COMPREHENSIVE DRINKING WATER SOURCE TO TAP ASSESSMENT GUIDELINE

Draft for Pilot Assessments

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Ministry of Health Services
&
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INTRODUCTION

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I. Background on Comprehensive Drinking Water Source to Tap Assessments in B.C.

Safe drinking water is a basic necessity of life and a vital public health priority in British Columbia, where water supply systems are regulated under the *Drinking Water Protection Act (DWPA)*. Requirements for water suppliers to undertake assessments are outlined in Part 3 of the *Act*, in which the Drinking Water Officer (DWO) may order a water supplier to complete a drinking water assessment. This guideline for conducting comprehensive drinking water source to tap assessments in British Columbia provides a structured and consistent approach to evaluating risks to drinking water, and satisfying the assessment requirement under the *Act*.

Under the *DWPA* and for the purposes of this assessment, a "water supply system" provides potable water to any single or multiple connections other than one single family residence. A water supply system consists of the physical infrastructure and management of the collection, treatment, storage, and distribution of drinking water from the source(s) to the consumers. Typical physical components of water supply systems include source waters and their catchment areas, intakes, wells, storage reservoirs, treatment facilities, pumps, distribution systems, and power sources.

This guideline fulfills the need for a comprehensive assessment ordered by a Drinking Water Officer when significant risks are identified for a water system through the self-screening tool or by some other means. In addition to fulfilling a regulatory requirement, this guideline serves as a tool for water systems to develop a more comprehensive understanding of the risks to drinking water safety and availability, how to operate more effectively, and how to produce the best possible water quality. This guideline can be applied equally well under orders by a DWO or as a voluntary measure by water suppliers wanting to understand risks to drinking water safety in their systems.

II. What Is a Comprehensive Source to Tap Assessment?

The primary aim in this assessment is to identify hazards and vulnerabilities that may threaten the safety and sustainability of the water supply (see Box I-1 for definitions of important terms), and to recommend risk management actions to address them. The assessment guideline was developed through an inter-ministerial source to tap assessment team (STAT). To ensure that the guideline addressed key issues, fulfilled regulatory requirements, and met stakeholder needs, ten principles were adopted to guide the development of the comprehensive drinking water source to tap assessment process. These ten guiding principles are described in Appendix IA.
Risk is considered from two perspectives in the comprehensive drinking water source to tap assessment guideline: identifying the hazards that threaten drinking water, and the vulnerabilities in the multiple barrier system intended to protect the drinking water system.

The outcome of the assessment is an improved and integrated understanding of the various components of the water supply system, their strengths and weaknesses, and the existing and potential threats to drinking water so that informed decisions can be made for effective risk management. When we understand the threats and vulnerabilities of our drinking water supplies and the interdependency of their components, we are able to make better decisions for reducing or mitigating risk.

BOX I-1. Definitions of important source to tap assessment terms and concepts

Hazards are the agents of harm – events, conditions, actions, inactions – that have the potential to impact the safety or availability of the water supply.

Vulnerabilities are the processes,

The comprehensive source to tap assessment guideline is:

- A consistent and structured, but flexible methodology for identifying and evaluating drinking water risks in the source to tap system.
- A flexible approach that can be adapted for water supply systems of all types and sizes.

The comprehensive drinking water source to tap assessment is not:

- A prescriptive assessment methodology.
- A set of detailed instructions on how to complete every assessment component. Where guidance is not provided, it is assumed that assessors are familiar enough with the subject matter that they will know of or create methods to fulfill the requirements for the assessment components.

III. What is the Comprehensive Source to Tap Assessment Process?

One of the prime objectives of the source to tap assessment is to identify and evaluate existing and possible threats and vulnerabilities to drinking water safety and sustainability. This guideline consists of eight modules containing guidance for identifying hazards and vulnerabilities in the source to tap system, and assessing the risks they pose to human health and sustainability of the water supply. The eight modules of the drinking water source to tap assessment are:

1. Delineate and characterize drinking water source(s)
2. Conduct contaminant source inventory
3. Assess water supply elements
4. Evaluate water system management, operation, and maintenance practices
5. Audit water quality and availability
6. Review financial capacity and governance of the water service agency
7. Characterize drinking water risks from source to tap
8. Recommend actions to improve drinking water protection

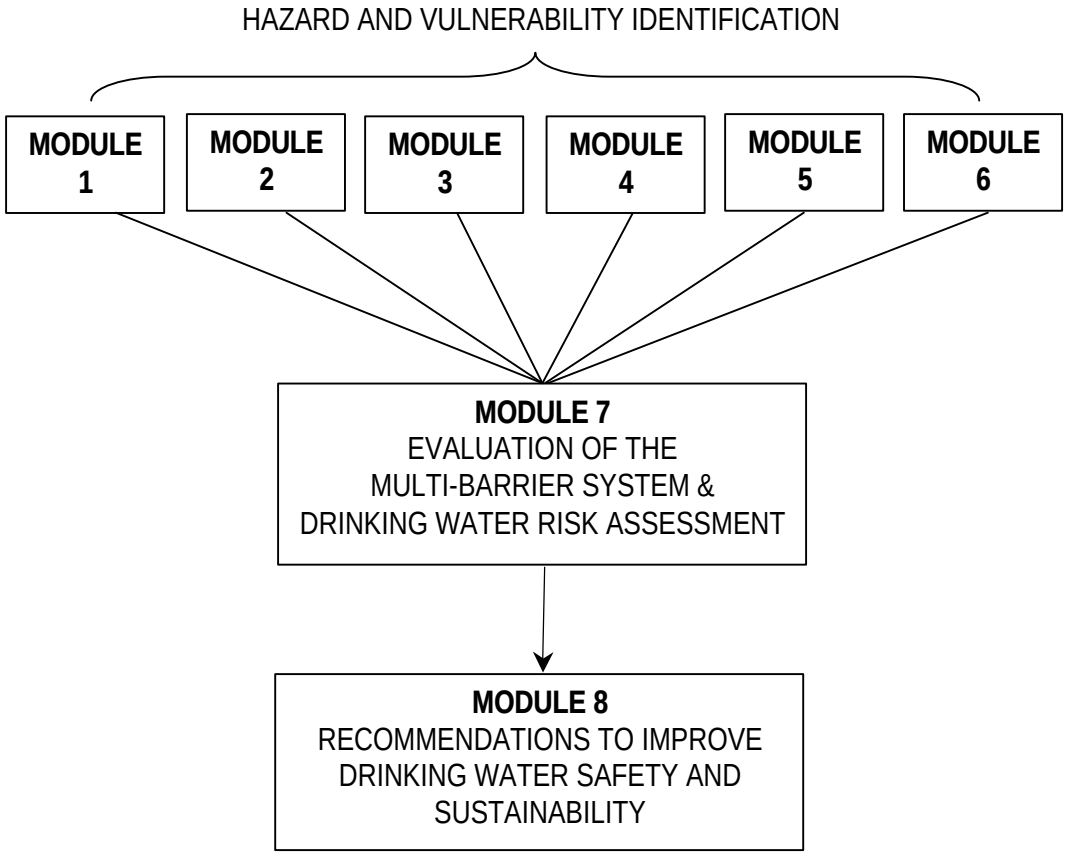

Figure I-1. Comprehensive drinking water source to tap assessment guideline process

In Modules 1 to 6 hazards and vulnerabilities are identified, characterized, and assessed, identifying threats and weaknesses as they become apparent in the course of evaluation. Module 7 evaluates the information collected in Modules 1 to 6 through a vulnerability and risk assessment, and an evaluation of the ability of the water supply system to reliably provide sufficient volumes of safe drinking water. Results of Module 7 are used in Module 8 to establish of a set of prioritized risk management actions for improving drinking water safety and sustainability.

Hazard and Vulnerability Identification

The broad objective of Modules 1 to 6 of the source to tap assessment is to identify existing or potential hazards to drinking water safety and sustainability. In each of those modules, any hazards revealed through the assessment are identified and recorded. Drinking water hazard identification is a subjective process and requires professional expertise and judgement on the part of assessors. Examples of hazards that could be identified in each of the first six assessment modules are presented in Appendix IB.

Hazards can be events, conditions, or situations that could compromise the provision of safe drinking water, and include the direct or indirect input of a potentially harmful substance into drinking water anywhere in the source to tap network.

For the sake of brevity in this guideline and for assessments, hazards themselves and situations leading to hazards will be referred to collectively as "hazards". Hazards can be:

- physical or less tangible in nature.
- pre-existing or potential.
- naturally-occurring or a function of human action or inaction.

To assist in identifying hazards, ask the question, *What could happen in this area of the water supply system that has the potential to pose a threat to public health?*

Extending beyond examining the physical hazards of the water source and system infrastructure, this drinking water source to tap assessment guideline also evaluates governance and financial systems, as well as the management and operation of the water supply system.

A hazard identification table (see Table I-1 for an example), is used in the assessment to document the hazards identified in each of Modules 1 to 6 and their possible effects, and any measures currently in place that prevent the hazard from causing harmful effects. The hazard identification table is an information tool to better understand the threats to water safety and the preventative measures in place. It is not intended to be a prescriptive reporting requirement, and assessors are invited to provide information in any way that is meaningful to the water supplier and DWO.

In the hazard identification table, a number should be assigned to each hazard in order to make referencing and identification of hazards throughout the assessment process easier. A suggested approach for numbering is to use the module number and then a number in sequence for each hazard identified. For example the first hazard identified in Module 1 would be assigned number "1-1". The third hazard identified in Module 6 would be "6-3".

When recording hazards, be as specific and detailed as possible to ensure that the nature of the hazard is clear and the corresponding response can be effective. All perceived hazards should be identified whether the water supplier has control over them or not.

In identifying hazards, it can be tricky to select a level of detail at which to define hazards. Assessors are asked to use their best professional judgment to define an appropriate level of detail, but hazards should be identified at the level at which the management action to address it would take place.

Table I-1. Sample hazard identification table from Module 4

Hazard No.	Drinking Water Hazard	Possible Effects	Existing Preventative Measures	Associated Barrier(s)
4-1	No cross-connection control	Cross-connections can	None identified.	Management

	program established.	allow unpotable water into the distribution system.		
4-2	Emergency response plan has not been updated for 5 years.	Emergency response plans function as the last barrier in emergency or abnormal operating situations. Contact phone numbers and information need to be current for the plan to be effective.	None identified.	Emergency Response Planning
4-3	No formal system of handling or recording customer complaints is in place.	Customer satisfaction is a key indicator of finished water quality and can provide a warning sign for problems.	None identified.	Management

Vulnerabilities are weaknesses in the source to tap system or the absence of drinking water risk prevention, reduction or mitigation strategies. Vulnerabilities can be identified by asking:

- What important protective or preventative strategies are absent?
- Where are the weaknesses in the multiple barrier system?
- How could a drinking water protection barrier be compromised or penetrated?

Water supply system vulnerabilities can be recorded along with the evaluation of drinking water protection barrier(s) in each module.

Multiple Barrier System Evaluation

Principles of the multiple barrier (multi-barrier) approach to drinking water source protection are embodied in this framework for comprehensive drinking water source to tap assessments. "The multi-barrier approach is an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health (CCME, 2004)."

The purpose of this approach to drinking water protection is to employ a series of preventative measures to ensure that safe drinking water is provided even if one of the barriers fails. Barriers function to protect drinking water quality by preventing contaminants from entering the water anywhere in the system from source to tap, removing particles from water, destroying microbes in the water, or by maintaining water quality during distribution. Barriers reduce the likelihood and degree of impact of risks. Barriers can be effective against both known and unidentified threats.

Six barriers for drinking water protection are applied in this guideline (Fig I-1):

1. Source Protection
2. Treatment
3. Water System Maintenance
4. Water Monitoring
5. Operator Training
6. Emergency Response Planning

Underpinning the multiple barrier system are three supporting mechanisms essential to the safe and reliable supply of drinking water to consumers:

1. Sound water system management
2. Affordability
3. Effective governance

Supporting mechanisms reinforce barriers by ensuring they are in place, reliable, and effective in preventing, minimizing or mitigating drinking water risks.

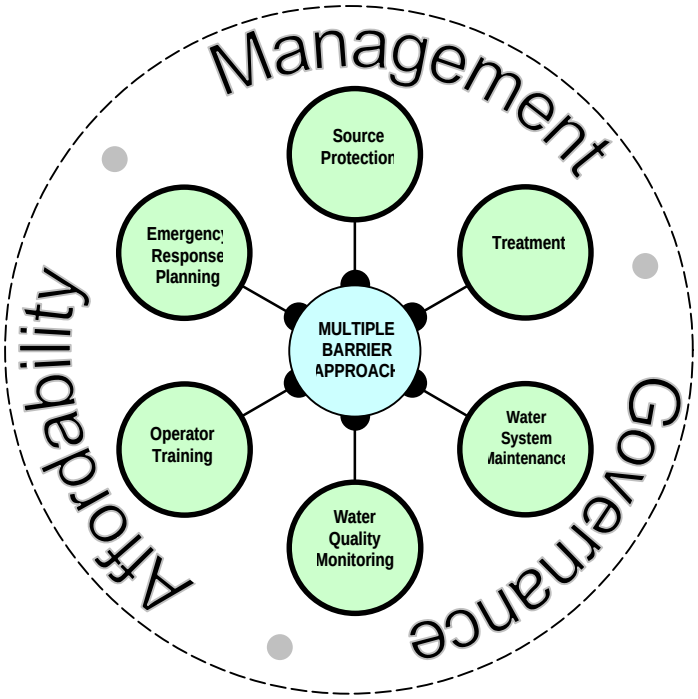

Figure I-1. Multiple Barrier System of Drinking Water Protection

In this assessment, the barriers that make up the multiple barrier system are evaluated through: (a) identifying vulnerabilities in the source to tap system throughout Modules 1 to 6, and (b) assessing the robustness (strength and reliability) of the barriers in Module 7. The qualitative risk assessment methodologies presented in Module 7 incorporate the results of the multiple barrier system evaluation through consideration of how protective and preventative strategies influence the level of risk posed by a hazard.

In the course of evaluating the source to tap system, the existence of vulnerabilities are going to become evident. Strengths and vulnerabilities should be identified for each barrier assessed in a particular module. This information is compiled to support the assessment of the multiple barrier system in Module 7.

IV. How To Use This Source to Tap Assessment Guideline

This guideline presents an eight-module process for conducting comprehensive source to tap assessments. Each module includes:

- essential assessment components (listed in box at the top right of the first page of each module).

- drinking water protection barriers and supporting mechanisms assessed (highlighted in circle at bottom right of the first page of each module).
- required qualifications of the assessment team for each module (section 1.1 of each module).
- guidance on how to undertake assessment components (section 2 of each module[1]).
- guidance on assessment documentation and reporting (section 3 of each module[2]).
- an overview of the assessment components, recommended methods, scope and documentation and reporting requirements (Appendix #A of each module).
- recommended assessment resources (Appendix #B of each module).

Because this guideline was developed to fulfill the need for a comprehensive source to tap assessment, some minimum requirements are included to ensure the reliability and consistency of resulting information. Assessment components make up the essential parts of the assessment. Some methods for completing assessment components are presented in each module as guidance in meeting assessment objectives. Other innovative or more advanced methods may be used where adequate data and resources are available. Assessors will need to draw upon additional resources to complete the assessments. Where possible these sources are identified directly in the text or in Recommended Resources, Appendix #B of each module.

This document is not intended to be all-encompassing or limit the ability of the water supplier and/or professional to identify issues outside of the scope or limitations of the guideline.

Modular Format

Recognizing that water systems are unique, this source to tap assessment guideline was designed to be applicable to the full range of water supply system sizes, from single connection commercial facilities to municipal systems. Consistent with the principle of flexibility in assessments, not all modules of this source to tap framework are required. Its modular format enables portions of the assessment procedure to be used if risk is perceived only in certain portions of a water supply system (see section IV of the Introduction). It should be stressed, however, that the strength of this source to tap assessment framework is in its comprehensiveness as a whole, where risks can be characterized and management decisions made in the context of the entire water supply system from source to tap.

In keeping with the principle of flexibility, there are a number of ways this guideline can be used for assessing water supply systems. It is designed for use when a DWO identifies the need for an in-depth assessment of a water supply system, or some aspect of it. In some cases, the DWO may identify a specific area of concern (e.g., distribution system, land use activities in the source area) as a focus for the assessment. In other cases, a more general

[1] Guidance on how to undertake assessment components is provided in sections 2 and 3 of Module 1.
[2] Guidance on assessment documentation and reporting is provided in section 4 of Module 1.

concern (e.g., history of water quality exceedences, poor management) may have triggered an assessment and the DWO may order a complete source to tap assessment.

In this guideline, Modules 1 to 8 do not have to be carried out entirely in sequence. Modules 1 to 6 may be carried out in any order or simultaneously, except Module 1 must always precede Module 2. For the guideline to be effective the following four restrictions on its use are necessary:

- **Modules 7 and 8 should always be completed in an assessment with at least one of Modules 1 to 6.** Modules 1 to 6 are the hazard identification modules and at least one of those modules is required in an assessment. Module 7 consists of risk characterization for the hazards and vulnerabilities identified in the source to tap system. In Module 8, a set of recommended risk management actions is developed. Modules 7 and 8 synthesize the information collected on hazards and vulnerabilities into a form that can be used to make decisions and manage risks. Hazard and vulnerability identification, risk characterization, and recommended risk management strategies are all essential components of a drinking water assessment.

- **Modules 1 to 6 (or the modules selected for a focused comprehensive assessment) have to be completed before proceeding with Modules 7 and 8**. Hazard and vulnerability identification must be finished before risk characterization can be performed.

- **Module 1 must be completed before Module 2 is started.** Assessment areas in Module 1 need to be delineated before a contaminant source inventory can be conducted in Module 2.

- **If a water supply system uses multiple sources, Modules 1 and 2 must be completed separately for each source** except where: 1) two or more wells are close enough together that one capture zone is delineated for all wells, or 2) two or more intakes are in the same surface water body. In both cases, conservative delineation approaches should be taken and the integrity and location of each well and intake should be evaluated individually.

Smaller Water Supply Systems

Small water supply systems can realistically complete a comprehensive source to tap assessment using this guideline because in many cases the scope and scale of the assessment will adjust automatically with the size of the system. Small systems tend to be simpler in composition, thus the volume of information generated from an assessment will be smaller, reducing the time and other resources required to conduct an assessment.

One exception is that water sources can be large and complex even for small water supply systems. Recognizing this, several aspects of Modules 1 and 2 of the guideline were designed to be adjustable to accommodate small systems:

In Module 1:

- Some simple source area delineation options with low data requirements are presented
- the depth of inquiry for source characterization can be also scaled to level of perceived risk or available resources.

In Module 2,

- the contaminant source inventory can be scaled down in scope and sophistication to suit the resources available.

Adopting a modular approach, as described previously, is another way to make a comprehensive assessment less onerous for smaller water systems because the focus is applied to the areas of greatest concern.

V. When Does a Water Supplier Complete a Comprehensive Source to Tap Assessment?

Self-screening tool

A drinking water source to tap screening tool has been developed as the first tier in the drinking water assessment process. This survey is completed by the water supplier and submitted to the Drinking Water Officer who evaluates the results. If significant risks are identified, the DWO can order a water supplier to undertake a comprehensive source to tap assessment to further analyze the risks.

Steps in the Process of a DWO-Ordered Comprehensive Source to Tap Assessment

1. DWO orders water supplier to do a source to tap assessment stipulating the specific modules or components of the assessment to be completed. In the order, the DWO specifies the scope of the assessment – which of modules 1 to 6 are to be completed - and the physical endpoint of the drinking water supply system (e.g., property line, tap?).

2. Water supplier is responsible for having an assessment, but comprehensive source to tap assessments must be conducted by a team of qualified professionals experienced in water supply systems (see assessor competencies in Section VII of the Introduction).

3. DWO may order the water supplier to prepare an assessment response plan (DWPA s. 22), consisting of the measures the water supplier can reasonably undertake to reduce risks and plans to complete within a specified period of time. The assessment response plan will often be based on the risk management strategy proposed in Module 8 of the assessment report, but should also incorporate local input based on the priorities and needs identified by the DWO, water supplier, and water users.

4. Concurrently or perhaps as part of the assessment response plan, there are two other processes commonly used to safeguard drinking water: 1) source protection plans (e.g., Well Protection Toolkit), and 2) water system risk management programs.

5. There are no sweeping requirements for updating or repeating comprehensive source to tap assessments. Assessments shall be updated as required by the DWO based on risk level or changes to the system.

Joint Source Water Assessments

Situations exist where two or more water supply systems use the same source (same lake or stream, or wells close together), where undertaking a joint source assessment would be the most efficient and cost-effective approach to assessing risks to drinking water in the source. Joint assessments can be accommodated through this guideline provided that the objectives for source assessment of all water systems involved are met. When ordering assessments for risks associated with water sources, drinking water officers are asked to consider opportunities for joint source assessments to facilitate opportunities to pool resources. Joint drinking water source assessments require that cooperative efforts and cost-sharing agreements between the participant water systems be established.

VI. Who Should Use this Guideline?

Professionals who will be conducting assessments, drinking water officers, and water suppliers are the intended audiences for this guideline. It is written with the assumption that the reader has knowledge of drinking water sources, treatment and conveyance systems and associated public health risks. A glossary and list of acronyms are provided at the end of the document to define and clarify terms.

This guideline contains a combination of specific assessment methods (e.g., water source area delineation techniques) and general instructions for acquiring and analyzing information. Sometimes general instructions are given without many details to avoid being overly prescriptive especially where established methods have not been developed, and to allow professionals flexibility in achieving assessment objectives. It is expected that assessors will be experienced and able to fill in the details of assessment processes based on their knowledge of water supply systems and best practices.

VII. Who Should Conduct and Participate in Assessments?

This guideline is written under the assumption that assessments will be conducted by a multi-disciplinary team of professionals who collectively have the necessary expertise to evaluate the safety and sustainability of water supply systems. It would be extremely rare to

find one individual with the breadth and depth of knowledge required to undertake a comprehensive drinking water source to tap assessment.

Assessor Qualifications

Generally assessors should have knowledge and experience related to:

- the collection, treatment, storage and conveyance of water
- public health issues related to drinking water
- legislation related to surface water, groundwater, and drinking water
- risk assessment and risk management
- water chemistry
- drinking water microbiology

Collectively, the assessment team should have knowledge and experience related to the qualifications identified specifically for each module applied in the drinking water assessment.

Professional Supervision and Sign-off

The assessment report is an important document used to inform significant decisions for drinking water protection. For this reason, it is recommended that in addition to experienced individuals conducting the assessment, the assessment report should be signed off by a professional engineer, geoscientist, agrologist, and/or forester with all the listed competencies for submission to the water supplier and DWO.

Technical Advisory Committee

The *Drinking Water Protection Act* specifies that the drinking water officer may establish a technical committee to provide advice on the preparation, form, content, area of coverage, and time allowed for completion of the assessment, as well as to review the draft assessment report. A technical advisory committee could be used in any drinking water assessment, but is recommended where land use activities in the source area are a concern.

Where established, the technical committee should be multi-disciplinary, with one representative from each of the following organizations as appropriate:

- Water supplier
- Public health engineer
- Local health authority (Environmental Health Officer/Public Health Inspector or Drinking Water Officer)
- Ministry of Water, Land and Air Protection
- Local government
- Resource agencies with activities potentially affecting source water (e.g., Ministry of Forests, Ministry of Sustainable Resource Management, Land and Water BC, Ministry of Energy and Mines, Ministry of Transportation)

A terms of reference document for the committee should be established in consultation with the Drinking Water Officer so the role of the committee is clear to its members and the assessment team.

VIII. Roles and Responsibilities

Protecting drinking water is a shared responsibility. Various agencies are participants in comprehensive source to tap assessments with roles and responsibilities as outlined in Table I-2.

Better illustrate that there are many players.

DRAWING

The comprehensive drinking water source to tap assessment is a technical exercise, and as such it is not appropriate to formally involve water users or stakeholders in the process. Input from water users and the public will be most valuable during the subsequent development of the Assessment Response Plan or some other risk management plan.

Table I-2. Roles and responsibilities of participants and regulatory agencies in comprehensive drinking water source to tap assessments

Participant	Roles and Responsibilities
Water System Owner/Purveyor	• Responsible for assessments.
Drinking Water Officer (Regional Health Authority)	• Orders an assessment when he/she has reason to believe necessary to assess threats to drinking water.
Assessment Team	• Responsible for completing source to tap assessments and recommending a drinking water risk management plan.
Technical Advisory Committee	• Sets Terms of Reference for assessments • Advises and directs assessment team • Provides advice on the preparation, form, content, area of coverage, and time allowed for completion of the assessment. • Reviews assessment
Ministry of Water, Land and Air Protection	• Lead in source water protection and responsible for source water quality standards, monitoring, compliance and enforcement. • Provides information on drinking water sources for assessments. • Participates in technical advisory groups where required.
Ministry of Community, Aboriginal and Women's Services	• Assists municipalities and regional districts in capital planning and accessing federal-provincial infrastructure grants.
Ministry of Sustainable Resource Management	• Ensures land use planning addresses drinking water issues. • Provides information for assessments. • Part of assessment committee where required.

Ministry of Forests	• Administers forest practices legislation. • Provides information on forestry and grazing activities. • Part of assessment committee where required.
Ministry of Energy and Mines	• Administers mining and oil and gas activities taking into consideration the protection of drinking water. • Provides information on energy- and mining-related activities for assessments. • Part of assessment committee where required.
Ministry of Agriculture, Fisheries and Food	• Oversees environmental farm management to prevent contamination from agriculture and range activities. • Provides information for assessments on a range of issues including water, soil, and nutrient management; pesticides, cattle grazing, and irrigation. • Part of assessment committee where required.
Local government	• Part of assessment committee where required.

IX. What Information is Required in the Assessment Report?

The end-product of the drinking water source to tap assessment process should be a comprehensive report that clearly identifies and evaluates existing or potential drinking water hazards, presents the results of a risk characterization of all hazards, assesses the existing multi-barrier system, and proposes a risk management strategy for improving drinking water safety.

Specific reporting requirements are given at the end of each module in the guideline. The final assessment report should contain a summary that is a suitable for decision makers and the public. In addition to providing a set of directions, this guideline offers information tools to aid in assessing the various factors affecting risk. Requirements for maps, graphics, and tables in the assessment report are provided as aids to organize and present information in an understandable way rather than as prescriptive presentation requirements. Information in the assessment report should be presented in a clear and succinct manner to facilitate decision making to improve drinking water protection.

All members of the assessment team contribute to the final assessment report, and it must be signed off by qualified professionals as indicated in the Assessor Competencies in section VII of the Introduction. Copies of the final report should be submitted to the water supplier, DWO and to the Ministry of Water, Land and Air Protection when Modules 1 and 2 of this guideline are used and anytime drinking water source issues are identified in an assessment. When a technical advisory committee has been established, it would review a draft of the report as specified in the committee's terms of reference.

It is the responsibility of the water supplier to make the results of the assessment public. Various means for public reporting exist, including making copies of the report available in a local library, for viewing at the municipal hall or water supplier office, or on a Web page. A

public meeting may also be held as an opportunity to present assessment findings and seek input on the assessment response plan and/or source protection planning. What should the minimum public reporting requirement be?

ACRONYMS

AE	Analytical Equations
AFR	Arbitrary Fixed Radius/Modified Arbitrary Fixed Radius
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARP	Assessment Response Plan
AVI	Aquifer Vulnerability Index
CCME	Canadian Council of Ministers of the Environment
CCP	Critical Control Points
CFR	Calculated Fixed Radius/Modified Calculated Fixed Radius
DRASTIC	Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact on the vadose zone, and the hydraulic Conductivity of the aquifer.
DWO	Drinking Water Officer
DWPA	*Drinking Water Protection Act*
DWPR	Drinking Water Protection Regulation
EHO	Environmental Health Officer
EOCP	Environmental Operators Certification Program
GPS	Global Positioning System
HACCP	Hazard Analysis and Critical Control Points
HM	Hydrogeological Mapping
MAFF	Ministry of Agriculture, Food and Fisheries
MCAWS	Ministry of Community, Aboriginal and Women's Services
MEM	Ministry of Energy and Mines
MoF	Ministry of Forests
MSRM	Ministry of Sustainable Resource Management
MWLAP	Ministry of Water, Land and Air Protection
NHMRC	National Health and Medical Research Council
NM	Numerical Modelling
PHO	Provincial Health Officer
POD	Point of Diversion
QA/QC	Quality Assurance and Quality Control
RD	Regional Delineation
RHA	Regional Health Authority
SCADA	Supervisory Control and Data Aquisition
STAT	Source to Tap Assessment Team
TOT	Time-of-Travel
UTM	Universal Transverse Mercator (Geographic Coordinate System)
WELL	WELL Database
WLIS	Water Licensing Information System

GLOSSARY

Many of the definitions in the glossary are taken from the following sources:

Horton, G.A. 2000. *Water Words Dictionary*. Nevada Division of Water Planning, Department of Conservation and Natural Resources. http://www.state.nv.us/cnr/ndwp/dict-1/waterwds.htm.

Ministry of Environment, Lands and Parks & Ministry of Health. 2000. *Well Protection Toolkit*. Victoria: Province of British Columbia. http://www.elp.gov.bc.ca/wat/gws/well_protection/acrobat.html.

B.C. Acts and Regulations:

- *Water Act* http://www.qp.gov.bc.ca/statreg/stat/W/96483_01.htm
- Groundwater Protection Regulation
- *Drinking Water Protection Act* http://www.qp.gov.bc.ca/statreg/stat/D/01009_01.htm
- Drinking Water Protection Regulation http://www.qp.gov.bc.ca/statreg/reg/D/200_2003.htm

ANNULAR SPACE
The space between two concentric well casings or between the outermost casing and the surrounding materials.

AQUIFER
A geological formation, group of formations, or part of a formation that comprises sufficient saturated permeable materials to yield economical quantities of water to wells and springs.

AQUIFER VULNERABILITY
An intrinsic measure of how easily an aquifer can be contaminated from activities at the land surface, based on the aquifer's geologic and hydrologic characteristics only. Vulnerability for an aquifer is defined regardless of the type and intensity of the human activities at the land surface.

ASSESSMENT AREA
The area of a drinking water source in which assessment activities are undertaken. The Assessment Area may correspond with the capture zone or watershed, a portion of it, and/or additional areas outside of the capture zone.

BIOGEOPHYSICAL
Biological, geological, and physical characteristics.

CAPTURE ZONE
The zone around a well contributing water to the well; the area on the ground surface from which a well captures water.

CATCHMENT AREA
The land area supplying water to an intake or well.

COLIFORM BACTERIA
A group of bacteria predominantly inhabiting the intestines of humans or animals but also found in soil. While typically harmless themselves, coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms.

CONNECTION
Service line or pipe by which a residential, commercial or industrial customer or other water user obtains water from the supplier's distribution system.

CONTAMINANT
(1) In a broad sense any physical, chemical, biological, or radiological substance or matter in the environment. (2) (Water Quality) In more restricted usage, a substance in water of public health or welfare concern. Also, an undesirable substance not normally present, or an usually high concentration of a naturally-occurring substance, in water, soil, or other environmental medium.

CONTAMINANT SOURCE INVENTORY
An office and field survey that identifies and locates potential sources of contamination in a specified area such as a capture zone area. Potential sources of contamination can be septic tanks, vegetable fields, contaminated industrial site, etc.

CONTRIBUTING WATERSHED
The portion of the watershed supplying water to an intake.

CORRIDOR ZONE
The zone delineated around a stream or lake as the assessment area for watersheds exceeding 500 km^2 in size.

CRITICAL CONTROL POINT
A point, step or procedure at which a control can be applied and a drinking water hazard ca be prevented, eliminated, or reduced to acceptable levels (AWWA, 2002).

CROSS-CONNECTION
Any actual or potential connection between the potable drinking water supply system and any source or system containing non-potable water or other substances.

DISCHARGE (STREAM)
(1) The volume of water passing through a channel during a given time, usually measured in cubic metres per second (CMS) or cubic feet per second (cfs). (2) With reference to groundwater, the process by which groundwater leaves the zone of saturation via evaporation, evapotranspiration, or by flow to the surface through springs and seeps.

DISCHARGE, MEAN ANNUAL
The arithmetic average of the annual discharges for all complete water years of record whether or not they are consecutive. The term average is generally reserved for average of record and mean is used for averages of shorter periods; namely, daily mean discharge.

DOMESTIC WATER SYSTEM
A system by which water is provided for human consumption, food preparation, sanitation, and other household uses.

DRILLED WELL
A well that is constructed with a drilling rig, such as an air rotary or cabletool drilling rig.

DRINKING WATER SOURCE
A stream, reservoir, well or aquifer from which drinking water is taken.

DUG WELL
A well that is dug by hand or excavated by backhoe. Dug wells are usually shallow and often unsanitary.

ELEVATION
The variation in the height of the earth's surface as measured by the vertical distance from a known datum plane, typically Mean Sea Level (MSL).

EROSION
Detachment of soil particles under the influence of water and/or wind.

FECAL COLIFORM BACTERIA
A group of bacteria normally present in large numbers in the intestinal tracts of humans and other warm-blooded animals. Specifically, the group includes all of the rod-shaped bacteria that are non-spore-forming, Gram-Negative, lactose-fermenting in 24 hours at 44.5°C, and which can grow with or without oxygen. Bacteria included in this classification represent a subgroup of the larger group termed Coliform.

FLOODPLAIN
The flat land adjacent to a river, formed by deposition of fluvial materials.

FRACTURE
A general term for any break in rock, which includes cracks, joints, and faults.

GIS
Geographic Information System, a computer software and database that stores and analyzes geographic data. ArcInfo is an example of a GIS software.

GOVERNANCE
The organizational authority responsible for delivering potable water.

GROUNDWATER
Water occurring beneath the surface of the ground.

GROUNDWATER SOURCE
A groundwater source is the aquifer (geological formation) that supplies water to the well and, in particular, the catchment area to the well (or the capture zone).

HAZARD
An event, condition or circumstances that may result in a water supply system a) providing water that is not potable, or b) unable to supply sufficient water volumes.

HYDRAULIC CONDUCTIVITY
A property of the aquifer that provides a measure of ease of flow of water through a cross-section area under a unit hydraulic gradient. Hydraulic conductivity is usually expressed in metres per day or feet per day.

HYDROGEOLOGIC MAPPING
Mapping groundwater and groundwater-related features. For example, a contour map of the water table, a map outlining the aquifer boundary and aquifer thickness, or a map showing the rate and direction of groundwater flow in an aquifer are examples of hydrogeologic maps.

HYDROGEOLOGY
The science of subsurface waters and related geologic aspects of surface waters.

HYDROGRAPH
(1) A graphic representation or plot of changes in the flow of water or in the elevation of water level plotted against time. (2) The trace of stage (height) or discharge of a stream over time, sometimes restricted to the short period during storm flow. (3) A graph showing stage, flow, velocity, or other hydraulic properties of water with respect to time for a particular point on a stream. Hydrographs of wells show the changes in water levels during the period of observation.

HYDROLOGY
(1) The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings. (2) The study of the movement and storage of water in the natural and disturbed environment. (3) The condition of the aquatic environment at some specified time and place. Most frequently, the term is used in reference to water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

IMPERVIOUSNESS
The portion of a sub-basin, sub-watershed, or watershed, expressed as a percentage, that is covered by surfaces such as rooftops, parking lots, sidewalks, driveways, streets, and highways. Impervious surfaces are important because they will not absorb rainfall and, therefore, cause almost all of the rainfall to appear as surface runoff.

INFILTRATION GALLERY
A water collection system constructed to collect water from a surface water source via subsurface infiltration through coarse-grained sediments.

INTAKE
The point of entry of water into a drinking water system.

INTAKE PROTECTION ZONE
The area within 100 metres (330 feet) of the intake.

INTAKE STREAM
The stream upon which an intake is located.

KARST AQUIFER
Limestone aquifer where groundwater flows through openings formed by water dissolving the rock fractures; the openings are commonly much larger than fracture openings (e.g., caverns, cracks).

LAND USE
The primary or primary and secondary uses of land, such as cropland, woodland, pastureland, etc. The description of a particular land use should convey the dominant character of a geographic area, and thereby establish the types of activities that are most appropriate and compatible with primary uses.

LITHOLOGY
All the physical properties, the visible characteristics of mineral composition, structure, grain size, etc. which give individuality to a rock.

MEAN ANNUAL PRECIPITATION
The average of all annual precipitation values known, or an estimated equivalent value derived by such methods as regional indexes or isohyetal maps.

MEAN ANNUAL RUNOFF
The average value of all annual runoff amounts usually estimated from the period of record or during a specified base period from a specified area. Expressed as a volume per area or “depth” measurement-e.g., mm or inches.

MULTI-BARRIER APPROACH
A system that incorporates six barriers to ensure safe drinking water. The six barriers are: the protection of source water quality; ensuring that there is adequate treatment; providing safe storage and distribution of water; and monitoring drinking water quality at the tap and enforcing standards; ensuring that operators of drinking water systems are adequately trained; and emergency response planning.

NON-POINT SOURCE CONTAMINATION
Contamination where the source is diffuse (e.g., agricultural runoff).

NUMERICAL MODEL
A computer model that is designed to solve a set of mathematical equations that describe the physics of the system that one is modelling (such as an aquifer). Numerical models are usually developed to predict the water table elevation, flow rates, and/or chemical concentrations of a particular contaminant in different parts of the aquifer and over time and is a useful tool to assess implications of different policies or actions being contemplated for an aquifer area.

PATHOGEN
A disease-producing agent; usually applied to a living organism (i.e., biological). Generally, any viruses, bacteria, or fungi that cause disease.

PERMEABILITY
The capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow. Permeability is usually expressed in metres squared (m^2) or feet squared (ft^2). It is closely related to the hydraulic conductivity.

pH
A numerical measure of the acidity or alkalinity of water ranging from 0 to 14. Neutral waters have pH near 7. Acidic waters have pH less than 7 and alkaline waters have pH greater than 7.

PITLESS ADAPTOR
A mechanical device attached to a well casing usually below the frost level, for underground conveyance of water from the well.

POINT SOURCE CONTAMINATION
Contamination where the source is site specific (e.g., landfill).

POROSITY
The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected relative to the total rock or soil volume.

POTABLE WATER
Water provided by a water supply system that meets the standards prescribed by regulation, and is safe to drink without further treatment.

PROTECTION AREA
The area in which source protection activities are conducted. The Protection Area may be the same as the capture zone/watershed or it may be larger or smaller based on administrative boundaries or the physical environment.

PUBLIC HEALTH
Organized efforts of society to protect, promote, and restore people's health emphasizing the prevention of disease and the health needs of the population as a whole.

PUMPING TEST
A test that is conducted to determine aquifer or well characteristics. A pumping test is usually conducted to determine the transmissivity and storativity characteristics of an aquifer and the capacity of a well supply.

PURVEYOR
The person or entity that owns the water supply system and is responsible for the ongoing operation of the water supply system, or in charge of managing that operation. If parts of the water supply system are owned by different persons, or all or part of the system is jointly owned by different persons, all of those individuals are purveyors. See also Water Supplier.

QUALITY ASSURANCE
The overall verification program which provides producers and users of data the assurance that predefined standards of quality at predetermined levels of confidence are met.

QUALITY CONTROL
The overall system of guidelines, procedures and practices which are designed to regulate and control the quality of products or services with regards to previously established performance criteria and standards.

RAW WATER
Untreated water from the source.

RECHARGE AREA
Land area where water infiltrates into the ground and replenishes the aquifer.

RELATIVE RELIEF
Indicates the steepness of a watershed (likelihood of landslides and other physical processes that may be happening that affect water quality). Calculated by finding the difference between the intake elevation and maximum elevation and dividing that by the square root of the watershed area.

RELIEF
The range of topographic elevation within a specific area.

RESERVOIR
(1) A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water. (2) An artificially created lake in which water is collected and stored for future use.

RUNOFF
(1) That portion of precipitation that moves from the land to surface water bodies. (2) That portion of precipitation which is not intercepted by vegetation, absorbed by the land surface or evaporated, and thus flows overland into a depression, stream lake or ocean (runoff called “immediate subsurface runoff” also takes place in the upper layers of the soil). (3) That part of the precipitation, snowmelt, or irrigation water that appears in uncontrolled surface streams, rivers, drains or sewers. It is the same as streamflow unaffected by artificial diversions, imports, storage, or other works of man in or on the stream channels. Runoff may be classified according to speed of appearance after rainfall or melting snow as direct runoff or base runoff, and according to source as surface runoff, storm interflow, or ground-water runoff. (4) The total discharge described in (1), above, during a specified period of time. (5) Also defined as the depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it.

Meteorological Factors Affecting Runoff:
[1] Type of precipitation (rain, snow, sleet, etc.);
[2] Rainfall intensity;
[3] Rainfall amount;
[4] Rainfall duration;
[5] Distribution of rainfall over the drainage basin;
[6] Direction of storm movement;
[7] Antecedent precipitation and resulting soil moisture;
[8] Other meteorological and climatic conditions that affect evapotranspiration such as temperature, wind, relative humidity, and season.

Physical Basic Characteristics Affecting Runoff:
[1] Land use;
[2] Vegetation;
[3] Soil type;
[4] Drainage area;
[5] Basin shape;
[6] Elevation;
[7] Slope;
[8] Topography;
[9] Direction of orientation;
[10] Drainage network patterns; and
[11] Ponds, lakes, reservoirs, sinks, etc. in the basin that prevent or alter runoff from continuing downstream.

SALT-WATER INTRUSION
The invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface or groundwater bodies. The term is applied to the flooding of freshwater marshes by seawater, the migration of seawater up rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.

SANITARY SURFACE SEAL
Sealant placed in the annular space around the outside of the outermost well casing and between multiple well casings, extending from the land surface to several metres deep. The sanitary grout seal functions to prevent any contaminated surface and near surface water from seeping down the side of the well to the aquifer.

SOURCE AREA
A general term that is used to refer to the land area supplying water to a drinking water supply. Source area is synonymous with watershed for surface water sources and capture zone for groundwater sources.

SPECIFIC CAPACITY
The rate of discharge of water from a pumping well per unit of drawdown, commonly expressed in litres per second per metre of drawdown or gallons per minute per foot of drawdown. Specific capacity varies with duration of discharge.

SPRING
(1) A concentrated discharge of ground water coming out at the surface as flowing water; a place where the water table crops out at the surface of the ground and where water flows out more or less continuously. (2) A place where ground water flows naturally from a rock or the soil into the land surface or into a body of surface water. Its occurrence depends on the nature and relationship of rocks, especially permeable and impermeable strata, on the position of the water table, and on the topography.

STATIC WATER LEVEL
The unpumped level of water in the well or in the aquifer.

STREAM
A general term for a body of flowing water; natural watercourse containing water at least part of the year. In hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal.

STREAM GRADIENT
A general slope or rate of change in vertical elevation per unit of horizontal distance of the water surface of a flowing stream.

STREAM ORDER
Designation of stream segments within a drainage basin; a system of numbering streams according to sequence of tributary size. The smallest perennial tributary is designated as order 1, the junction of two first-order streams produces a stream segment of order 2, etc.

SUPPLY ELEMENT
A physical or operational component of a water system.

SURFACE CASING
The well pipe inserted as a lining nearest to the surface of the ground to protect the well from near-surface sources of contamination.

SURFACE WATER SOURCE
A surface water source is defined as those a water source that is open to the atmosphere at the point of withdrawal. Surface water sources include streams, lakes, rivers, reservoirs, and springs (including the aquifer and catchment area that supplies water to a spring). A water system acquiring water from a surface source requires a water license under the B.C. *Water Act*.

TIME-OF-TRAVEL (TOT)
The time it takes for a particular contaminant to be transported through groundwater flow to a specified location. Time-of-travel is commonly used to relate the distance of a contaminant source to a drinking water well (i.e., that gas station is located within a 1-year time of travel distance from the community well).

TOPOGRAPHY
The configuration of a surface including its relief and the position of its natural features.

TURBIDITY
The amount of suspended particulate matter in water measured by the clarity of the water. Units are Nephelometric Turbidity Units (NTU).

WATER SERVICE AGENCY
Organizational entity that owns the water supply system and is responsible for providing potable water.

WATERSHED
(1) An area that, because of topographic slope, contributes water to a specified surface water drainage system, such as a stream or river. An area confined by topographic divides that drains a given stream or river. (2) (Catchment) The natural or disturbed unit of land on which all of the water that falls (or emanates from springs or melts from snowpacks), collects by gravity, and fails to evaporate, runs off via a common outlet. (3) All lands enclosed by a continuous hydrologic drainage divide and lying upslope from a specified point on a stream; a region or area bounded peripherally by a water parting and draining ultimately to a particular water course or body of water. Also referred to as Water Basin or Drainage Basin.

WATERSHED AREA (DRAINAGE AREA)
The watershed area at a point in the stream refers to the area of the earth from which the water concentrates toward that point, through the drainage system.

WATER TABLE
The top of the unconfined aquifer; water level where the pressure is equal to that of the atmosphere; water level in a shallow well.

WATER SUPPLIER
The person or entity that owns the water supply system and is responsible for the ongoing operation of the water supply system, or in charge of managing that operation. If parts of the water supply system are owned by different persons, or all or part of the system is jointly owned by different persons, all of those individuals are water suppliers. See also Purveyor.

WATER SUPPLY SYSTEM
A water supply system is the combination of the physical infrastructure and management of the collection, treatment, storage, and distribution of drinking water from the source(s) to the consumers.

WATER SYSTEM (as defined by the *Health Act* [B.C. Reg. 230/92])
(1) A waterworks system is a system of water supply including its source, treatment, storage, transmission and distribution facilities, where water is furnished or offered for domestic purposes, but does not include a water supply serving only one single family residence. Also referred to as water supply system or community water system.
(2) Water system can also be used to refer to only the treatment, storage, and distribution works separate from the water source.

WELL (WATER)
An excavation (pit, hole, tunnel), generally cylindrical in form and often walled in, drilled, dug, driven, bored, or jetted into the ground to such a depth as to penetrate water-yielding geologic material and allow the water to flow or to be pumped to the surface.

WELL CAPACITY (OR POTENTIAL YIELD)
The maximum rate at which a well will yield water under a stipulated set of conditions, such as a given drawdown, pump, and motor or engine size. Well capacity may be expressed in terms of gallons per minute, cubic feet per second, or other similar units.

WELL CASING
A pipe which protects and supports the wall of the well and maintains access to the water supply.

WELL COVER
A secure, vermin-proof cover, lid or structure that prevents direct or unintended or unauthorized access to the well.

WELL LOG
A record that is kept during well drilling of the various formations and rock materials and the depths at which they are encountered.

WELL PROTECTION ZONE
The area within 100 metres (330 feet) of a well.

WELL RECHARGE ZONE
The area of land from which water percolates into an aquifer and is transmitted from there into one or more wells that are used, or are intended to be used to provide drinking water.

WELL SCREEN
A wire-wound filtering device that allows water but not sediments from entering the well.

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APPENDIX IA
GUIDING PRINCIPLES

The drinking water source to tap assessment guideline was developed based on ten guiding principles:

Drinking water protection is a public health issue, hence drinking water assessments should focus on threats to public health.
The objective of drinking water assessments is to identify threats to drinking water quality and ultimately, public health. Assessments should focus on those issues that have the greatest potential to impact public health.

Drinking water assessments should be a tool to assist in the protection of drinking water.
Drinking water assessments should be useful to the water purveyor, health region, and the community to promote public health protection and to ensure safe drinking water. Health regions should be consulted in assessments to identify specific needs and important issues that need to be addressed.

Drinking water assessments should be conducted in an integrated manner, with consideration for both source and system components.
The source to tap assessment should identify hazards associated with the source and system, and evaluate risks with consideration of the source to tap system as a whole. That is, the source should not be assessed in isolation of the water system or vice versa. This approach facilitates an integrated view of drinking water issues for a water system and assists in budgeting, planning, and implementing short and long-term improvements.

Drinking water assessments should embody the multi-barrier approach.
Assessments should help to identify where a water system will receive the most benefit for investment in terms of the "multi-barrier approach." In the multi-barrier approach to drinking water protection several preventative measures are employed concurrently to ensure that if one barrier fails, that others are in place to protect water quality and human health.

Drinking water assessments should be an opportunity for education and communication among stakeholders.
Drinking water assessments should help educate the purveyor, environmental health officers, and other stakeholders in better understanding the water system and water sources and identify potential problems that need to be addressed. Furthermore, the source assessment portion should foster shared stewardship of the water resource among all stakeholders.

Drinking water assessments should be focused on preventing problems.
Assessments should be prevention-based since drinking water quality in British Columbia is generally good. Ultimately, assessments should be proactive in preventing problems, not just responding to them.

Drinking water assessments should be science-based.
The methods used in drinking water assessments should, wherever possible, be based on supporting science rather than political decisions.

Drinking water source assessments should be flexible and tailored to the size and type of the water system and the level of risk to its users.
Water systems exist in numerous configurations with varying levels of financial and technical capacity. The source to tap assessment should be adaptable to the full range of size, type, and risk associated with water systems.

Drinking water assessments should result in the development and implementation of specific actions and/or recommendations.
After the source-to-tap assessment is complete, the assessor should make specific recommendations for action and improvement of the water source and system. The assessment is only the first step in the process of enhanced drinking water protection. Once specific threats to drinking water are identified, solutions need to be developed to minimize risk. Implementation of these solutions can be in the form of direct action, or where control by the water purveyor is limited, mitigation strategies including development of emergency response plans and drinking water protection plans. Forwarding the results of source water assessments to land use planning and development processes are other proactive measures.

Drinking water assessments should foster and promote the highest water quality possible through stewardship and involvement of the broader community.
If a multi-barrier approach to drinking water protection is adopted, it implies that others (e.g., provincial, regional, and local government, landowners) need to do their part in protecting water resources. To allow this to happen, the information gathered and the issues identified from the assessments should be made available, in some format, to the public and decision-makers with authority in the watershed or over the aquifer, so drinking water can be duly considered in their decision-making.

APPENDIX IB
EXAMPLES OF HAZARDS

**NOTE: This list is not intended to be restrictive or comprehensive, and hazards listed do not pertain to every water supply system. The purpose of this list is to provide a sense of the types of situations, events, or conditions that assessors would consider in each module of the comprehensive source to tap assessment.

Assessment Module	Examples of Drinking Water Hazards	Corresponding Drinking Water Barrier
MODULE 1 – Delineate and characterize water source(s)	• Variations in source water quality beyond GCDWQ	Source Protection
	• Unconfined/shallow aquifer	
	• Unsanitary well or intake	
	• Channel/bank erosion	
	• Salt-water intrusion of coastal aquifer	
	• Seasonal variations in water volumes	
	• No alternative water sources	
	• Unsuitable intake/well location	
	• Natural disasters	
	• Algal blooms	
	• Soil erosion/unstable terrain	
	• Inadequate riparian areas	
	• Presence of naturally-occurring contaminants (e.g., arsenic, uranium, radon)	
MODULE 2 – Conduct contaminant source inventory	• Non-point source pollution	Source Protection
	• Industrial discharges	
	• Use of fertilizers or pesticides on agricultural lands	
	• Manure storage	
	• Major spills	
	• Public roads/highways	
	• Fuel storage tanks	
	• Landfills	
	• Abandoned wells	
	• Human access/recreational activity	
	• Wildlife	
	• Unrestricted livestock	
	• Pipeline crossings	
	• Stormwater discharges	
	• Septic system discharges	
	• Sewer ditch close to well/intake	
	• Contaminated sites	
	• Chemical storage in pumphouse	
MODULE 3 – Assess water supply elements	• Aging infrastructure	Water System Maintenance
	• Absence of backflow preventers	
	• Inappropriate materials/coatings	
	• Corrosion in pipes/reservoirs	
	• Leaks in piping systems	
	• Insufficient back-up equipment/parts	

	• Equipment failure or malfunction	
	• Build-up of sediment or biofilms variations in distribution system pressure	
	•	
	• Inappropriate equipment/processes	Water System Maintenance
	• Lack of process control	
	• Failure of alarms and monitoring equipment	
	• Inadequate security systems	*Management*
	• Peak demand exceeds flow capacity of transmission mains or reservoir	
	• Disinfection not provided for surface water source	Treatment
MODULE 4 – Evaluate water system management, operation, and maintenance practices	• Operator not certified to the appropriate level	Operator Training
	• Inappropriate chemical dosing	Operator Training
	• Inadequate inspection and maintenance procedures	Operator Training
	• Inadequate record keeping procedures	Operator Training
	• Lack of cross-connection control program	Water System Maintenance
	• Infrequent water main flushing	Water System Maintenance
	• Unmanaged dead ends	Water System Maintenance
	• Inappropriate use of automated monitoring systems	Water System Maintenance
	• Lack of sufficient emergency response plan	Emergency Response Planning
	• Power failures	Emergency Response Planning
MODULE 5 – Audit finished water quality and availability	• Inadequate finished water quality monitoring program	Water Monitoring
	• Presence of indicator organisms or pathogens in finished water	Treatment
	• Ineffective disinfection	Treatment
	• Inadequate disinfection residual	Treatment
	• Formation of excessive disinfection by-products	Treatment
	• Elevated concentrations of contaminants	Treatment
	• Concentrations of contaminants exceeding Canadian Guidelines for Drinking Water Quality	Treatment
	• Variations in pressure at the tap	Water System Maintenance
	• Excessive demand	*Management*
MODULE 6 – Review financial capacity and governance structure of water system	• Inadequate resources to maintain water supply system	*Management, Affordability*
	• Lack of a financial plan for annual operating budget and long-term capital expenditures	*Management, Affordability*
	• Governance structure limiting availability of funding for water system improvements	*Governance*

	• Lack of accountability for providing safe drinking water	*Governance*