Assessment Watersheds
for Regional Level Applications

A new standard product of the 1:20 000 Freshwater Atlas
February 2009

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This document provides the background, objectives, principles, and production methods for a new standard delineation of assessment watersheds for British Columbia, developed jointly by the Ministry of Environment (Water Stewardship Division), the Ministry of Healthy Living and Sport (Water Protection), and the Integrated Land Management Bureau (GeoBC).

1.0 BACKGROUND

Resource managers, researchers, modelers, government regulators, practitioners, and other citizens in BC are interested in watersheds. They routinely report results, compare watersheds, present information and monitor at a regional level of detail, using watersheds for these purposes which are about 1,000 to 10,000 hectares in size. At this scale, hillslope and channel processes generally remain well linked.

To date, the most widely used watershed mapping available for this purpose is from BC's 1:50 000 scale Watershed Atlas (specifically the 3rd order watersheds product). This dataset portrays watershed units with a modal size of about 5,000 ha though with a very wide range. Despite historically being an excellent modeling and presentation source due to its hierarchically linked watersheds, a major weakness is the inclusion of many very large units extending up every major drainage in addition to very small units of ~100 ha. In addition to their disparate size, the large elongate units cannot be placed in a meaningful spatial (upstream/downstream) relationship with other units.

The newly completed **FRESHWATER ATLAS** based on 1:20 000 base mapping is designed to supersede and replace the 1:50k Watershed Atlas. The Freshwater Atlas provides more detail (100 times the number of stream segments & watersheds and derived from, and consistent with BC's operational base map (i.e. TRIM at 1:20k) and it remedies a number of identified weaknesses of the 1:50k Watershed Atlas.

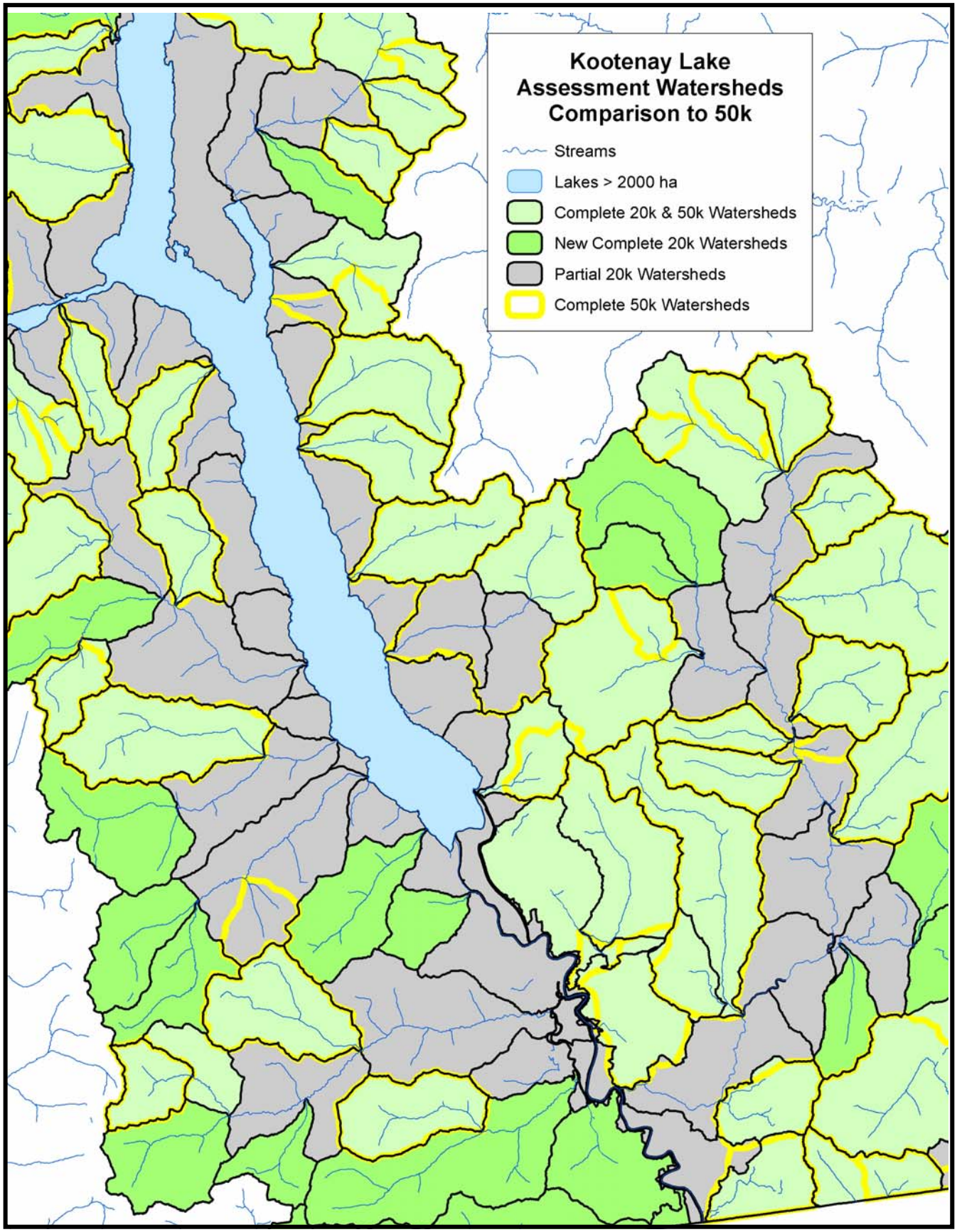
The **FRESHWATER ATLAS** (previously known as the Corporate Watershed Base) provides:

- the authoritative hydrographic network for BC (at 1:20,000) which is complete, connected, consistent and 3D;
- a network that includes all rivers, streams, lakes, man-made water bodies and wetlands;
- explicit identification of the watershed of each stream segment;
- watershed codes that give the correct upstream/downstream relationship for all features;
- a high level of detail; 3.2 million watersheds are identified (with an average size of 30 ha); and
- free and public access to the complete dataset.

There is a demand to replace the widely used 3rd order 1:50k watershed product with a similar but improved product that is consistent with the Freshwater Atlas. The initial watershed mapping provided by the Freshwater Atlas identifies watersheds at a great level of detail, on average, 30 hectares in size. These small watersheds must be grouped together in a logical way to create larger units relevant to the information needs of regional level applications.

In response, in 2007 the Ministry of Environment's Water Stewardship Division (MoE) led the development of an approach to manually create assessment watersheds, applying it to two pilot Timber Supply Areas. Subsequently, MoE teamed up with the Integrated Land Management Bureau (ILMB) and the Ministry of Healthy Living and Sport's Health Protection Branch to substantially revise this manual approach by replacing it with a set of GIS-based rules to be applied across the province to the new 1:20,000 Freshwater Atlas.

The hierarchical watershed code on every small watershed places each in its correct upstream/downstream relationship with all other watersheds. Manipulation of this code allows a hydrologically reasonable grouping (see definition in next section) of small units into larger units. This task of forming larger assessment watersheds from these much smaller watersheds is the main thrust of the present work. The resultant Assessment Watersheds (AWs) map data set will be a standard Freshwater Atlas component product, freely and publicly available.


Kootenay Lake
Assessment Watersheds
Comparison to 50k
Streams
Lakes > 2000 ha
Complete 20k & 50k Watersheds
New Complete 20k Watersheds
Partial 20k Watersheds
Complete 50k Watersheds

2.0 OBJECTIVE

The objective of this work is to provide a standard, consistent and hydrologically reasonable set of assessment watersheds suitable for collecting field data, reporting out results, facilitating monitoring, modeling and supporting other studies related to land-based effects on aquatic systems. In addition it is anticipated that this standard product will be used to present information on themes not directly correlated with watersheds, such as wildlife ranges or climate data. The result will be a single seamless coverage or map (*see foot note # 1 on last page*).

In this context, the following definitions apply:

Standard

- designed to serve the largest number of users and applications, because of the advantages that stem from many different groups using the same framework for collecting, analyzing, grouping and presenting their work and data;
- designed to serve as a general subdivision of the land for many applications beyond hydrologic-related applications; and
- comparable (as much as possible) to the existing 1:50k product, in size and delineation of matching watersheds.

Consistent

- identified watersheds are similar in size, with a target of about 3,000 to 5,000 ha; and
- units are derived by amalgamation of smaller watersheds following logical rules.

Hydrologically Reasonable

- the delineation of the Regional Watersheds ensures that the resultant watersheds can be ordered in an upstream-downstream relationship and given a hierarchical code to allow further hydrologic analysis;
- the boundaries between Regional Watersheds are at significant hydrologic features, as opposed to being established arbitrarily (e.g. at major confluences versus minor confluences); and
- the greatest proportion as possible of watersheds (by count and by area) are complete watersheds (a complete watershed is an area of land drained by a mapped stream to a point and does not have any upstream areas draining into it (*see foot note # 1 on last page*).

3.0 PRINCIPLES

The challenge is to create a standardized watershed dataset that can replace the widely used 1:50k 3rd order watersheds from the previous Watershed Atlas. This product will be a freely and publicly available standard component of the Freshwater Atlas. The case for standardization is strong, because of the many advantages that stem from many different groups using the same boundaries and framework and therefore enabling straightforward data sharing. The following characteristics are desirable for such a product:

1. Standardized, well specified and documented.
2. Widely useful for many applications.
3. Easy to use and as simple as requirements allow.
4. Freely accessible.

Consideration of these desirable characteristics suggests that the product should:

1. Be created in a consistent way from the much smaller component watersheds (typically 100 small watersheds are amalgamated to create one 3,000-ha Assessment Watershed), meaning little or no manual interpretation.
2. Err on the side of more detail rather than less, when selecting a scale of minimum assessment watershed size (because one can simplify up to larger units but not down).
3. Be well documented and ready-to-use, including ease of generalization to larger units.
4. Available in all the ways that the Geographic Warehouse allows, including free public download.

The following three principles have guided the development of the Assessment Watersheds:

1. The target size of Regional Watersheds is about 3,000 ha, as this seems to provide the best one-to-one match to the earlier 1:50k product. A relatively homogeneous size distribution is also sought. The general mean size of these units has been well accepted in previous work.
2. The proportion, by count and area, of complete watersheds is maximized (*see foot note # 1 on last page*).
3. Construction of the Regional Watersheds takes advantage of the watershed codes built into the Freshwater Atlas so that:
   a. the Assessment Watersheds can be constructed largely by GIS routines (limited manual post-processing is acceptable)
   b. roll-up of the Regional Watersheds to larger watershed units is straightforward.

4.0 Description of the Approach

Following the principles above creates an inherent tension in the methodology because they cannot be simultaneously met.

The following are key elements of the approach:

1. The units are based on TRIM 1 data. As a result, they are consistent in scale and also scale-dependent attributes such as stream order and magnitude. For this reason the more detailed scale of TRIM 2 (1:10,000), available only for half of BC, has not been used.
2. The creation of the Assessment Watersheds are based on amalgamation of the Fundamental Watersheds (average size 30 ha) from the Freshwater Atlas. These Fundamental Watersheds are the watersheds resulting from identifying the local watershed of every stream segment in the 20k stream network (a segment is the part of a stream between two confluences, typically 400 m in length). Assessment Watersheds are created by building up from these core components.
3. The key methodological rules are:
    a. Identify all complete watersheds that are greater than 2,000 ha which do not contain any watersheds greater than 2,000 ha.
    b. Create Assessment Watersheds for all lakes over 2,000 ha in area.
    c. Split the residual areas into areas of at least 3,000 ha in size. The size is calculated beginning at the upstream end of these areas. The only candidate locations for the boundary of the split are the confluences of larger tributaries (> 2,000 ha) and lake inlets and outlets.
    d. Attempt to conduct a second round of splitting as above, for all large residuals and complete watersheds of area greater than 10,000 ha. In this round, splits are permitted at tributaries of area greater than 1,000 ha.

Note that this is a subdivision based solely on the hydrologic network. This does not necessarily reflect ecological characteristics or administrative boundaries.

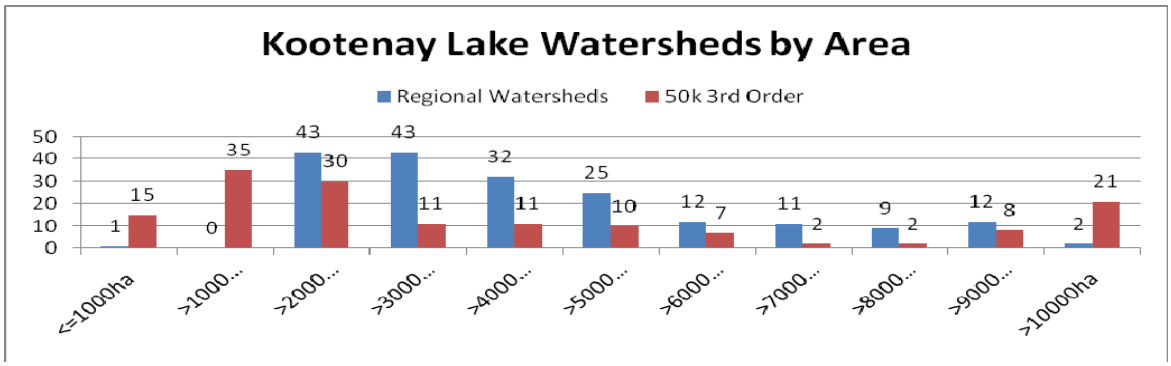
5 Comparison/Descriptions of the two scales

Two areas of the province are used to compare assessment watersheds with 1:50K watersheds. The Kootenay Lake area has high relief and large waterbodies (lakes). The Sahtaneh River area is in the relatively low relief area of the north east of the province.

The two tables below illustrate the differences between the Assessment Watersheds and the 3rd order watersheds from the 50k Watershed Atlas. In general the assessment watersheds are more consistent in size, and by area include many more complete watersheds. The main reason for this is the elimination of the long narrow 1:50k watersheds that extended along the mainstems of most streams and rivers.

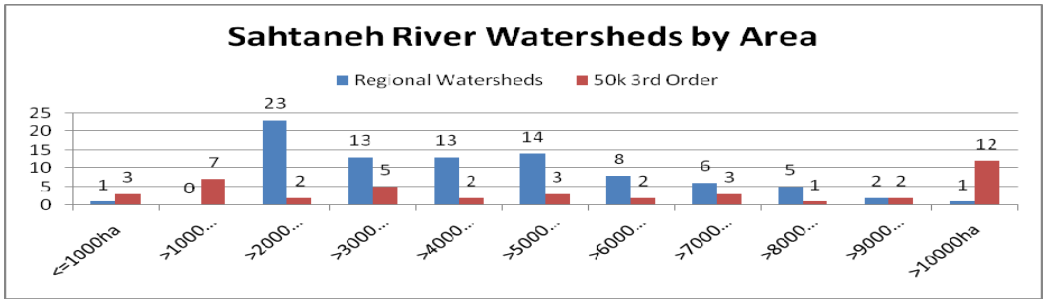
Kootenay Lake Statistics

	FWAAssessment Watersheds	**1:50K Watersheds**
Total watershed count	190	152
Total area of watersheds (ha)	936,950	938,518
Average area of watersheds (ha)	4,931	6,174
Standard Deviation of watershed areas (ha)	3,468	15,268
Count of complete watersheds	127	105
Total area (ha) of complete watersheds	583,569	353,781
Average area (ha) of complete watersheds	4,595	3,369
Standard deviation of complete watershed areas (ha)	2,325	2,635
% complete watersheds, by count	**67%**	**69%**
% complete watersheds, by area	**62%**	**38%**



Sahtaneh River Statistics

	FWA Assessment Watersheds	1:50K Watersheds
Total watershed count	86	42
Total area of watersheds (ha)	405,234	411,403
Average area of watersheds (ha)	4,712	9,795
Standard Deviation of watershed areas (ha)	2,169	13,781
Count of complete watersheds	63	29
Total area of complete watersheds (ha)	288,491	171,166
Average area of complete watersheds (ha)	4,579	5,902
Standard deviation, complete watershed areas (ha)	2,295	4,848
% complete watersheds, by count	**73%**	**69%**
% complete watersheds, by area	**71%**	**42%**



Foot note # 1 Complete watersheds versus other types of watersheds

Please note that any subdivision of BC into a single seamless coverage (i.e. no gaps between units and no overlapping units) of Assessment Watersheds cannot result in only so-called complete watersheds units. A complete watershed is an area that has no streams draining into it from outside, and all the area is drained by an interior stream to a point on the boundary of the area. Areas that do not fit this definition are the so-called face units along the coastline, lakeshores and the banks of large rivers where the land is not drained by a stream to a point. Islands also present some definitional issues, for example many small coastal islands will be grouped together into a single assessment watershed. In general, assessment watersheds can be categorized into the following types of units:

1. *complete watersheds, as described above.*
2. *lower part of a complete watershed; if a complete watershed can be formed by including only units directly upstream. This usually occurs where the partial watershed drains to a point, but there are streams draining into it.*
3. *part of a complete watershed; if a complete watershed can be formed by including up and downstream units. This is usually an interior face unit on a larger stream, this unit does not drain to a point, but if amalgamated with upstream and downstream units it would form a large r complete watershed.*
4. *coastal face units and islands that drain directly to the ocean, not through a stream.*