).
- There are overlaps between water quality and quantity in terms of aquatic ecosystem health and human health. Some indicators can be applied to more than one category. For example the Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) http://www.ccme.ca/ourwork/water.html?category\_id=102 (refer to Example of Assessment Method) can be used as an indicator for both human health and aquatic ecosystem health, if different parameters and objectives are applied (CCME 2001).
- Understanding the scale for which an indicator was developed is an important consideration. Is the indicator of choice sensitive enough (will it yield meaningful results) to be used at the scale identified for the assessment? (See Example of Assessment Method for an example of scalar challenges).
- Indicators that incorporate economic valuation are emerging. Assess
  whether it is feasible to include economic considerations in the assessment method.

Box 1: Considerations when selecting water *quality* indicators (in relation to aquatic ecosystem and human health)

- Scale: There are international (e.g., World Health Organisation), national (e.g., CCME or Health Canada) and provincial guidelines for drinking water quality. Parameters and standards vary accordingly.
- Flexibility and Adaptability: The CCME Water Quality Index (CCME 2001) http://www.ccme.ca/ourwork/water.html?category\_id=102 is the only index to be accepted by all Canadian provinces and territories and adopted nationally, as it is flexible and adaptable.

- Natural Baselines: Are there any natural and anthropogenic water quality considerations, e.g., naturally occurring arsenic?
- Objectives: Identify the variables (i.e. parameters) that are to be assessed (e.g., pathogens, chemicals, metals). Can the selected parameters to be measured be calculated using the indicator formula? Identify which objectives will be used.
- Water Source: The water source will influence the choice of indicators available (groundwater, surface water or integrated i.e., both surface water and groundwater).
- Sampling Frequency: Sampling and testing frequency will vary depending on the type of system and regulatory requirement. Municipal systems will likely test daily, compared with private well owners who may only sample annually.¹ Sampling frequency directly affects the indicator results. Sampling should be done quarterly, at a minimum, to reflect seasonal variation, or after a major rainfall event, or significant up-land activity (such as a mining activity or construction of new buildings).
- We recommend ecological sampling at least four times a year, ensuring that sampling coincides with poor water quality events. For example, testing in the Pacific region could be carried out in:

March or after the spring snow melt

August or peak dry season

November after heavy rains in the fall (which could flood septic systems)

January or after road salt applications

(Additional samples could be taken to correspond with significant changes in upland activities).

• Infrastructure: Infrastructure indicators can include aquatic ecosystem health and human health. They range from treatment levels (water and wastewater) to facility design, or 'number of dam upgrades to meet safety criteria'.

<sup>&</sup>lt;sup>1</sup> Water quality sampling at the municipal scale is conducted on a regular basis, and some of this information may be accessible to the public (contact your local water provider). However, few jurisdictions require private well owners to share water quality testing results. The BC-based Private Well Network is an example of a community-based initiative designed to encourage well owners to test well water quality on a regular basis and share results.

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Box 2: Considerations when selecting water *quantity* indicators (in relation to aquatic ecosystem and human health)

- Scope: Avoid narrowly defined indicators that examine supply or demand in isolation. An integrated indicator, which assesses supply in relation to demand, is more robust.
- Method and Scale: Consider the method and scale of assessment, both
  of which can influence the indicator results.
- Data sensitivity: Data sensitivity will influence the results. For example, whether the data are diurnal, weekly, monthly, seasonal or annual. Seasonal variations in supply and demand will present a different picture to annual reporting. Likewise, diurnal data is the most sensitive. Also, consider whether data are from dry or wet years.
- Use: Does the indicator fully address consumptive use, or just reflect withdrawals?
- Source: If water is supplied from an integrated water source, it is important to select an indicator that is sensitive enough to reflect groundwater concerns as well as surface water. Ideally, all sources of water supply and consumption should be accounted for.
- Infrastructure: Has the infrastructure type and integrity been reflected in the selected indicators?
- Economic instruments and conservation: Pricing, investment and conservation initiatives should ideally be reflected in the assessment framework.

### STEP 5 - ANALYZING AND REPORTING RESULTS

Once indicators are calculated the results need to be analyzed, categorized and reported. The category's range needs to be determined to facilitate results analysis. Many ranges for reporting indicators are very subjective and not based on science (e.g., rankings are based on equal intervals between the best ranking and the worst ranking and are not based on critical thresholds). The methodology for ranking indicators should be stated and justified.

The next step, and a critical component of the assessment method, is communicating results to the decision-makers. The results can be presented in a variety of ways from traffic lights (red, yellow, green), to slider bars or maps (for illustrative examples refer to Table 3, and *Figures 2 and 3*).

Table 3: An example of water security assessment categories

Symbol	Initial Assessment	Follow up Assessments
<b>⊘</b>	Indicator of Secure Water based on pre-determined ranges.	Significant change, in direction of meeting objective (improvement)
$\otimes$	Needs Work to Achieve Water Security, but within range of meeting goals	No significant change (little or no change)
8	Insecure Water – indicates that major work is needed to achieve goal	Significant change, in direction away from meeting objective (deterioration)
•••	Insufficient or no comparable data	

Informing decision-makers of positive or negative changes needs to be done in a timely manner (information needs to be accessible, transparent and clear). If the results are adverse, then steps to improve water security must be clearly identified and strategies to implement necessary changes must also be clearly identified (see *Step 7*). The elements of risk should also be incorporated to give a more comprehensive view of overall water security (see *Step 6*).

## STEP 6 - RISK ASSESSMENT AND BACK-CASTING (STATUS IN RELATION TO WATER SECURITY GOALS)

A detailed risk assessment (as outlined in  $Part\ II$ ,  $Section\ 2$ :  $Water\ Security\ Risk\ Assessment\ (WSRA)$ ) is a critical component to understanding the security of water quality and quantity in terms of aquatic ecosystem and human health. As outlined in  $Part\ I$ , if we consider the term "secure", we generally mean that currently something is secure, but this terms also implies there is a strong likelihood that it will remain so into the indefinite future. If we are saying that water is secure, then implicitly we are saying that right now the quality and quantity of water are meeting some performance measure (such as below a guideline for drinking water quality) and that the rate of use is sustainable. In addition, we also need to factor in how vulnerable or susceptible water quality and quantity are to deterioration over the longer term. This requires assessing risks ( $Part\ II$ ,  $Sections\ 2\ \&\ 3$ ), as well as identifying how the risk(s) will be managed ( $Part\ III$ ).

Back-casting is increasingly common in sustainability research and policy engagement. It involves working backwards from a 'desired future state' to determine the changes in laws, policies, behaviours and management practices needed today to achieve the goal of water security. If the assessment is to inform decision-making within an adaptive governance framework, there needs to be a commitment to ongoing assessments at intervals that can be expected to detect change.

## **STEP 7 - GOVERNANCE MECHANISMS**

Narrow governance approaches often fail to link water quality and quantity both in terms of human health and aquatic ecosystem health, and can hinder the ability of communities to achieve water security. Furthermore, inadequate assessment of status and risk hinder long-term plans for communities to achieve water security. In short, a broad, integrative (and proactive) approach is needed. Practicing good governance is crucial for communities to achieve water security and an adaptive governance approach can facilitate this. Adaptive governance is a methodological approach to resource management, whereby policies are implemented as experiments and learning is integral to resource stewardship.

The utility of indicators is greatly enhanced when linked to decision-making. Adaptation is linking findings back to behaviour change. Adaptive governance is not just about changing plans, but assessing the effectiveness of management actions on the ground, formalizing a "learning by doing" approach that can link science and policy. Policies and decision-making processes are then adapted over time, creating a closed (and hopefully virtuous) feedback cycle.

Indicators of success should be part of the assessment process from a management or performance point of view as well as from a results perspective. As more information and new technologies change, the process can be revised and updated. Decision-makers need access to timely information (demonstrating whether a system is moving closer to, or further away from the outlined goals) in order to respond (adapt) governance and management. Step 7 should include the development of short and long-term policy recommendations for water security. An adaptive governance approach allows for communities to react to - and continually revise plans- as new information becomes available. It is an iterative, systematic process that emphasizes "learning by doing" for improving environmental management policies and practices, whereby decision making is made through a structured process in the face of uncertainty.

### APPLICATION OF ASSESSMENT METHOD

The WSSI was applied in a case study community (Township of Langley, BC). For additional information please refer to our Water Security Briefing Note, and journal article: Norman, Emma S., Karen Bakker, Gemma Dunn. 2011. **Recent developments in Canadian water policy: An emerging water security paradigm**. Canadian Water Resources Journal 36(1), 53-66.

It is important to stress that this is just one example of application of the WSSI; the assessment method is designed to enable communities to identify indicators that best suit their needs and data availability.

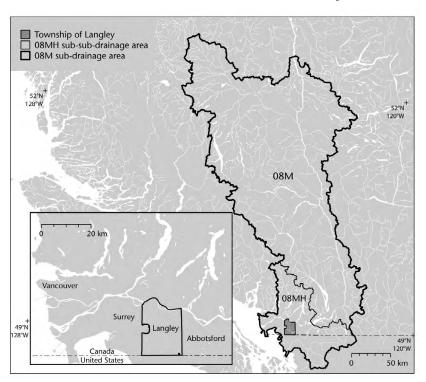


Figure 1. Map of study area, Township of Langley, British Columbia Canada and watershed areas (o8MH and o8M; Environment Canada) used for Water Availability Index Calculation

1The Township of Langley (ToL), located 47 kilometres southeast of Vancouver, British Columbia (BC), is a predominantly rural community of approximately 100,000 residents. The land use is a mix of agricultural with commercial, industrial and residential, with 75 percent of its land base in the Agricultural Land Reserve (ALR). Growing population pressures and increasing commercial, industrial, and agricultural demands are impacting water supply and quality. For example, in some areas (solely dependant on groundwater) peak summer water demand nearly exceeds the Township's existing municipal supply capacity. Elevated nitrate levels in groundwater indicate groundwater vulnerability to contamination due to agricultural activities and poor wellhead protection (ToL 2009). The ToL is part of the massive Fraser River watershed system, illustrated in Figure 1. The lower reaches of the Fraser River are concentrated in the Fraser Valley, which supports a large portion of British Columbia's human population. The area contains critically important fish habitat, including approximately 700 kilometres of fish bearing streams and numerous wetlands (BC Ministry of Environment (BC MoE) 2011; ToL 2009). The ToL differs from other municipalities of the region in that groundwater is the primary source (80 percent) of water to meet agriculture, commercial, industrial, and residential needs. The remaining water needs are supplemented from the Greater Vancouver Water District (GVWD). The ToL operates 18 municipal wells; in addition, 20 percent of the ToL residents obtain water from private wells (numbering at least 5,000) (ToL 2009). Water management is complicated by the transboundary nature of the watershed, with different administrative and legal systems, in addition to fragmented data sources associated with the waters. Although pathways exist to coordinate with counter-parts in the United States, data sharing efforts are nascent and coordination limited (Norman and Bakker 2009; Norman 2009).

Table 4 summarizes the indicators selected to assess Water Security Status in the Township of Langley, BC. These indicators are the key criteria necessary for water security assessment covering water quality and quantity with respect to human health and aquatic ecosystem health.

Table 4: Water Security Status Indicators used in the Township of Langley, BC

Indicators that define safe water for	Water Quality	Water Quantity
Human Health	1) CCME Water Quality Index (WQI)	<ol> <li>Environment Canada</li> <li>(EC) Water Availability</li> <li>Index (WAI),</li> <li>Water Management</li> <li>Plan, Township of</li> <li>Langley</li> </ol>
Aquatic Ecosystem Health	1) CCME WQI 2) Community Assess- ment, British Columbia Fish Protection Act	<ol> <li>Water Availability</li> <li>Index, Environment</li> <li>Canada</li> <li>Community Assessment, British Columbia</li> <li>Fish Protection Act</li> </ol>

To assess water quality for human health in ToL, the Canadian Council of Ministers of the Environment Water Quality Index was applied (CCME 2001). This index provides a framework for assessing ambient water quality conditions relative to water quality objectives. It is flexible in terms of:

- the type and number of water quality variables to be tested;
- the period of application;
- the type of water body tested;
- variables used (both human health parameters and aquatic ecosystem health parameters can be calculated separately).

The human health objectives were based on the Canadian Drinking Water Quality Guidelines. In order to calculate the WSSI a number of data sources were identified ranging from academic, non-government organizations, industry, agriculture, municipal, provincial, and federal, each with varying data quality, comprehensiveness, and accessibility. Since the majority of the drinking water in the ToL is drawn from municipal or private wells, the most comprehensive groundwater data sets were identified and used: the community Private Well Network (PWN), and the provincial Environmental Monitoring System (EMS) (refer to Part II, Section 5).

The WQI requires a minimum of four samples per site, testing at least four (of the same) parameters, ideally over a one-year period. A significant challenge was having sufficient data to calculate the CCME WQI matching the criteria. Even when the two data sources (PWN and EMS) were combined, only a small number of wells had sufficient data that matched the CCME WQI criteria.

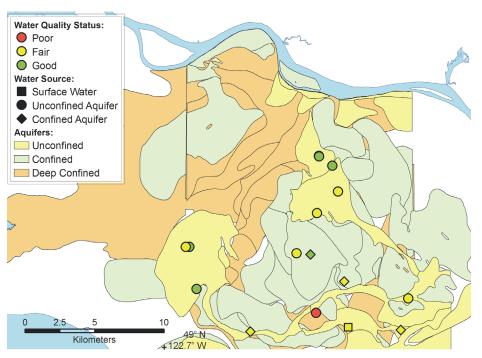


Figure 2. Geospatial Assessment Map for Water Quality in Township of Langley (refer to Part II, Section 5)

Data Sources: ToL 2009, British Columbia Ministry of the Environment (2011)

The WQI results ranged from "good" to "poor", with the majority (60 percent) indicating "fair" or "marginal" water quality. This diversity of water quality is unsurprising given the variety of aquifers in the ToL (confined and unconfined with different sediment types and variable chemical constituents). Each of these aquifers may have a unique sensitivity to natural and anthropogenic contaminants, which is a result of the complex hydrogeology of the ToL.

To assess water quality for aquatic ecosystem health, the CCME WQI was applied again, this time using surface water data, and parameters and objectives specific to aquatic ecosystem health. Finding 'objectives' for parameters to assess aquatic ecosystem health was harder than for human health.

Surface water (stream) data for Bertrand Creek (a representative creek in the ToL) were extracted from the provincial EMS database. Data availability was a significant issue. Of the two sampling sites in Bertrand Creek, only one site had sufficient data for CCME WQI to be calculated. Another significant issue was the time period of the sampling. Ideally, WQI data should cover at least one year; however, the data for sites were collected weekly over a one-month time period, which does not enable seasonal variation analysis. The parameters assessed were also selected based on data availability. Objectives were selected from either the CCME's Water Quality Guidelines for the Protection of Aquatic Health; Environment Canada's Freshwater Quality Index ecosystem health parameters; or from provincial guidelines (Environment Canada 2010b).

In addition to applying the WQI, we also identified the number of "critical streams" within the boundaries of ToL and number of known endangered fish species. Compromised riparian habitat and a reduced flow are causing conditions of hypoxia in several streams in the region and impacting fish pop-

ulations. Specifically, the Nooksack Dace and Salish Sucker (Catostomus sp.) have "endangered" status (Environment Canada 2010a).

To assess water **quantity** for **aquatic ecosystem** and **human health**, the Water Availability Index (WAI) currently under development by Environment Canada (EC) was selected. This federal indicator calculates the volume of water in rivers compared to the amount of water used.

The WAI was selected for this project as it appears to be the only Canadian indicator integrating demand in relation to supply at the watershed scale.1 (Canadian water quantity indicators typically assess either demand or supply, more often supply). Furthermore, the objectives of the WAI were to include aquatic ecosystem health, human health, groundwater and surface water suggesting close alignment with our water security project. However, this index is challenged by data limitations. Limited groundwater and aquatic ecosystem health data has resulted in these components of the index being excluded for the short to medium term. Currently, the WAI assesses water supply and demand for surface water in a limited number of Canadian sub-watersheds.

The WAI is designed to be a national or regional indicator assessing with-drawals at the watershed scale (although for our case study community the index was calculated at a sub-sub watershed scale). The WAI is calculated using data from three national surveys (EC's Municipal Water and Wastewater Survey, Statistics Canada's Industrial Water Use Survey, and Agricultural Water Use Survey), plus data from national hydrometric monitoring stations (HYDAT). Environment Canada is currently planning to report on this index approximately every two years (determined by data availability – national surveys are typically carried out once every two years).

At the time of testing the WAI was still under development and information on this index was not publically available. We collaborated with Environment Canada to explore the possibilities of applying the WAI at a scale that would be more meaningful at a municipal level. Using Environment Canada's watershed boundaries the WAI was calculated for the watershed that includes the Township of Langley (08M), and the neighbouring (08G) watershed (see Figure 1). As such, the WAI was also calculated at the sub-watershed (08M) scale and the sub-sub watershed (08MH) scale.

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## **Surface Water Quantity** Good **Fair Poor** Human **Ecosystem** Health Health **Groundwater Quantity** Good **Fair Poor** Human **Ecosystem** Health Health

- **Ecosystem Habitat** is **poor** as preferred egg-laying sites are at groundwater discharge areas, which are declining.
- **Surface water** quantity for **human health** is **good** with drinking water available from Greater Vancouver Water District (although at a high price)
- Groundwater quantity for human health (drinking water) is poor/fair with growing demands and declining well levels

Figure 3. Water Quantity Slider Bar Assessment
Data Sources: ToL (2009); Environment Canada (2010); British Columbia Ministry of the Environment (2011)

The index results for both sub watershed (08M) and sub-sub watershed (08MH) were in the 'low stress' category, implying that there are no availability constraints in this region (Environment Canada 2010b: 15). The same results were seen at the sub-watershed scale, and in the neighboring (08G) watershed (i.e., Low >10%).

These results differed from the ToL studies, which identified a challenge in its ability to meet demand in relation to supply (ToL 2009). This discrepancy relates to scale of assessment, method of assessment, and data availability. Furthermore, these findings highlight that in this region, distribution (i.e., infrastructure) may be more the challenge rather than available natural supply. Other factors that could influence these results include: a mismatch of administrative and watershed boundaries; data availability; frequency of reporting; the lack of sensitivity to groundwater sources. Although the watershed is transboundary (Canada - U.S.), the calculations were run only using information available from the Canadian side of the watershed. Environment Canada used data from 2005 and 2007 national surveys, which were relatively wet years (Environment Canada's databases are only updated every two years). Data from dry years such as 2001 and 2002 were not used in this calculation. Seasonal variations in supply and demand would also present a different picture to annual reporting. The index also focuses on water withdrawals; consumptive use has not yet been fully incorporated into the index.

However, even if the all the above factors were adjusted the final WAI results are unlikely to change for this test community. This finding suggests the need for greater development of indicators that are accessible and sensitive at a subwatershed scale and include both supply and demand. Thus, for the calculation of the WSSI assessment method, we suggest the application of more localized indicators, if available. For example, the ToL is currently undertaking a water balance study that could be applied to the WSSI assessment method. Other indicators relevant to groundwater supply include measured decline in groundwater level.

To provide additional assessment of water quantity and quality for aquatic ecosystem health, existing studies for aquatic ecosystem health were identified and results incorporated into the overall assessment. In our case study area, the British Columbia Fish Protection Act has started to assess fish habitat. The Act, for the first time, provides legislative authority for water managers to consider status of fish and fish habitat in approval (or renewal) of licenses for development projects. This Act focuses on four key areas: "ensuring sufficient water for fish; protecting and restoring fish habitat; improved riparian protection and enhancement; and stronger local government powers in environmental planning" (BC MoE 2011). This study provides an on-the-ground assessment of conditions related to aquatic ecosystem health using indicators species.

## RECOMMENDATIONS AND FURTHER AREAS FOR RESEARCH

In closing, the inclusion of stakeholders is an essential component to integrated assessment methods, as they provide valuable local knowledge, access to data sources, and long-term commitments to adaptive planning. We argue that assessment methods such as the WSSI may close the gap between scientific assessment, policy, and behaviour-change, particularly if these methods are flexible in nature and incorporate adaptive management and community involvement. This may, we suggest, contribute to attaining goals of water security at the community level and beyond.

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