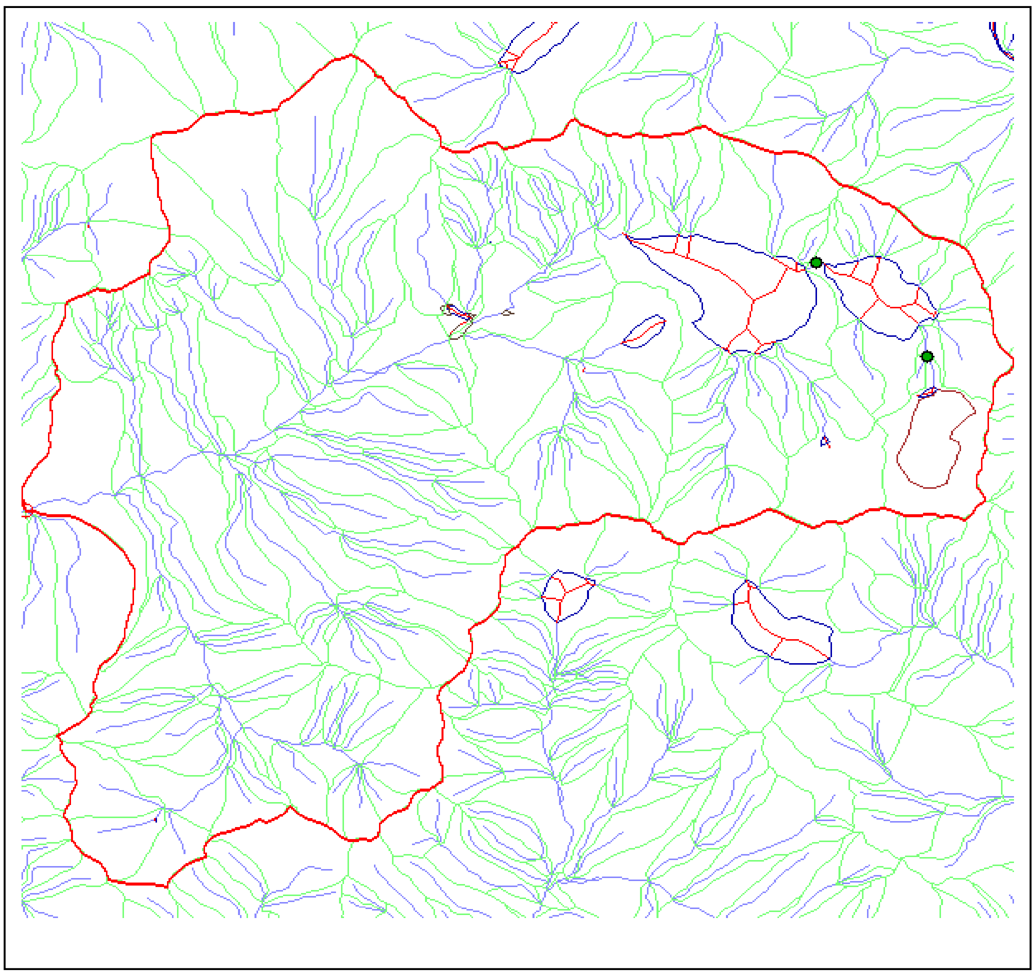
Province of British Columbia

User Manual For The British Columbia TRIM HoL (Height-of-Land) Database

(Version 1)



March 2001

GEOGRAPHIC DATA BC
MINISTRY OF ENVIRONMENT, LANDS AND PARKS

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This document was prepared by:

SPATIAL VISION GROUP

Spatial Vision Group Inc.
444 East 17th Street
North Vancouver, BC
Canada V7L 2W2
www.spatialvisiongroup.com

1. Introduction

1.1 Purpose of This Manual

This manual describes how to use the British Columbia TRIM Height-of-Land (HoL) database. It provides an introduction of the HoL database concepts as well as a procedural guide to using the data to support the business needs of Primary Users (GIS Analysts and Technicians who work in the following agencies: Ministry of Forests, BC Parks; and Crown Lands).

1.2 Revision History

This manual is written for Version 1.0 of the database. The revision history of the database is provided in the table below.

Table 1 - Revision History for the TRIM HoL Database

DATABASE VERSION	EFFECTIVE DATE	ARCHIVE PLAN
Version 0.5	March 31, 2000	Archived independently (to enable the Ministry of Forests to continue to reference adopted administrative boundaries)
Version 1.0	April 1, 2001	From Version 1.0 on, all updates will be kept in the database.

2. Usage Guidelines for the TRIM HoL Database

2.1 Motivation for the HoL Database

Geographic Information Systems (GIS) and other digital tools are widely used by Government to construct digital representations of administrative boundaries. Where these boundaries are based on physical features like heights-of-land (HoL) and waterbodies, different organizations currently use different topographic maps and manually or digitally interpreted contour information. This has resulted in inconsistencies and duplication of effort among Ministries in boundary interpretations due to the use of different base maps and the subjective nature of the HoL interpretation, especially in areas of low relief.

<u>Example of HoL Descriptions – Metes and Bounds:</u> Within Government, administrative boundaries are often described by metes and bounds definitions that often include references to watershed boundaries (or heights-of-land). Table 2 provides an example of the description of a boundary running from the southwest corner of a district lot to the summit of a mountain for the boundaries of the Serb Creek and Zymoetz River watershed.

Table 2 - Example of a Height-of-Land Legal Description

- *Commencing at the southwest corner of District Lot 5540;*
- *thence due South to the southerly boundary of the watershed of Serb Creek;*
- *thence in a general southeasterly direction along the southerly boundary of the watershed of Serb Creek to the easterly boundary of the watershed of Zymoetz River;*
- *thence in a general southerly direction along the easterly boundary of the watershed of Zymoetz River to the summit of Cascade Mountains, as defined in the Interpretation Act.*

While the description of this boundary is unambiguous, the process of delineating it on the ground or depicting it on a map are both open to interpretation. With the advent of Geographic Information Systems (GIS) and other digital tools used by Government, the need to construct a digital representation of such boundaries became evident. To meet this need, individual organizations started depicting Heights-of-Land by manually interpreting contour information from the topographic base map that their organization used. This resulted in duplication of effort and conflicting boundary representations due to the use of different base maps and the subjective nature of the HoL interpretation especially in low relief areas.

Clearly, there was a need to provide a common, authoritative, digital GIS source of HoL data for these users.

2.2 History of HoL and Stream Segment Value-Adds to TRIM

In 1995 a project was initiated to automate the generation of a single, consistent 1:20,000 TRIM-based representation of heights-of-land for the Province. The goal was to eliminate duplication of effort and to minimize conflicting line-work arising from different manual and semi-automated delineation techniques.

Associated with this was the creation of a connected single-line stream network which, when completed, would become, with additional feature coding and addition of unique identifiers for all waterbodies,, the British Columbia corporate stream network at 1:20,000. Together, the two related databases form the corporate source for defining watersheds and waterbodies in British Columbia at this level of detail.

2.3 Principles of Use – The Role of TRIM HoL Data

The TRIM Watershed Atlas is the single, standardized, corporate, province-wide source available for representation of administrative boundary segments based on HoL or waterbodies at 1:20,000 scale in British Columbia. Except where the height of land has been defined by legal survey, all organizations within Government and those private organizations that deal with the Province, should use only the TRIM Watershed Atlas (TWA) exclusively for this purpose where the HoL exists.

BC resource ministries are supportive of its use because they recognize the value of a standardized source. The Ministries recognize that the TWA's HoL data enables representation of the boundary for mapping purposes only. The physical characteristics of the height of land or waterbody on the ground govern the actual location for legal purposes. Any boundary that is questioned for legal purposes would still have to be surveyed under instructions from the Surveyor General of BC.

2.4 Modification of Existing Procedures

The decision to use the TRIM HoL as the corporate provincial standard will require the modification of existing boundary determination procedures.

The diagram to the right presents a schematic view of the old and new procedures and the new role of the TRIM HoL data.

Table 3 provides a discussion of the pro's and con's of the three methods shown in the table (field survey is used in both the old and new business processes).

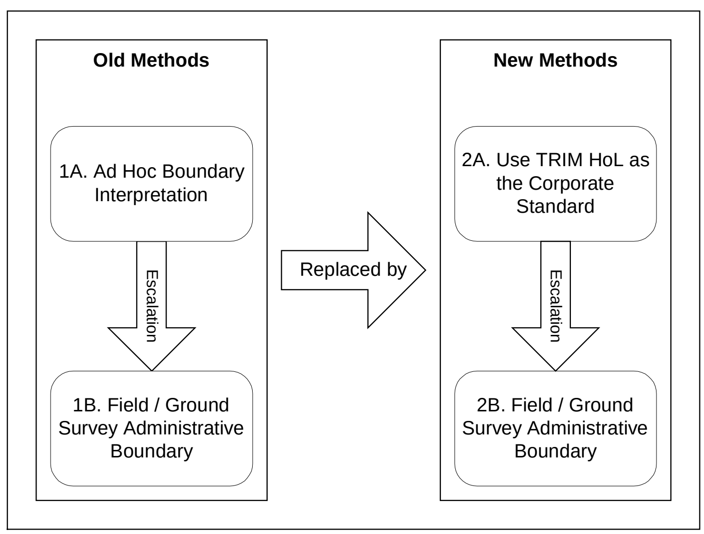


Table 3 – Comparison of TRIM HoL Data versus Alternative Data Sources

AD HOC BOUNDARY INTERPRETATION (OLD METHOD)

Pros:

- Established methods already in place for most agencies;
- No additional cost to Crown or Crown agencies.

Cons:

- Conflicting boundary representation among Ministries;
- Duplication of effort to interpret HoL;
- Additional resources required to interpret locations;
- Veracity of Government data may be questionable because of inconsistent representation of boundaries.

Use of TWA HoL Database as the Corporate Standard (New Method)

Pros:

- Reduces duplication of effort and unintentional conflicts;
- Eliminates conflicting boundary representations;
- Provides consistent results to all corporate users;
- More efficient and effective use public sector funding;
- Reduces the possibility of legal action due to inconsistent administrative boundary definition

Cons:

- Automated solution is based upon certain geomorphic assumptions. Where these do not hold, the system can produce counter-intuitive results.
- Unfunded cost to Crown agencies to convert their data to fit the new shapes.

(Section 3.4 provides additional detailed information about the accuracy and quality of the HoL database)

FIELD / GROUND SURVEY OF ADMINISTRATIVE BOUNDARY (SAME FOR OLD AND NEW)

Pros:

- High accuracy level;
- Will be required for any legal interpretation, but can be done on an as needed basis generally funded by the resource sector.

Cons:

- Prohibitively expensive;
- High accuracy level is only required in certain instances;
- Inefficient use of public sector funding.

2.5 Limitations on Use of the HoL Data

While the HoL database is an important corporate information source, there are also a number of applications for which the dataset *is not* appropriate. Examples include: engineering design and flood control; detailed land use planning and site layout; and floodplain mapping.

Projects which require this type of data must consider other relevant sources that do not follow the height of land such as: boundary definitions that use monumented points (e.g. metes and bounds); and other natural features not included in the HoL database such as subsurface flows.

3. GENERAL DATABASE DESCRIPTION

3.1 Description and Use of the TRIM HoL Database

3.1.1 What is the TRIM HoL Database?

The TRIM HoL (Height-of-Land) Database is a component of the TRIM Watershed Atlas (TWA). The HoL database provides a comprehensive inventory of height-of-land in British Columbia derived from the TRIM 1:20,000 digital basemap.[1]

Data: The data stored in the TRIM HoL Database includes the following classes of data:

- Watershed boundaries (heights-of-land);
- A collection of watershed polygons (one per stream segment);
- A single-line stream network;
- Hydrological features (modified TRIM);
- Associated planimetric features (unmodified TRIM);
- A non-gridded Digital Elevation Model (unmodified TRIM).

The data is stored in geographic coordinates for seamless coverage of the Province. The TRIM HoL Database is a very large dataset, containing almost 200 million DEM points, several hundred thousand breaklines and associated planimetric features, and approximately 16 million stream segments.

Business Applications: This database has been developed for both internal government users and external users. Possible application areas include: fisheries, forestry, water management, land administration, etc.

The intention in creating this database was to support the needs of Provincial Ministries and Agencies by establishing a common set of heights-of-land linework that can be used to establish the position of boundaries. The determination of a single set of line work will greatly reduce duplication of effort and discrepancies that currently arise during boundary interpretation by different groups. Additionally, a number of hydrological applications will be supported by the TRIM HoL data.

3.1.2 Creation of the TRIM HoL Database

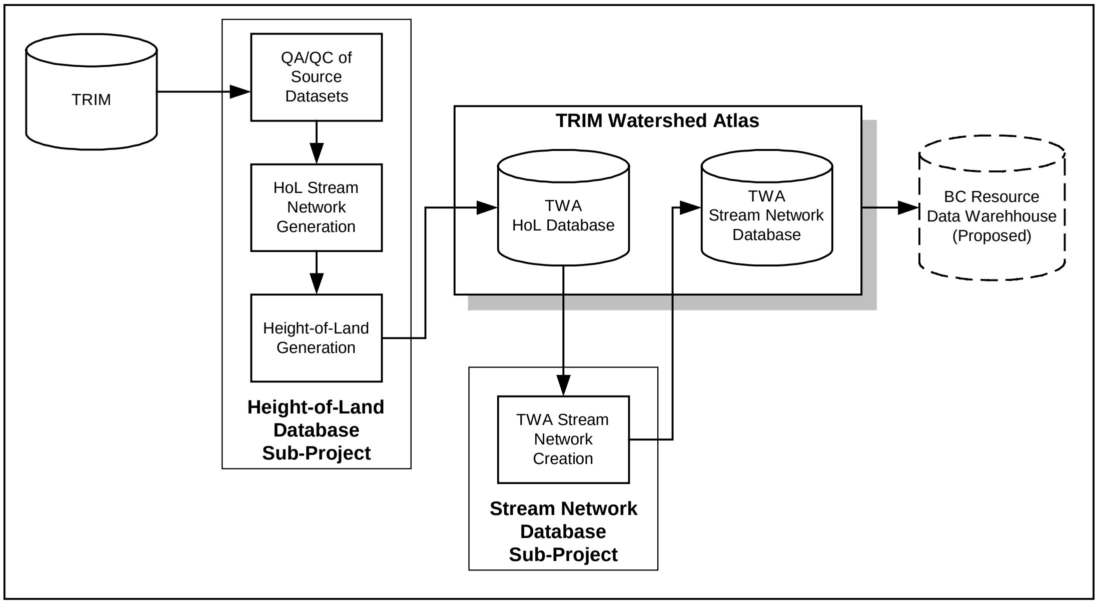
A high-level view of the process that was followed to create the HoL database is shown in Figure 1. Two projects are shown: the Height-of-Land subproject (which produced the database described in this manual) and the Stream Network subproject (which produced the stream network database). The stream network features are used to represent fisheries information and to support advanced hydrological analysis.[2] Together, the two datasets form the complete TRIM Watershed Atlas (TWA).

Version 1.0 of the HoL database was derived from TRIM I. Updates to the database will come from TRIM II and possibly other stream mapping initiatives.

[1] Technical terms such as TRIM, GIS and Height-of-Land are defined in a Glossary at the last part of this document.

[2] The description of the Stream Network Database component of the TWA and its potential uses is out of scope for this manual.

Figure 1 – Process of Creating the TRIM HoL Database



3.1.3 Typical User Organizations

Many different private and public sector groups can make use of the TRIM HoL Database to address some of their administrative boundary issues. Table 4 provides a short list of some of these organizations.

For Version 1 of this database, the intended users are BCMOF and BCMOELP. The key target system formats are ESRI's shapefile format and Intergraph's IGDS data structure.

Table 4 – Examples of Organizations Who Could Use the TRIM HoL Database

BC Government Ministries: • Aboriginal Affairs • Agriculture, Food and Fisheries • Energy and Mines • Environment, Lands and Parks • Forests • Municipal Affairs • Transportation and Highways • Small Business, Tourism and Culture Provincial Agencies & Crown Corps.: • BC Assessment Authority • BC Fisheries • BC Hydro • BC Stats • Elections BC Federal Government Departments: • Department of Fisheries and Oceans • Environment Canada • Forestry Canada	Local Governments Other Provinces/Territories: • Province of Alberta • Yukon, Northwest Territories Private Sector: • Forestry companies • Mining companies • Environmental consultants • Engineering firms First Nations Public & Interest Groups: • Citizens • Ducks Unlimited, Sierra Club, Western Canada Wilderness Committee U.S. Federal and State Agencies

3.1.4 Potential Business Applications

Table 5 identifies potential uses that can be addressed by combining the TRIM HoL dataset with other spatial and tabular information.

Table 5 - List of Typical Business Applications of the TRIM HoL Database

• Administrative Boundary Definition	• Hydrometric Sites
• Regional and Subregional Planning	• Salmon Escapement
• Habitat & Species Management	• Route Selection For Corridors
• Recreation Planning	• Watershed Management
• Pollution Tracking	• Power System Planning
• Water Management	• Fish Production
• Water Licensing	• Treaty Negotiations
• Pulp Mill Environmental Effects Monitoring	• Engineering Studies
• Commercial Fishing	• Point/Non-Point Pollution Source Analysis

3.2 Key Characteristics of the TWA HoL Database

3.2.1 Data Elements

The main content of the database is the derived HoL and stream network features, plus modified and unmodified TRIM features that were relevant to the calculation of the HoL linework. Figure 2 on the next page provides a high-level summary of the content contained in the database.

Appendix B provides a complete data dictionary of the features contained in the TRIM HoL Database.

3.2.2 Key Data Characteristics

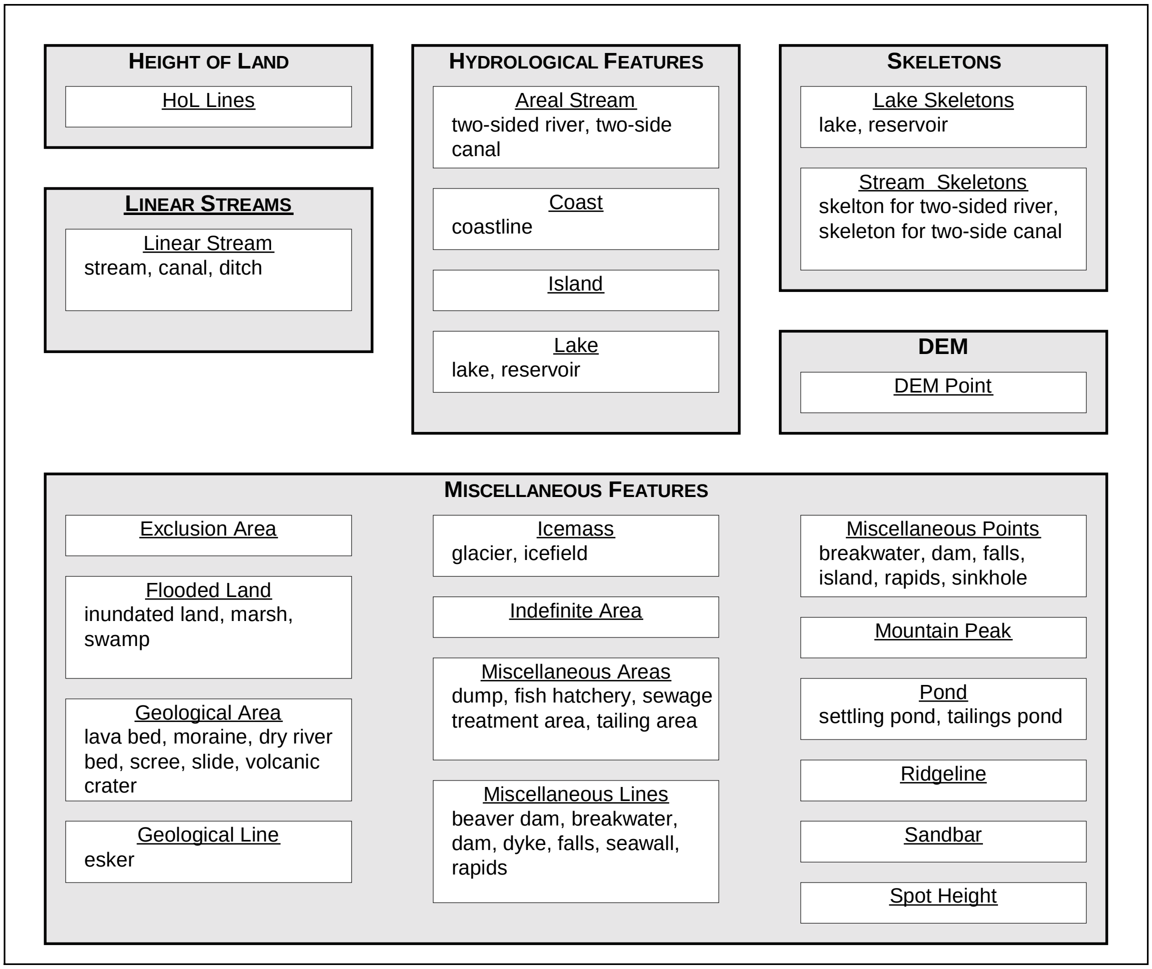
<u>A Common Height-of-Land Dataset:</u> One paramount characteristic of the TRIM HoL Database is the establishment of a common set of heights-of-land linework, which can be used for defining the position of boundaries. The availability of a single set of linework as a seamless, province-wide dataset is expected to greatly reduce duplication of effort and discrepancies that arise during boundary interpretation by different stakeholders.

<u>Three-Dimensional Data:</u> The source dataset used to calculate the height-of-land boundaries was collected as three-dimensional features (i.e. features with X, Y, Z values). This is important for supporting applications such as stream gradient mapping and other hydrological analysis.

<u>A "Topological" Dataset:</u> The TRIM HoL Database is not simply a set of coloured lines on a computer screen. The underlying data model can be used to create "topology" or the *connectedness & adjacency* between features. For example:

- *Connectedness* could represent how tributaries drain into a river.
- *Adjacency* could help determine the heights-of-land that surround a set of lakes.

Figure 2- High-Level Summary of HoL Database Content



Representation of Flow Directions: In addition to showing the drainage network, the TRIM HoL Database also stores information which describes the direction of flow. In this way, the flow directions can be used with the network to allow a user to model the movement upstream or downstream throughout the network.

Not a Layered Dataset: The HoL dataset does not organize features into layers or coverages. All objects exist and interrelate in one “space”. Users who need to migrate this dataset to an ARC/INFO or Microstation environment will most likely use coverage or layer and feature coding concepts within those target environments.

Feature Coding: Included in the database are TRIM-like feature codes for each feature. Some of the codes are taken directly from TRIM, and some new codes were created for this dataset. The new feature codes do not describe any features in the original TRIM model, and cannot be found in any TRIM dataset.

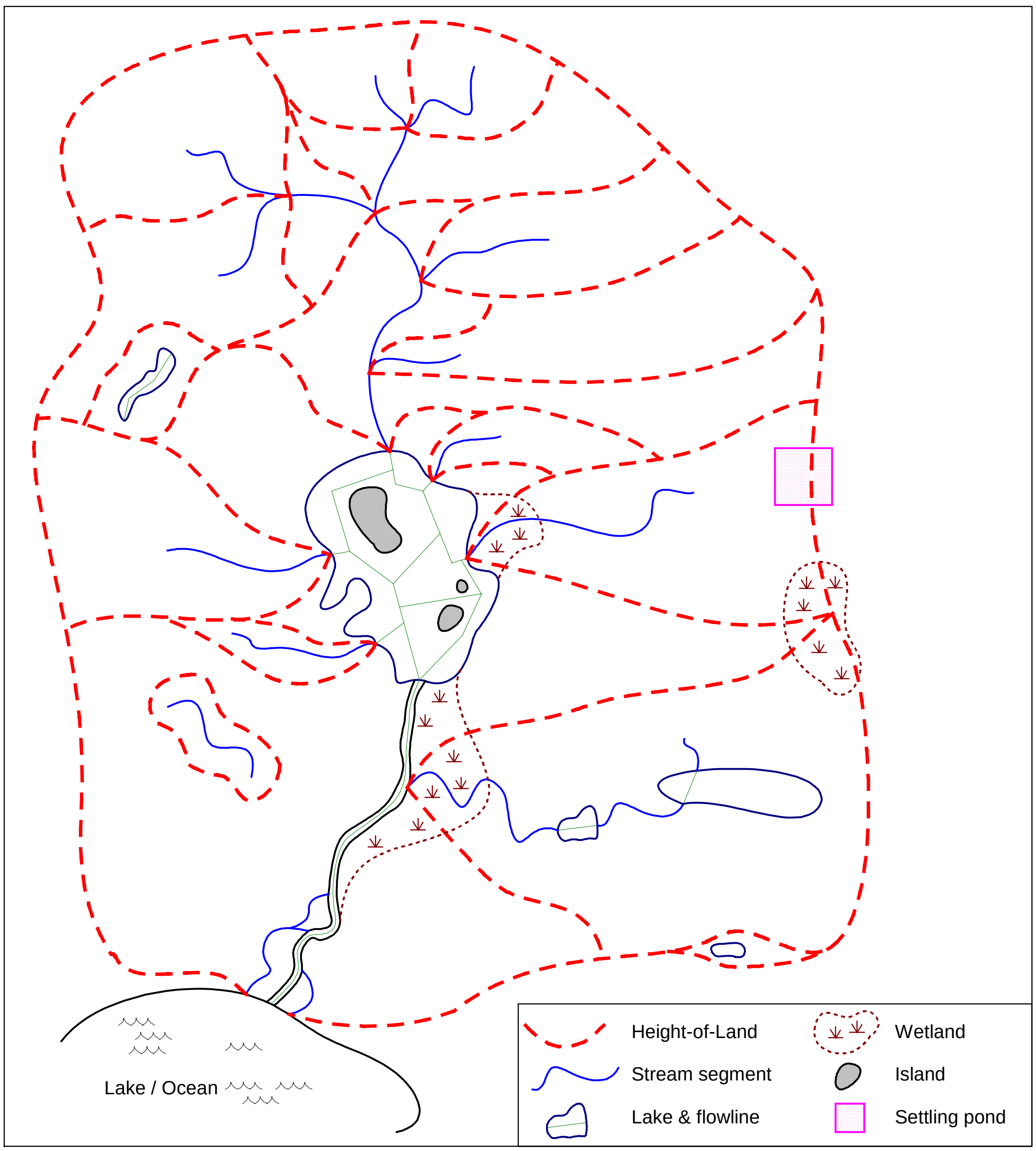
Adherence to Open GIS Standards: Because of the broad spectrum of potential user organizations, the TRIM HoL Database must be usable in a wide range of GIS, CAD and spatial analysis tool environments. The TRIM HoL Database is made available using the FME software product to allow the dataset to be translated into other GIS formats such as Shapefile and Microstation.

3.3 Interpreting the HoL Data

As with all databases, the TRIM HoL Database has its own internal rules and assumptions. This section discusses some of the key characteristics specific to this dataset.

As a starting point, Figure 3 provides an example of a U-shaped valley which drains southward to the ocean. Various features are shown such as single- and double-line rivers; wetlands along the edges of the central lake; isolated wetlands, lakes and streams; side channels; islands within lakes; and a man-made settling pond. The dashed lines are the HoL boundaries that would have been produced by the derivation algorithms discussed in Appendix D .

Figure 3 - Example of Hydrographic Data and Derived HoL Linework



The following subsections identify various TRIM HoL interpretation issues. Each one includes a description, a diagram of the key features, and a discussion of the implications for users of the database. The diagrams are typically drawn from the example on the previous page.

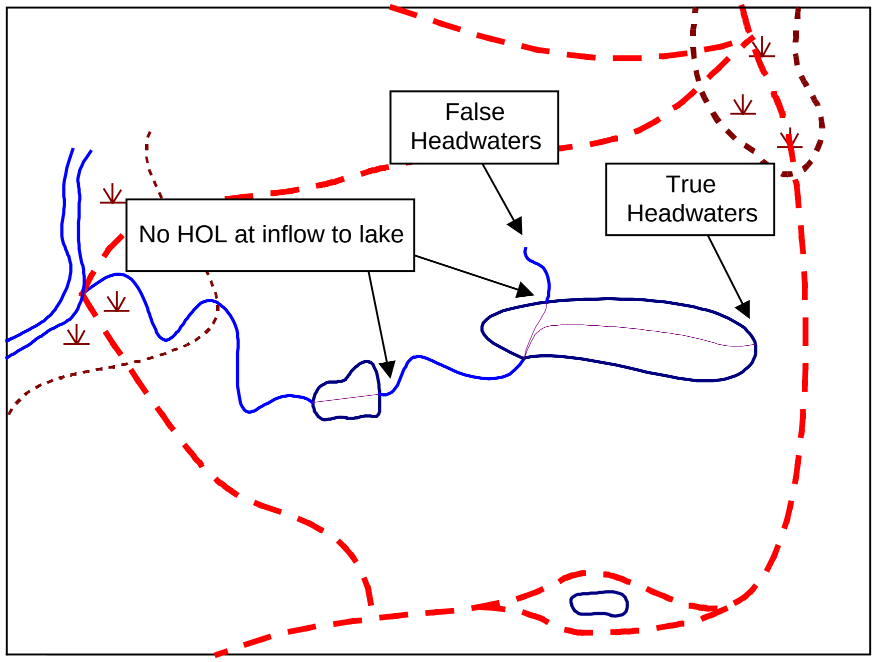
3.3.1 Lake Tributaries – One Inflow, One Outflow

Description: The diagram shows a lake with one inflow and one outflow. The HoL calculation will not put a line at the inflow to the lake as there is no confluence at that point.

Implications: It is not possible to determine the catchment area above the stream at that point.

Description: If the lake was the headwaters of the system, a minor inflow creek could mistakenly be defined as the actual headwaters.

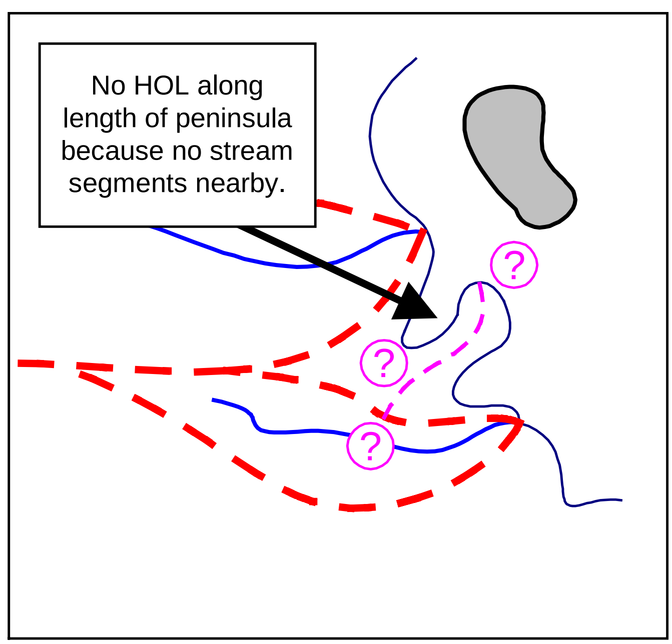
Implications: Distance calculations to the end of the headwaters may not be correct.



3.3.2 Heights of Land for Peninsulas

Description: If a peninsula has no streams along its length, there will be no local HoL linework. This is because there are no stream segments nearby to "flood" up to nearby hypsographic breaklines (see Appendix D for a discussion of how the HoL is derived).

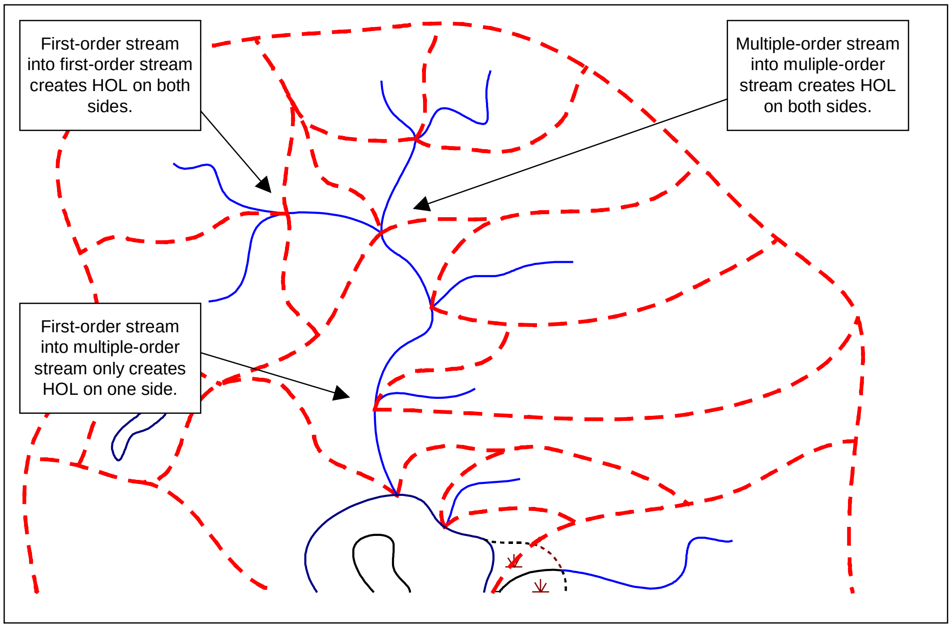
Implications: A local HoL will have to be determined either using the local hypsographic breaklines as a source of evidence, or via a field survey.



3.3.3 Mainstem and Tributary Junctions

Description: When considering the intersection of first-order and higher-order streams, there are three possible combinations: (1) single-single, (2) single-multiple, and (3) multiple-multiple. In the first and third combinations, the HoL is calculated in the same manner: a HoL line is extended from BOTH sides of the junction. For the second combination (single-multiple), a HoL line is only extended from the same side as the single-order stream. If you consider a small first order stream flowing into the Fraser near its mouth, there typically would be no obvious HoL on the opposite bank. In TRIM the opposite bank would not be noded at that location.

Implication: It is not possible to correctly calculate the drainage area above that point.



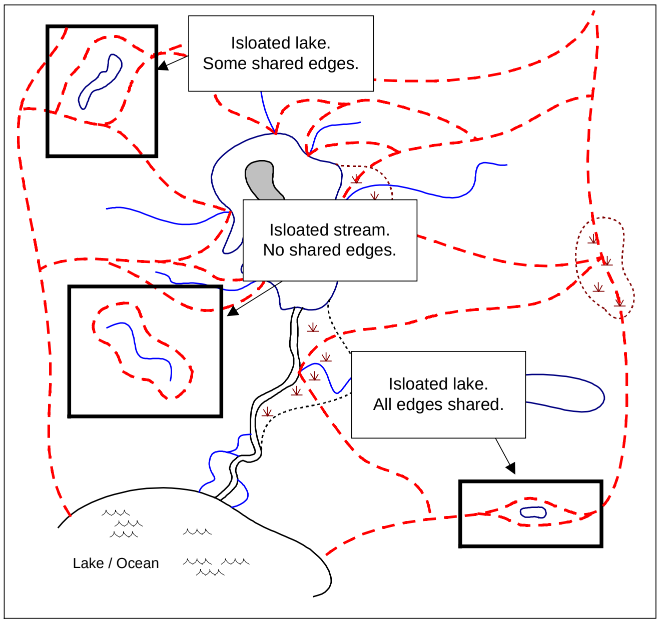
3.3.4 Handling of Isolated Streams and Lakes

Description: The HoL is calculated for isolated waterbodies as shown in the diagram. No connector line is added between the waterbody and the rest of the drainage network as there is no observed data to base this on.

There are various combinations of shared edges. In some cases, the waterbody is completely surrounded by shared edges.

Implication: If an edge is shared, it may not be possible to determine which way the water should flow.

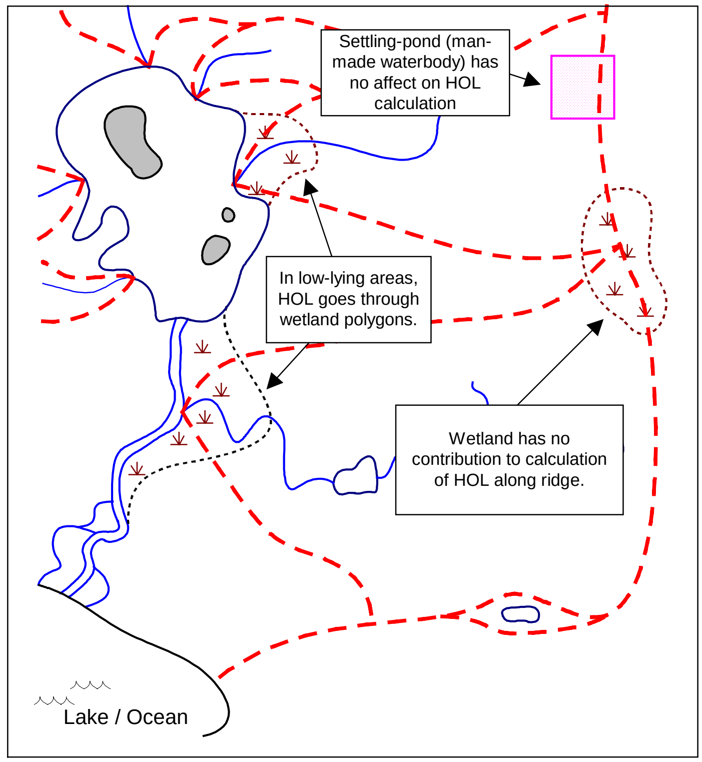
Without the connector lines, it is not possible to trace downstream to the rest of the network.



3.3.5 The HoL Calculation Ignores Wetlands and Other Features

Description: Initial investigation into the TRIM I data set showed that the TRIM representation of wetlands and ice fields would not support HoL delineation (i.e., multiple streams would flow through the same wetland). Additionally, man-made features such as tailing ponds are not considered as legitimate sources for defining HoL boundaries.

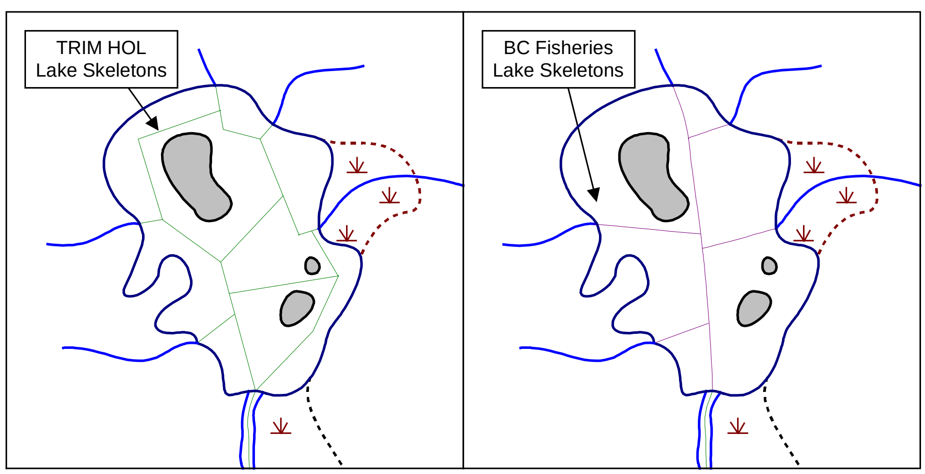
Implication: The HoL boundary will go through these features.



3.3.6 Skeletonization Through Streams, Lakes, and Around Islands

Description: TRIM HoL calculates the medial axis for lakes using a line Voronoi calculation. It divides lakes into areas equidistant to all shorelines. This does not support the idea of a main stem used by BC Fisheries.

Implication: For certain applications, equal distance from all shorelines may not be the correct assumption. The alternative flow lines are seen to be more appropriate. For example, the thalweg may be a more appropriate line to follow through the lake.



Discussion: A second set of skeletons deemed to be more appropriate for certain applications will be produced in a future release of the HoL database. Both types of skeletons will be maintained.

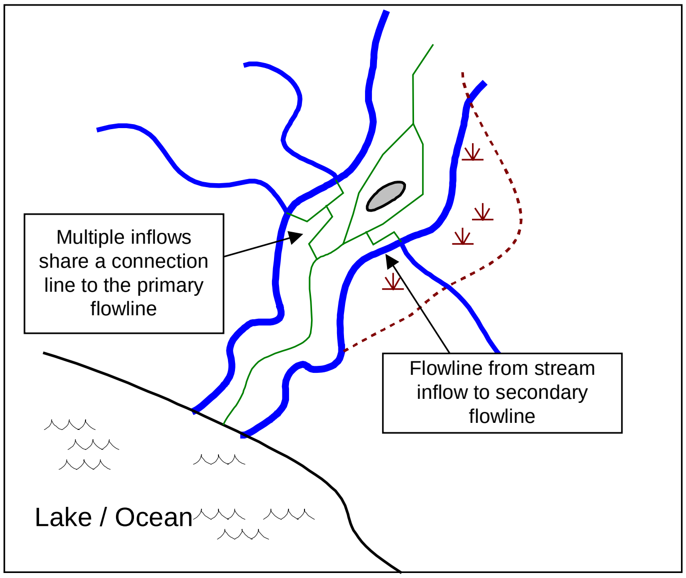
3.3.7 Skeletonization for Double-Line Rivers

Description: For double line rivers, multiple inflows may share a flowline before connecting to the primary flowline.

Implication: An upstream query cannot tell which of the two streams is upstream of the other.

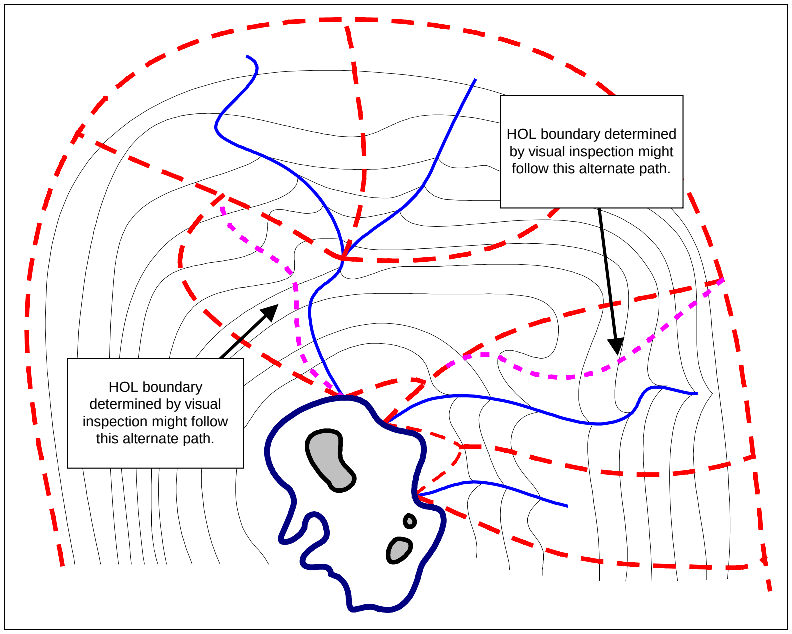
Description: Single stream inflows may not connect directly to the flowline. The line may follow along the shoreline for a distance before connecting up with the main flowline.

Implication: Upstream distances from that inflow will be incorrect.



3.3.8 TRIM HoL versus TRIM Contours

Description: TRIM users who are familiar with displaying elevation contours on top of HoL boundaries develop an eye for interpreting the slope of the land and can very effectively evaluate the quality of a HoL edge. While a match between the HoL and TRIM contours is desirable, the algorithms that calculated the new TRIM HoL boundaries produced a result that does not always agree with the older TRIM contours. As shown in the example to the right, some apparent inconsistencies between the TRIM contours and the HoL boundaries will indeed be visible.



The TRIM contours were calculated from the source data using contouring software that had its own internal statistical assumptions that determined how a "surface" was fitted to the DEM points. A different contouring package (such as the one that produced the TRIM II contours for example) could use a different interpolation surface and produce significantly different contours for the same input data set especially in areas of low relief. The end result was a graphical product of contour lines that was easier to interpret than a collection of DEM points and breakline features.

The TRIM HoL boundaries were calculated as a "best estimate" from the original data, and did not take the contours into account. The input data to the two processes were slightly different.

The TRIM contours use the DEM file which contains the non-gridded DEM points, and three types of break lines, hypsometric, hydrographic, and anthropocentric (man-made features). The hydrographic and anthropocentric break lines are decimated (thinned) versions of the planimetric features. For the TRIM HoL boundaries the hypsometric break lines, the actual hydrographic features and the non-gridded DEM points were used as input. An error model of ± 10 meters horizontally and ±5 meters vertically was used in the HoL computation.

Implications: There will be times when the local statistics will produce what appear to be inconsistent results when compared with the TRIM contours. In very few cases, it is possible that the TRIM contour is indeed better. In other cases, it is possible that neither the TRIM contour nor the TRIM HoL are correct because of the local conditions. As always, the implications of using statistical methods to automate the processing of such a large dataset as TRIM means that the algorithms will be optimal for a specific set of assumptions, and these models can fail when the assumptions are invalid.

3.4 Accuracy and Quality Considerations

This section is written for GIS Analysts who must know the strengths, limitations and key assumptions made to create of this database. It discusses key points regarding the accuracy and quality of the TRIM HoL Database.

TRIM Source Data: The dataset is a derived product from the TRIM base mapping. The TRIM dataset was collected using photogrammetric techniques from 1:60,000 or 1:70,000 scale aerial photography. This photography was controlled using differential GPS ground surveys.

Some of the TRIM features have been duplicated in the TRIM HoL Dataset. Appendix B provides a list of all of the features contained in the dataset.

Automated HoL Calculation: The HoL dataset is derived from TRIM using automated techniques. This is positive in that the TRIM source is the best available hypsographic and hydrographic dataset of the complete Province available today. The negative impact is that TRIM errors will affect the calculation of height-of-land.

Use of Breaklines to Determine Heights-of-Land: As discussed in Appendix D , the HoL calculation used the TRIM DEM points and breaklines as source data. The following comments can be added to that description:

- Hydrographic Breaklines: The TRIM positional data that is delivered in digital form to most user organizations contains a decimated version of the stream features. The HoL calculation process used the original non-decimated, higher density data.
- Hypsographic Breaklines: These breaklines represent discontinuities on the surface and do not necessarily represent HoL. In some instances part of a break line will represent a HoL and the rest of the line will not. Additionally, within the vertical accuracy of TRIM break lines can float on top of, or be ‘burned’ into the surface as described by surrounding DEM points.

Positional Accuracy of Source Data: The positional accuracy is defined by the TRIM accuracy standards. This standard specifies that all planimetric features are accurate to within 10 metres (i.e. 0.5 mm x 20,000) of their true positions 90% of the time (see the TRIM specification for more details and a discussion of the positional accuracy specification).

Elevation (Altimetric) Accuracy of Source Data: TRIM elevations are accurate to within 5 metres, 90% of the time. These elevations relate to ground not sufficiently obscured by vegetation or other features to cause significant error (see the TRIM specification for more details and a discussion of the altimetric accuracy specification).

Correction of TRIM Data: In the process of creating the height-of-land data, it was essential that all the data met basic quality characteristics as specified in the TRIM standard. Unfortunately, the source dataset contained a number of errors that had to be identified and corrected. Examples of errors include: unclosed polygons, incorrect streamflow directions, mistyped features, duplicated stream segments, and left bank / right bank miscoding. A set of correction routines were developed and then applied to each of the TRIM mapsheets.

Positional Accuracy of Derived Features: The positional and altimetric accuracy of the source data is not the same as that for the derived HoL linework. The HoL edge will be a function of the local relief. In areas of high relief the positional accuracy will approach that of TRIM, in areas of low relief the accuracy will decrease. (In areas where the local relief is less than the ±5 meters vertically accuracy of TRIM the HoL is simply placed half way between the two stream segments that generated the HoL. A plausible assumption, but not an observed estimate).

Logical Consistency: Single line river features are shown as a single line without width. If a user zooms in on a single line river feature, the line will not get wider as the scale increases. At medium to large scales of display, this could lead to misinterpretations of the relative widths of single and double-line river features.

Correctness: The database presents a snapshot in time of a dynamic physical environment. Some features will have changed since they were surveyed. For certain applications, users should consider whether or not changes such as movement of stream channels, distributaries, etc. will affect their analysis.

Data Not Provided: The database does not provide bathymetry, nor does it provide legal ownership/ boundary data. Because the dataset was extracted from TRIM, the planimetric features from the TRIM source can be displayed and analysed with this dataset.

4. DETAILED PROCEDURES

4.1 Overview

This section describes the key procedures that would be followed by a GIS Analyst or Technician who plans to use the TRIM HoL database to support the determination of administrative or park boundaries in the Province of BC.

Figure 4 introduces the procedures described in this manual. The procedures are arranged into three groups:

- Data Preparation procedures would be used during the set-up phase of a project;
- Business Use procedures are the typical day-to-day tasks a GIS Analyst would follow while working on an administrative boundary.
- The Data Maintenance and Administration procedure would be followed on an irregular basis depending upon the data quality issues encountered by GDBC and the core users as the HoL Database is used to determine administration boundaries.

Figure 4 – Procedures Described in this Manual

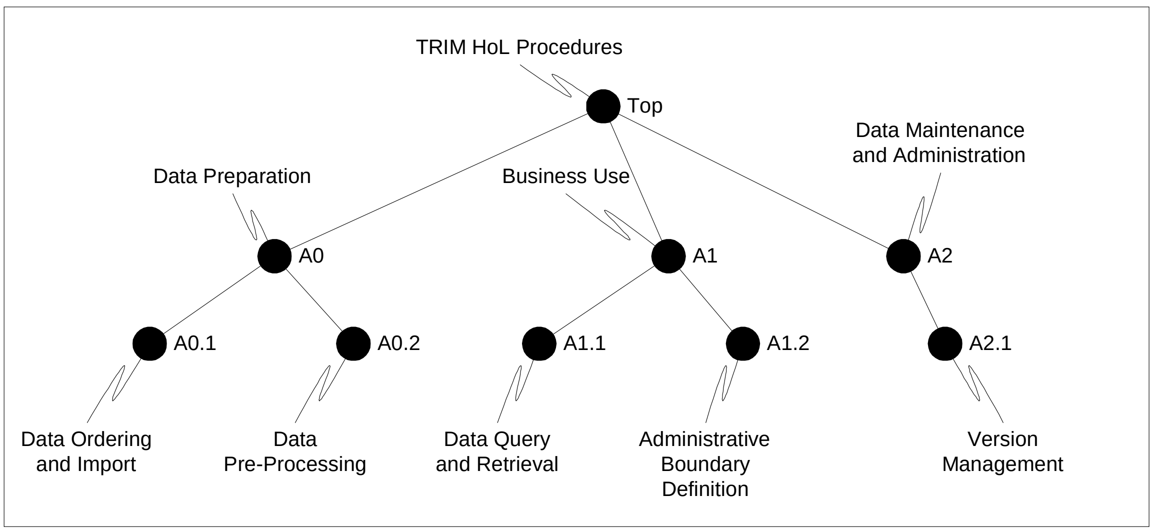


Figure 5 presents a high-level view of the relationships between the procedures, data stores and data flows that would be followed to create or update administrative boundaries

The remainder of this document describes each procedure. Each description follows the structure described in Table 6. The procedures are written in a product-independent manner since the HoL database may be used in a number of target GIS environments.

Figure 5 –High-Level Data Stores, Data Flows and Procedures

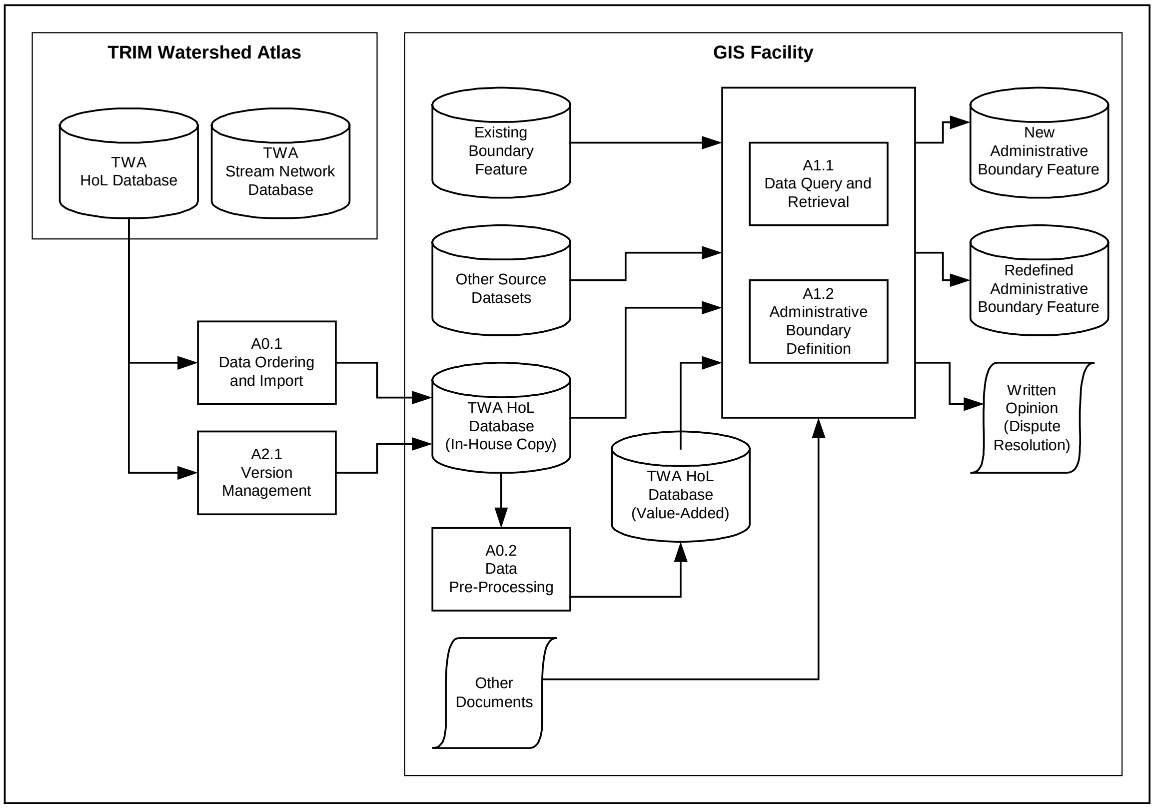


Table 6 – Content of Each Procedure

ITEM	DESCRIPTION
PURPOSE	Describes why the procedure is required.
TRIGGERS	Describes the events that will cause the procedure to be performed.
SYSTEM / FLOW DIAGRAM	Provides a schematic view of the business procedure being followed, or the key systems, datasets and data flows involved in this procedure.
INPUTS	Identifies the HoL content used, as well as other datasets that may be required to perform this procedure.
PROCESS	Lists and explains the main steps to be followed.
OUTPUTS	Describes what it produced by the procedure.
DISCUSSION	Provides additional information if required regarding: • Best Practices / Pitfalls To Avoid: Suggests the best means of achieving a goal, or describes possible problems that may be encountered by the user. • Data Quality / Integrity Considerations: Discusses how to avoid compromising the integrity and quality of the dataset. • Other Information: Provides additional supporting information that may be required by the Analyst.

4.2 Data Ordering and Import (A0.1)

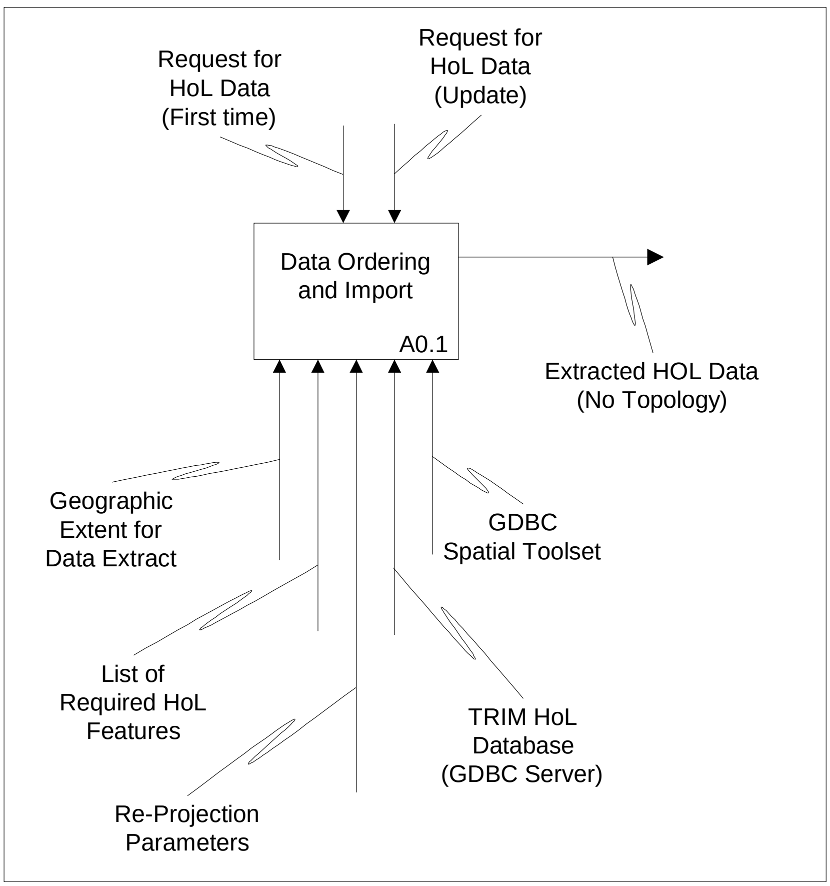
PURPOSE This procedure is used when a user requires a copy of all or a portion of the TRIM HoL database.

TRIGGERS There are two cases in which a user will apply this procedure:

1. The user is acquiring the database from GDBC for the first time.
2. The user needs to update the in-house version of the database because GDBC has published an update to the database. This update might be published to implement corrections or enhancements to the database.

SYSTEM /FLOW DIAGRAM Figure 6 presents a simplified diagram of the triggers, inputs, outputs, and supporting mechanisms for the Data Ordering and Import procedure.

Figure 6 –Data Ordering and Import Procedure (A0.1)



INPUTS

- Geographic Extent for Data Extract: The GIS Analyst provides GDBC with a description of the geographic extent of the data to be extracted. Examples include:
  - The Analyst may use a BCGS map neatline for a 1:250,000 letter block extent, quarter letter blocks (e.g., NW, SE, etc.), a 1:20,000 TRIM extent, or irregularly shaped polygons such as existing administration boundaries.
  - The Analyst may choose to use derived boundaries such as a buffered version of an existing administrative boundary, or a polygon which contains a selected set of stream segments.
- TRIM HoL Database: The table below identifies which HoL data themes/features are typically imported.
- Re-Projection Parameters: If the User of GIS Analyst does not have access to high-quality re-projection software, it is possible for GDBC to re-project the data as part of the delivery process. GDBC should be provided with a description of the target projection desired.

HoL Data Theme	Sample Features	Imported?
Height of land	HoL line	Yes
Hydrological features	Two-sided river, lake	Sometimes
Linear streams	Stream, canal, ditch	Sometimes
Skeletons	Lake and stream skeleton	Sometimes
DEM	DEM point	No
Miscellaneous Features	Flooded land, icemass, breakwater, falls, rapids	Rarely

PROCESS The typical steps in ordering a TRIM HoL dataset are as follows:

1. Ordering Data: A User or GIS Technician will provide GDBC with the bounding polygon(s) that defines the extent of the data to be “clipped out” of the TRIM HoL Database. In addition, the user can provide a list of the specific features to be extracted. Some users may wish to have the complete HoL dataset, while others may only need the HoL linework or the stream network. A user can provide an irregular clip boundary to GDBC but only in Shape, IGDS, MID/MIF or SAIF. ESRI E00 format is not supported as it is not a published data interchange specification.

2. Data Re-Projection: GDBC will re-project the data if requested.

3. Data Extraction: GDBC will run the extraction routine and place the data on their FTP site. The output format will be either a Shapefile or Microstation file.

4. Data Download: The user organization will then download the dataset from the FTP site and import the data into their own GIS. The Open GIS Consortium’s (OGC’s) XML specification (GML 2) will be supported in the future.

5. Data Structuring: If the end result of this process is to produce linear- or polygon-topological data, then the user will need to run the topology generation routine in the target GIS environment. For example, in the ESRI environment, a user would run the CLEAN and BUILD routines. (see Procedure A0.2)

OUTPUTS The HoL data is provided in one of the following formats:

TARGET ENVIRONMENT	DATA INTERCHANGE DELIVERY FORMATS	COMMENTS
Microstation	IGDS	One layer for HoL and skeletons. The skeletons will be in different colours.
ARC/INFO, ArcView, GeoMedia	Shapefile	One Shapefile per feature. On request this can also include MELP feature codes.

DISCUSSION

- Data Ordering: The TRIM HoL Database can be ordered from Geographic Data BC (GDBC). This data can be ordered by contacting the database administrator directly (Mr. D. Skea, 250-387-9316, DSKEA@mail.gdbc.gov.bc.ca).
- Typical Geographic Extents: Most users will order data in the quarter letter block form or larger. The 1:20,000 TRIM mapsheet extent is typically too limiting, especially for use in addressing boundary definition issues.
- Quality Assurance: The GIS Analysts who have experience with the HoL dataset typically do not expend any effort on quality assurance. These users work under the assumption that the Data Custodian has supplied a product that meets the published standards. In any case, it is not feasible to manually check anything but the smallest subset of the HoL dataset. Since errors will undoubtedly be encountered on occasion, a process for capturing issues and defects has been put in place (see Procedure A2.1)
- Data Administration: In some cases, the Users will need to work with data covering an extremely large geographic extent. It is expected that Database Administrators at the Users' site will manage these large copies of the data.
- Mixing and Matching Datasets: There are a number of possible scenarios for ordering HoL data and combining it with other datasets:
  - Going "Backward": Some Users may wish to only order only HoL, and then combine the data with the original TRIM features (e.g. TRIM hydrography). This is not recommended because the precision of the original TRIM data is not as high as the HoL data.
  - Use Only HoL Data: Some Users will wish to use only the features contained in the HoL dataset. This will be acceptable for many users.
  - Going "Forward" to Include TRIM Stream Segment Data: Some Users will find the TRIM HoL dataset limiting and will want to take advantage of the value-added capabilities of the stream segment data, or to associate external data such as the Fish Information Summary System (FISS) linear segmentation dataset.
- Dataset Versions: Although the update methodology has not been finalized, some sites (e.g. the MOF-RTE and the MELP warehouses) will most likely keep two versions of the HoL data: (1) a "release" version (such as Release 1.0 being described here), and (2) a "current" version which will contain the most recent data. While the second dataset may only be consistent in terms of "local" HoL calculations, it will at least provide GIS Analysts with the most recent stream and local HoL (which may be helpful in addressing HoL issues).

4.3 Re-Generation of Polygon and/or Linear Topology (A0.2)

PURPOSE Once the HoL database has been imported into the target environment, the Analyst may wish to re-project the data and to re-create the topology of the source dataset. The Analyst has the choice of recreating the original HoL polygon and stream segment linear topologies.

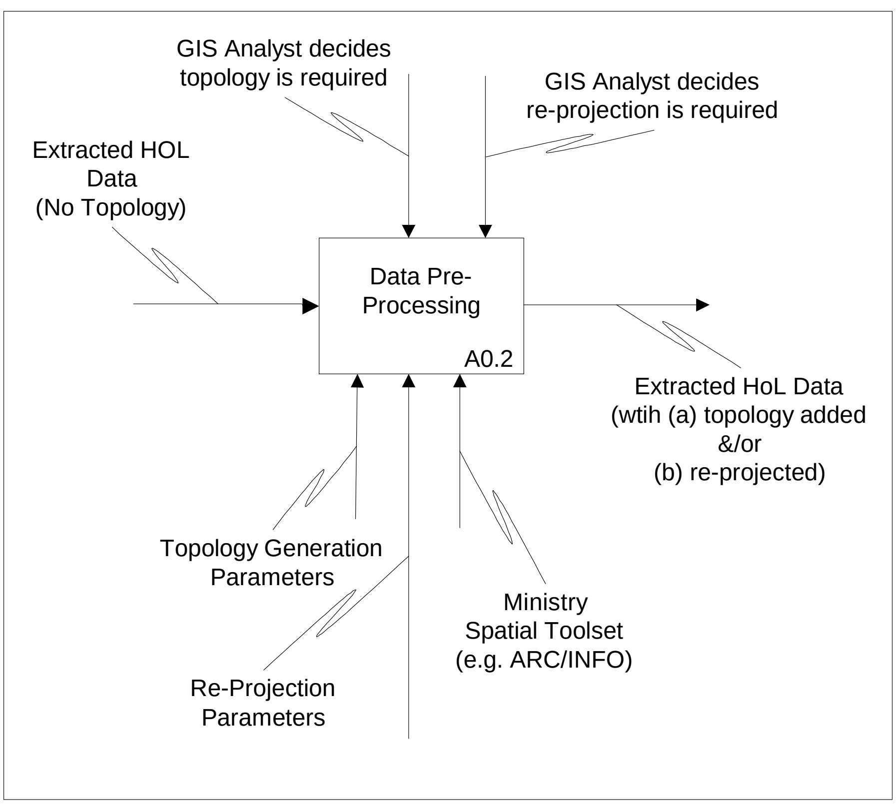
This value-added procedure will allow Analysts to take advantage of the more powerful features of this database.

TRIGGERS This procedure would be used in two cases:

1. This procedure would be used if the Analyst wishes to make use of topology in ARC/INFO to support basic spatial overlay queries such as “point-in-polygon”, “line-in-polygon” (e.g. determine if a GPS surveyed location lies within the HoL polygon, determine if a particular stream lies within a HoL polygon). Advanced GIS Analysts could also perform “upstream” and “downstream” linear queries once the line topologies were re-established. A special case is the potential use of the topology to support the boundary definition process.
2. This procedure would be used if the Analyst wishes to perform spatial analysis operations or biological/physical systems modeling on either the polygon HoL features, or linear stream segment features.

SYSTEM /FLOW DIAGRAM Figure 7 presents a simplified diagram of the triggers, inputs, outputs, and supporting mechanisms for data pre-processing..

Figure 7 – Data Pre-Processing Procedure (A0.2)



INPUTS

- TRIM HoL Database: The table below identifies which HoL data themes/features are typically re-processed.

HoL Data Theme	Sample Features	Re-generate Topology?
Height of land	HoL line	Sometimes
Hydrological features	Two-sided river, lake	No
Linear streams	Stream, canal, ditch	Sometimes (both themes together)
Skeletons	Lake and stream skeleton	
DEM	DEM point	No
Miscellaneous Features	Flooded land, icemass, breakwater, falls, rapids	No

- Other Source Datasets: none.

PROCESS The typical steps for pre-processing the dataset are as follows:

1. Define topology-generation parameters.
2. Re-project data if necessary
3. Run topology generation.
4. QA/QC the re-projection of the data. Ensure that the project has been performed successfully.
5. QA/QC the topology. Validate the results (e.g. do a few upstream/downstream queries, or validate that the resulting closed polygons are correct).
6. Publish the data onto the file server.

OUTPUTS TRIM HoL Database with the internal topological structures re-created.

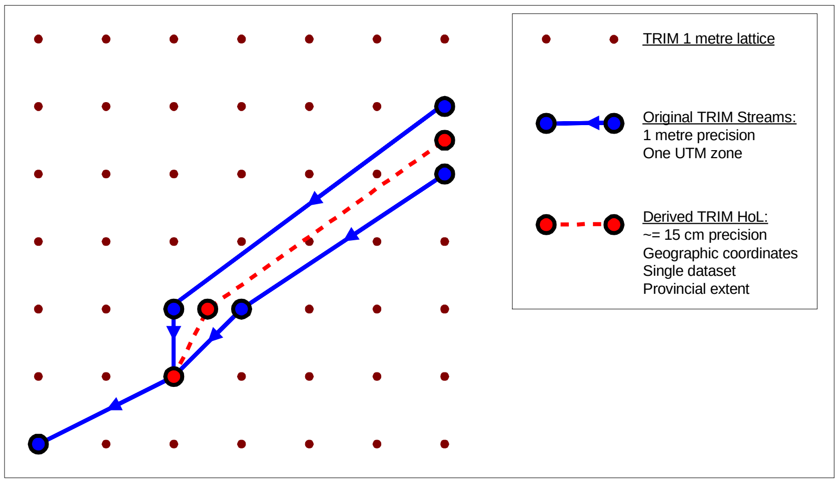
DISCUSSION

- Is Topology Required?: The Analyst should review Section 3.3 (Interpreting the HoL Data) to decide if generating topology using this dataset will support the business need.
- Maintaining Data Integrity: If upstream or downstream network traces are to be performed, the Analyst should take care to ensure that the complete sub-drainage has been clipped out. Ensuring that the user has access to a complete, seamless view of the watershed drainage will reduce the likelihood of queries and linear traces being incorrect.

- Differing Precision Models: The original TRIM data and the new TRIM HoL datasets have different precision models: the TRIM HoL is more precise. This can cause the situations shown below:

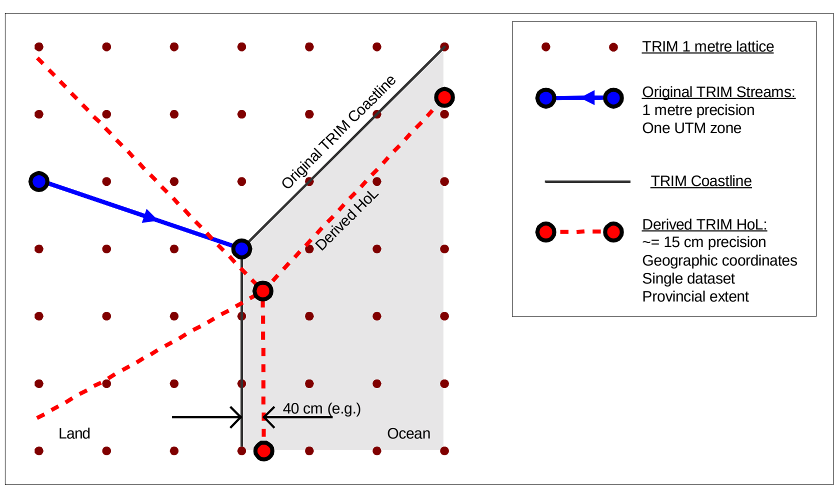
  - TRIM Streams and HoL (Figure 8): The TRIM streams can be sufficiently close that the HoL that goes between them cannot be represented by the TRIM precision. If a user performs a "clean and build" using the TRIM precision, the HoL and one of the streams will end up being collinear since the stream must "snap" to either one or the other stream segments. This could cause problems with some analysis / tracing routines.

Figure 8 – Comparison Between TRIM and TRIM HoL Precision Models (Example 1)



  - TRIM Coastline and HoL (Figure 9): The original TRIM coastline and the derived coastline will not be collinear. Nor will the confluence of the original coastline and stream that drains into the ocean be the same point as the confluence of the derived HoL features. In addition, the HoL lines for the streambed, properly contain the segment except for the last 10's of centimeters as they approach the outlet point. While this is a minor issue for manual/visual applications, this would cause the creation of numerous sliver polygons during an automated analysis.

Figure 9 – Comparison Between TRIM and TRIM HoL Precision (Example 2)



- Limitations of Re-Projection Software: The user should understand the capabilities and limitations of the re-projection software being used. The user may wish to have the data re-projected by GDBC as a part of the data extraction procedure. Users can avoid the data re-projection step if desired by requesting that GDBC deliver the HoL data in the desired projection. GDBC can generate that data in the projections typically used in the Province of BC including: UTM, Albers, Polyconic, Lambert Conformal, Mercator, Modified Mercator, and geographic (native format).

- Datasets Not Supported: The re-generated topology will not produce the BC Watershed/Waterbody Identifier System, nor will it create the other associated indexing/numbering systems such as the FISS (Fish Information Summary System) or the fish macro reach linear segmentation data structures. If this is required, the user must either: (1) download the 1:50,000 Watershed Atlas and associated tables, or (2) download the TWA Stream Network database (currently available for only parts of the Province).

- Many Different Target Environments: Other target environments for this data include: Smallworld, MapInfo, GeoMedia, and Open GIS Consortium (OGC) compliant GIS products. Topological structures may need to be re-created for some of these target environments.

4.4 Data Query and Retrieval (A1.1)

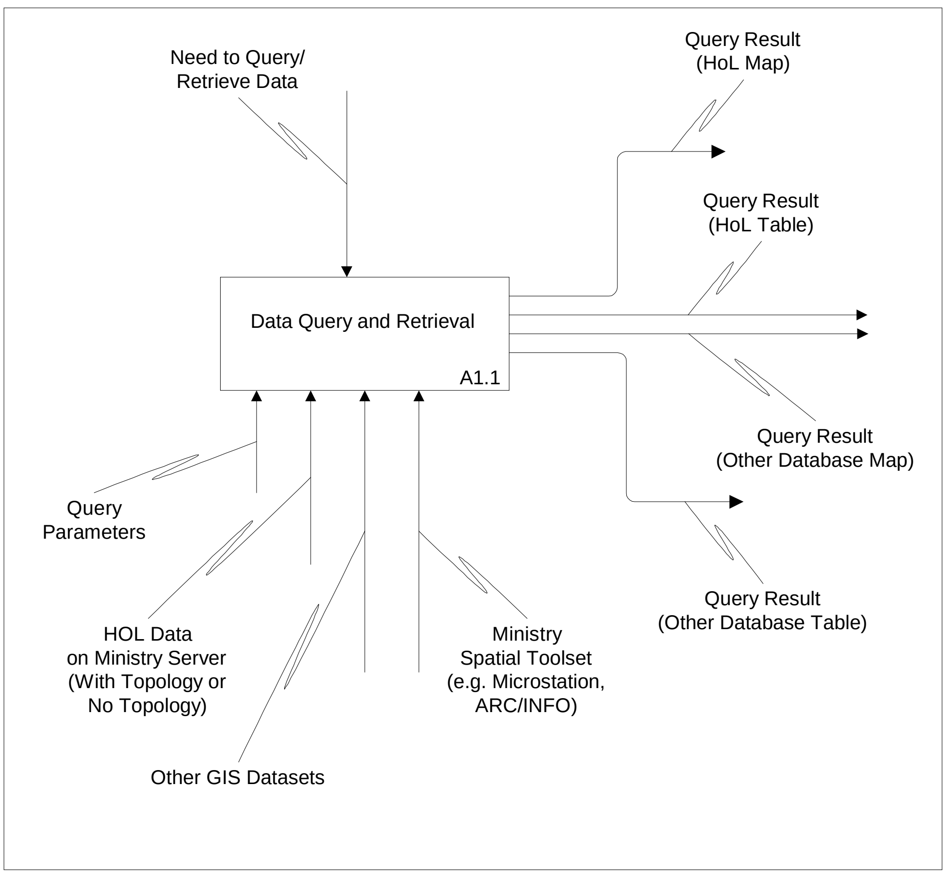
PURPOSE This procedure is used to perform ad-hoc spatial and attribute queries which can support the assessment, creation or editing of an administrative boundary.

TRIGGERS There are many cases in which a user will use this procedure:

- To find the height of land that surrounds or borders a waterbody;
- To find HoL polygons or stream segments within a study area;
- To determine major versus minor watersheds (usually required by Parks users);
- To calculate areas within one or more HoL polygons;
- To select features from other datasets that are within or near a HoL polygon.

SYSTEM DIAGRAM Figure 10 presents a simplified diagram of the triggers, inputs, outputs, and supporting mechanisms for the data query and retrieval procedure.

Figure 10 –Data Query and Retrieval Procedure



INPUTS

- Query parameters: The input parameters depend upon the type of query being performed:
  - Spatial Query – HoL Data Only: The GIS Analyst uses only the HoL database to select features. The Analyst may draw a bounding polygon, or (if topology is present) point to a feature such as a stream segment and perform and upstream or downstream trace.
  - Spatial Query – HoL Data & Other GIS Datasets: In this case, the GIS Analyst uses spatial data (e.g. the geometry of a park polygon, mammal habitat, existing admin boundary, etc.) to select features from the HoL database.
  - Attribute Query: The GIS Analyst uses attributes to pull features out of the database. If the User has downloaded the HoL data without the associated TRIM Stream Segment information, the attribute queries will be limited to physical characteristics such as areas and lengths (e.g. select all stream segments less than 200 metres in length).
- TRIM HoL Database: The table below identifies which HoL data themes/features might be used to support a user query. The level of sophistication of the query will be partly determined by whether or not the topology has been re-generated.

HoL Data Theme	Sample Features	Queried?
Height of land	HoL line	Yes
Hydrological features	Two-sided river, lake	Sometimes
Linear streams	Stream, canal, ditch	Sometimes
Skeletons	Lake and stream skeleton	Sometimes
DEM	DEM point	No
Miscellaneous Features	Flooded land, icemass, breakwater, falls, rapids	No

- Other Source Datasets: Other GIS/CAD data such as existing administrative or parks boundaries, species or habitat polygons, etc.

PROCESS The typical steps for a query are as follows:

1. Determine query parameters / determine output format (e.g. map, table).
2. Perform queries or retrieval.
3. Summarize results and produce reports as necessary. Export results to another environment (e.g. ACCESS, Excel, hydrological model, etc.) if necessary

OUTPUTS Four types of resultants could be produced by a query:

- HoL Map (spatial data)
- HoL Table (attribute data)
- Other Database Map (spatial data)
- Other Database Table (attribute data

The format of the resultants might be softcopy results that are used to assess or edit a boundary, or hardcopy results to be delivered to a client.

DISCUSSION

- Affect of Version Updates on Query Results: Over time, the TRIM HoL database will be updated as errors are fixed and new stream segments from TRIM II are added to the database. These updates will change the HoL linework. In most cases, the existing subwatersheds will be subdivided; in a few cases, the changes could be more significant. If the results from a specific query are important to your individual business process, you should compare the updated HoL linework with the older dataset to decide if key queries should be re-run with the new data. At a minimum, Users should associate meta-data describing which version of the HoL dataset was used with the query result.
- Use of Topology: If topology has been re-generated, the GIS Analyst can make use of topological queries to find the HoL associated with waterbodies, park boundaries, etc. For example: finding the HoL that surrounds a waterbody could be determined through the use of a “contained-by” spatial query; finding the HoL that borders a waterbody could be produced by running a “touches” spatial query. Alternatively, this can be achieved by visual inspection of the geometries although this doesn’t guarantee the completeness or quality of the result.
- Limitations: The user cannot form queries that use either the FISS or the BC Provincial Watershed/Waterbody Identifiers because they are not a part of the HoL database. Since there is not a lot of attribution included with the HoL database, the GIS Analyst will probably only make limited attribute queries.

4.5 Administrative Boundary Definition (A1.2)

PURPOSE The purpose of this procedure is to use the TRIM HoL database to support the creation, modification, or review of a boundary.

TRIGGERS This procedure is triggered when there is a need to define a new boundary, redefine an existing boundary, or to resolve a boundary dispute. Specific examples include:

- New TFL / Split TFL
- New Park Boundary / Change Park Boundary
- Land Exchange
- Pulpwood Area
- Ongoing QA & Update (INCOSADA & CDMS)
- An administrative boundary between Ministry of Forest Regions, or between Ministry of Forest Districts is questioned.
- The degree of move of administrative boundary is questioned (e.g. a whole creek, a move of 100m or less).

SYSTEM /FLOW DIAGRAM Figure 11 presents a simplified diagram of the triggers, inputs, outputs, and supporting mechanisms for the Administrative Boundary Definition procedure.

Figure 11 – Administrative Boundary Definition Procedure

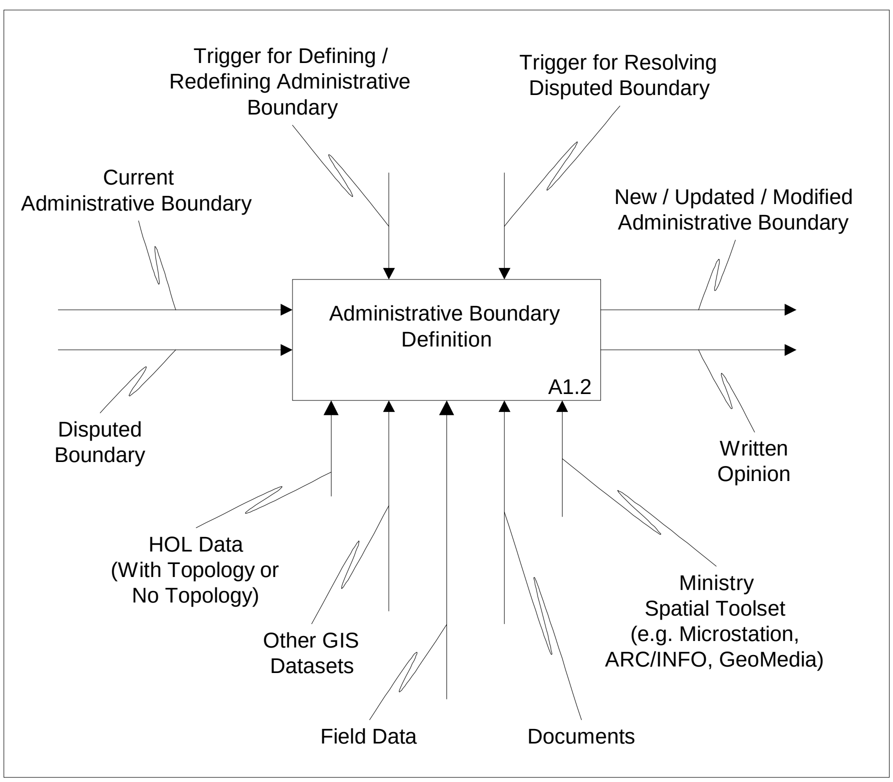
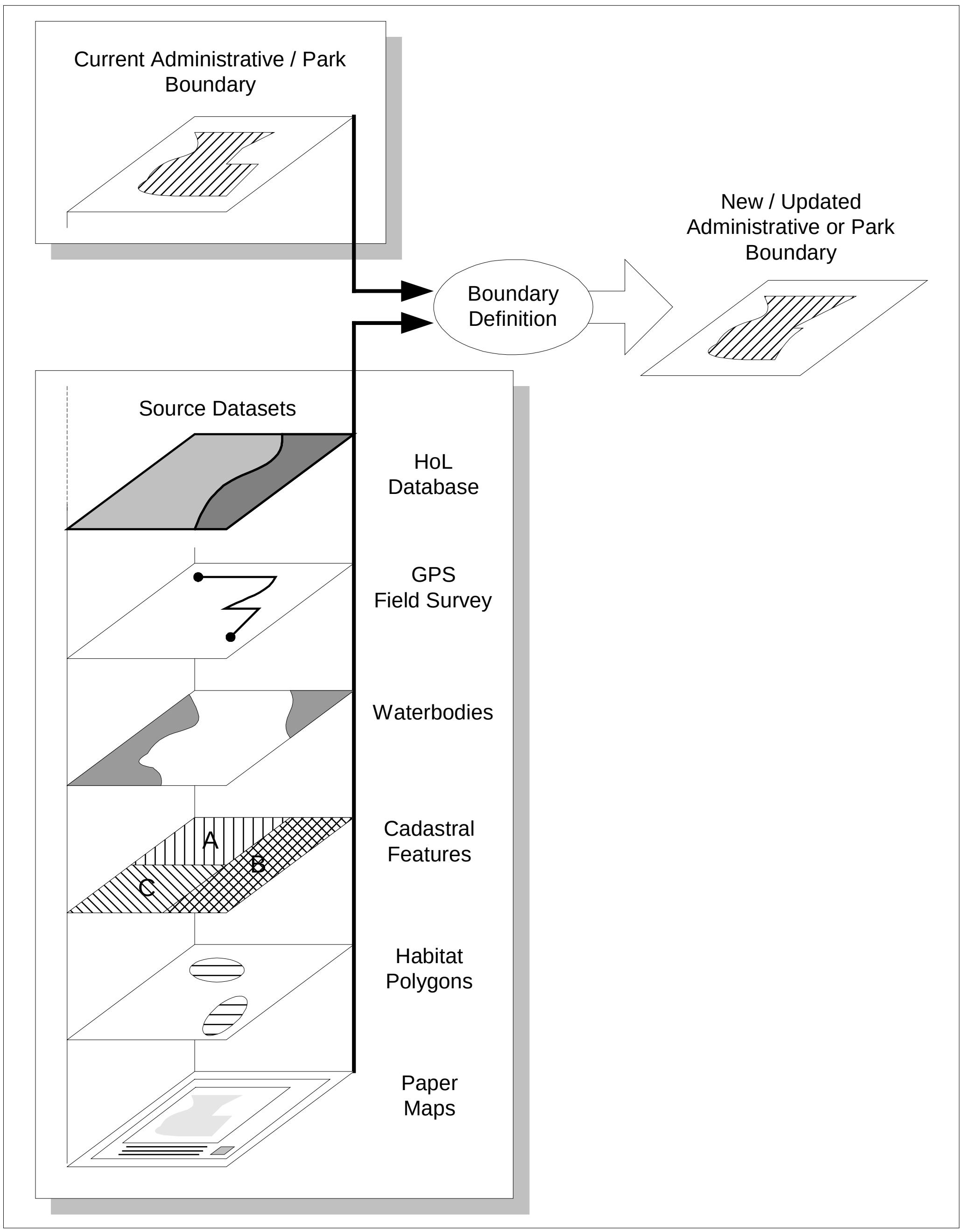


Figure 12 provides an example of how the HoL can be one of many different sources that are considered when creating or updating an administrative or park boundary. Except where the height of land has been defined by legal survey, all organizations within Government and those private organizations that deal with the Province, should use only the TRIM HoL exclusively for this purpose.

Figure 12 – Administrative Boundary Definition Concept



INPUTS

- Existing Boundary: A current administrative / park boundary (if it exists), or a disputed boundary
- TRIM HoL Database: The table below identifies which HoL data themes/features are used to define/update/assess administrative and parks boundaries.

HoL Data Theme	Sample Features	Used in Boundary Definition / Dispute Resolution?
Height of land	HoL line	Yes
Hydrological features	Two-sided river, lake	Sometimes
Linear streams	Stream, canal, ditch	Sometimes
Skeletons	Lake and stream skeleton	No
DEM	DEM point	No
Miscellaneous Features	Flooded land, icemass, breakwater, falls, rapids	No

- Other Source Datasets: The are numerous sources of information that might be used by the GIS Analyst or Technician to create or modify a boundary. The table below provides examples of some of these sources.

Type	Examples
BC Government Inventories	• TRIM, TRIM II (Streams, Coast, Waterbodies) • Existing boundaries (Admin, tenure, park) • Cadastral Data Management System (CDMS) • Tantalis • ABMS • Land or Land Title information • Metes and Bounds definitions • Official Plan Habitat polygons • Forest Cover maps (old FC1's and new INCOSADA) • Forest Atlas (FAMAP) • PSYU Maps (Region compartment lines)
Third Party Sources	• Forest company maps and photos (tenure holder) • Forest Region / Forest District • Hardcopy plans
Field Data	• GPS ground survey, Survey control points
Remotely-Sensed Data	• Aerial Photography (ortho, non-ortho) • Airphoto interpretation • Digital orthophoto and Satellite imagery

Some of these source are available in GIS form, and can be directly overlaid with the HoL data. Others are in analog form and may optionally be digitized or simply inspected visually for an independent check of a proposed change.

PROCESS While the actual process implemented by each Agency is specific to that organization, the overall process typically follows these basic steps:

1. Gather Data / Prepare Datasets: Pre-process and assemble the source datasets. A number of different digital and analog sources may be brought together. This can also include fieldwork.
2. Analyse: Consider the evidence and make a determination.
3. Document: Develop map products and written opinion to explain the conclusion.
4. Archive / Distribute: Store the result for future reference. This can include placing digital files on CD, storing a signed mylar, and distributing hardcopy plots to regional and district offices.

OUTPUTS A number of deliverables can be produced from this exercise:

- A new/updated/modified administrative or park boundary. This will typically be documented in a number of forms:
  - GIS database format for use by others (e.g. as a E00 file);
  - text (a metes and bounds description of the boundary);
  - HP plotfile; and
  - hardcopy (the HP plotfile is used to produce a mylar for signature).
    - A written opinion that explains the rationale for a decision.

DISCUSSION

- Use of Existing Best Practices: Both MOF and MELP have a number of established best practices. Examples include:
  - *"Bring in as much evidence as possible",*
  - *"Existing lines may not be HoL's. It could be straight run to follow historic cut line."*
  - *"If there is a surveyed administrative boundary that already exists, it should be used instead of the calculated HoL"*

  These practices are documented by RTE and Parks under separate cover.[3]
- Role of HoL Linework: While the HoL is one of many possible sources of evidence in boundary determination, it plays an important role. For MOF applications, approximately 15% of most forest administration boundaries are surveyed lot evidence, and 85% use HoL evidence. For Parks applications, the estimated proportions are 70% HoL and 30% other evidence such as surveyed lots and UTM lines.

[3] As an example, the document "Chapter 52 Mapping", BCMOF, Resource Tenures and Engineering (July 2000), provides descriptions of how to create Administrative Boundaries, Exhibit 'A' sketches and Clearances. This document can be found on the Geomatics Data Section's web page (follow the link to "Geomatic Data" on http://www.for.gov.bc.ca/RTE/index.htm)

- Limitation of HoL in Low-Relief Areas: Users must be cautious when using this dataset in flat areas such as floodplains. Small changes in elevation can affect a boundary by 10's of metres.
- Different Datasets: The TRIM, TRIM II and TRIM HoL are three different datasets. It is recommended that Analysts use the features in the TRIM HoL dataset whenever possible rather than going "backward" to use the original features from the TRIM dataset.
- Support Role of Senior GIS Analysts in Multi-Participant Boundary Issues: This type of work may involve many different players at once (RTE & GDBC & etc. etc.). It may be necessary to share the digital datasets between proponents as a part of the boundary resolution process. Each proponent may have a different target GIS environment. In this case, it is important that senior GIS Analysts oversee any translation, re-projection and topology re-generation tasks to ensure that the integrity of the positional accuracy and topology is maintained.
- Fieldwork & HoL Updates: If the team cannot resolve the issue, the team must go to the field and develop detailed cross-sections (typically by a professional land surveyor). The final HoL linework developed in the field will not be used to update the linework in the original HoL dataset.
- Affect of Version Updates on Boundary Determination: Over time, the TRIM HoL database will be updated as errors are fixed and new stream segments from TRIM II are added to the database. These updates will change the HoL linework. In order to keep track of which version of the HoL database was used to determine a boundary, each new/modified boundary feature should have associated meta-data that describes which version of the HoL dataset was used. For more complex determinations, the User should clip and store a separate copy of all of the linework (including the HoL) that was used to support the boundary determination work.

4.6 Version Management Procedures (A2.1)

PURPOSE To help ensure the quality of the database, the TWA HoL Steering Committee requested the development of version management procedures. These procedures were develop to meet two main requirements:

1. Allow data users to document errors, issues or gaps in the database;
2. Allow data users to be informed of the status of the database, and changes that have been made to the data.

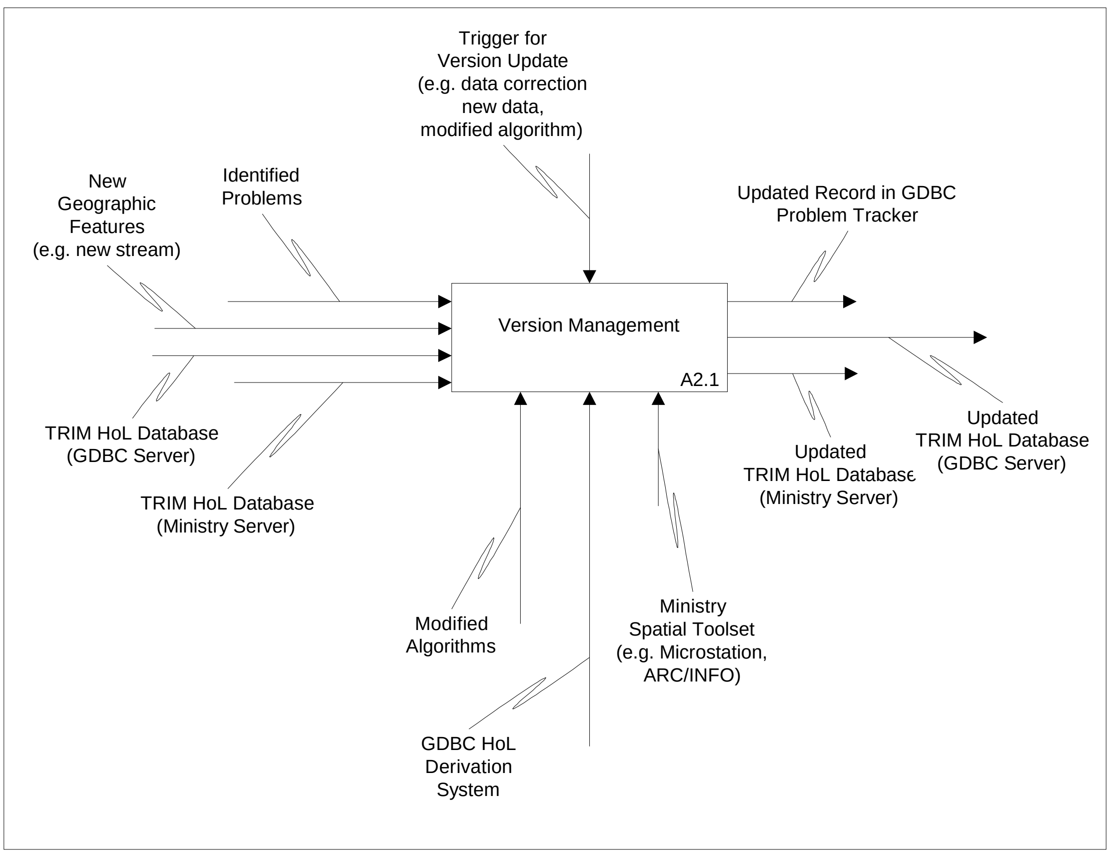
As the custodian of the TRIM HoL database, GDBC developed a comprehensive methodology for managing the process of correcting and updating the database. The Steering Committee provided input to the development of the procedures and approved the final approach presented in this document.

TRIGGERS This procedure is triggered when:

1. A user identifies a problem with the database that requires resolution by GDBC; or
2. GDBC has issued an updated version of the TRIM HoL database.

SYSTEM / FLOW DIAGRAM Figure 13 presents a simplified diagram of the triggers, inputs, outputs, and supporting mechanisms for the Version Management procedures.

Figure 13 – Version Management Procedures



INPUTS GDBC will use a variety of inputs to decide whether to fix, replace, retire a feature. The table below identifies which HoL data themes/features are version managed.

HoL Data Theme	Sample Features	Version Managed?
Height of land	HoL line	Yes
Hydrological features	Two-sided river, lake	Yes
Linear streams	Stream, canal, ditch	Yes
Skeletons	Lake and stream skeleton	Yes
DEM	DEM point by mapsheet	Yes
Miscellaneous Features	Flooded land, icemass, breakwater, falls, rapids	Yes

PROCESS Appendix E provides a detailed description of the background and purpose of the procedures, how features are added or updated, and how issues or errors are reported, tracked and resolved.

OUTPUTS

- Updated record in GDBC Defect Tracker
- Updated GDBC TRIM HoL Database
- Updated Ministry TRIM HoL Database

DISCUSSION

- It is anticipated that a set of best practices will emerge as the Defect Tracker is used to administer identified errors and requests for enhancements.

4.7 Future Updates to this User Guide

Since Ministry staff are still learning how to use this database effectively, the procedures are currently written from a general perspective. It is expected that future versions of this manual will provide more business and technical detail as the GIS Analysts and Technicians climb the learning curve and more effective best-practices are identified.

Suggestions for modifications to this document can be entered into the GDBC Defect Tracker.

Appendix A - GLOSSARY OF TERMS & ACRONYMS

ABMS — Administrative Boundary Management System: This is the provincial database for administrative boundary information. These divisions include school districts, municipalities and regional districts, agricultural regions, land districts, electoral districts, land title districts and assessment areas, plus regional and district boundaries used by various provincial ministries. All the boundaries used for provincial government administrative purposes are kept up-to-date and are made available as digital mapsheet layers.

Breakline — Terrain data points, whether in a regular or irregular pattern, always fail to represent terrain fully in areas where there are sharp breaks or discontinuities in slope. Such discontinuities occur along ridge lines, at the upper and lower edges of a steep embankment, along drainage lines (streambeds), and in the vicinity of constructed cuts and fills. In these areas, the DEM points must be supplemented by breaklines that indicate sharp changes in slope.

TRIM contains three types of breakline:

- Hypsographic breaklines (prominent land features such as ridges and cliffs);
- Hydrographic breaklines (the streams, rivers and lake edges);
- Anthropological breaklines (e.g. manmade features such as roads and railways)

Catchment Area — The entire area from which drainage is received by a river system. It is also referred to as a basin. Any point on a stream will define an upstream catchment area, whereas watersheds are typically defined only at confluences (places where streams meet).

CDMS — The system that manages the cadastral (property boundary) information for the province

DEM — Digital Elevation Model. A series of points and breaklines (such as ridges) defining the Earth's surface. In TRIM, the DEM data consist of individual (x,y,z)-tuples, as well as some ridge lines, streams and certain other linear features.

Digital Base Map — A metric (measurements can be made from it) representation of the ground, at a given scale, as seen from an aerial view. Typically, this representation includes: streams, lakes, roads, contours, buildings or groups of buildings, etc. In the past, base maps were a paper-based product, but now they are typically kept in digital form.

FRMB — Forest Renewal Management Branch. A Crown Corporation committed to protecting environmental and other values in BC's forests, creating more value and jobs from wood that is cut, meeting demands of changing international markets, and securing the future of workers and communities.

GDBC — Geographic Data British Columbia. See http://home.gdbc.gov.bc.ca/

GIS — Geographic Information System.

Height-of-Land — A portion of a watershed boundary. Often used in defining the legal definition of a land parcel. Definition from FAMAP Global Glossary: The high point of land which separates watersheds and which forms part of the legal description of various Forest Tenures

HoL	See Height-of-Land
Hypsography	The scientific study of the earth's topologic configuration above sea level, especially the measurement and mapping of land elevation. Hypsometry: The measurement of elevation relative to sea level.
INCOSADA	INCOSADA is a major forestry initiative to create a current, complete and managed database of information about the land base. See http://www.for.gov.bc.ca/isb/incosada/
OGC	Open-GIS Consortium
Planimetric Features	Geographic features whose two-dimensional representations have significance (unlike points and surfaces). These include all man-made features such as roads, buildings, fences, etc., as well as natural features such as streams, lakes, swamps, etc.
SAIF	Spatial Archive and Interchange Format. A language for modeling geographic data and a vendor-neutral format for archiving and distributing such data. Developed as a means of sharing spatial and spatio-temporal information. SAIF is designed to facilitate interoperability, particularly in the context of data exchange. SAIF follows a multiple inheritance, object-oriented paradigm.
Single-line stream network	A directed acyclic graph defining which streams and lakes (represented as a network of inflows and outflows) drain into which other streams and lakes.
Spatial Queries	Queries to a database or GIS in which the returned data are constrained by some spatial description (e.g., return all points within 100 meters from the well site at location (49:32:12.231N, 123:42:45.693W)).
Tantalis	Tantalis is a newly built information system designed specifically for the needs of the complex workings of CLRS and to provide automated support for all aspects of Crown land administration. It was designed to provide a foundation for integrating spatial data associated with mapping of survey plans and administrative boundaries with attribute data associated with legal documents and administrative records. See http://www.elp.gov.bc.ca/clrs/about_clrs/index.html
TRIM	Terrain Resource Information Management. The digital base map of British Columbia. Nominal scale, 1:20,000. Dataset includes a non-gridded DEM.
TWA	TRIM Watershed Atlas. A database comprising the HoL Database and the Stream Network Database.
Versioning Schemes	As new mapping is carried out in an area which has already been mapped, some features will be remapped. Versioning schemes are procedures for managing these changes and allowing reconstruction of the data at a particular point in time.
Watershed Polygons	Polygons describing the area on the ground from which water will flow into the defining stream system.
Watershed	A geographical area that drains into a particular stream, river, or other form of water body. A stream or river network will have an associated watershed. A river network watershed will be made up of a collection of sub-watersheds, one for each tributary and stream in the network. There is a hierarchical ordering to these watersheds.
World Wide Web	A vast collection of interconnected documents and multimedia resources on the Internet.

Appendix B - TRIM HOL DATA DICTIONARY

The table below provides a detailed list of the features contained in the TRIM HoL Database, Version 1.0. The other columns provide the following information:

- Feature Codes: The second column provides the "TRIM-like" feature code associated with each feature. While some of the codes are taken directly from the TRIM codes, some new codes were created for this dataset. These new feature codes start with a "WA" designation. Since these new codes do not describe any features in the original TRIM model, you will not find these features in any TRIM dataset. As an example, some of the features in the HoL dataset are area features. By comparison, TRIM only contains attributed linework and does not have a polygon topology or a linear stream network topology.
- Basic Spatial Types: The last three columns indicate whether the feature can be processed as a node, arc, and/or area. For example, a watershed polygon can be exported to another GIS in simple terms as a simple line, or in more complex terms as a closed polygon that shares edges with its neighbouring polygons.

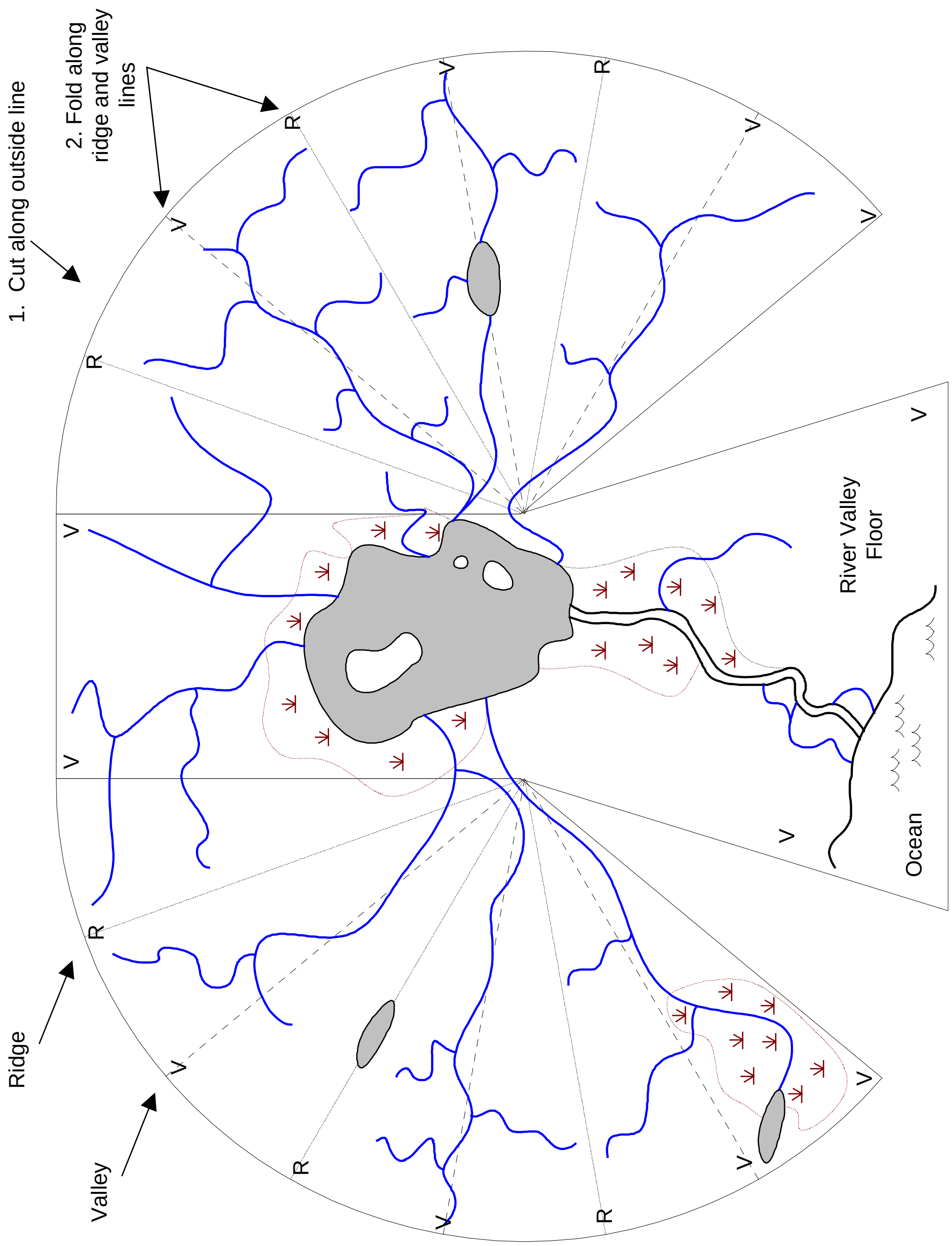
FEATURES	FEATURE CODE	BASIC EXPORT SPATIAL TYPES		
		NODE	ARC	AREA
Miscellaneous Features				
Miscellaneous line				
linear beaver dam	GA08450110		X	
linear breakwater	GE03050110		X	
dam - base	GA98450100		X	
dam - top	GA08450000		X	
dam - spillway penstock	GA28550000		X	
dyke	GE09400000		X	
falls linear	GA10450000		X	
seawall	GE26250000		X	
linear rapids	GA23500000		X	
miscellaneous area				
dump	AP09200000		X	X
fish hatchery	AF11150000		X	X
sewage treatment area	AP26750000		X	X
Tailing area	AP30300000		X	X
miscellaneous point				
point breakwater	GE03050120	X		
point dam	GA98450000	X		
point falls	GA90002110	X		
point island	GE98450000	X		
point rapids	GA23500110	X		
sinkhole	HB27550000	X		
Fire lookout tower	BF10950120	X		
icemass				
glacier	GD12300000		X	X
icefield	GD14450000		X	X

FEATURES	FEATURE CODE	BASIC EXPORT SPATIAL TYPES		
		NODE	ARC	AREA
sandbar				
sandbar	GE25850000		X	X
geological line				
esker	HB10200000		X	
geological area				
lava bed	HB15850000		X	X
moraine	HB18700000		X	X
dry river bed	GA24850130		X	
scree	HB26150000		X	X
slide	HB27900000		X	X
volcanic crater	HB07650130		X	X
flooded land				
inundated land	GB11350110		X	X
marsh	GC17100000		X	X
swamp	GC30050000		X	X
pond				
settling pond	EA26700110		X	X
tailings pond	AP90300100		X	X
exclusion area				
area of exclusion	HC90000000		X	X
indefinite area				
area of indefinite contours	HC90000100		X	X
mountain peak				
mountain peak	HB18800000	X		
ridgeline				
hypsographic breakline	HA90200120		X	
spot height				
spot height	HA28700000	X		
Linear Streams				
linear stream				
linear stream - definite	GA24850000		X	
linear stream - indefinite	GA24850140		X	
linear stream - intermittent	GA24850150		X	
linear canal	GA03950000		X	
ditch	GA08800110		X	
Hydrological Features				
island				
island - areal, definite	GE14850000		X	X
island - areal, position approximate	GE94850100		X	X
lake				
lake - definite	GB15300000		X	X
lake - indefinite	GB15300130		X	X
lake - intermittent	GB15300140		X	X
reservoir - definite	GB24300000		X	X
reservoir - indefinite	GB90100000		X	X
reservoir - intermittent	GB90100110		X	X

FEATURES	FEATURE CODE	BASIC EXPORT SPATIAL TYPES		
		NODE	ARC	AREA
proposed max reservoir level - definite	GB90100120		X	X
proposed max reservoir level - indefinite	GB90100120		X	X
proposed max reservoir level - intermittent	GB90100120		X	X
areal stream				
two-sided river	GA24850000		X	X
two-sided canal	GA03950000		X	X
Coast				
coastline	GA05800000		X	
Height-of-Land				
Height-of-land				
HoL lines	WA25100000		X	X
Skeletons				
lake skeletons				
skeletons for lake - definite	WA25200100		X	
skeletons for lake - indefinite	WA25200100		X	
skeletons for lake - intermittent	WA25200200		X	
skeletons for reservoir - definite	WA25200200		X	
skeletons for reservoir - indefinite	WA25200200		X	
skeletons for reservoir - intermittent	WA25200300		X	
skeletons for proposed max reservoir level – definite	WA25200300		X	
skeletons for proposed max reservoir level - indefinite	WA25200300		X	
skeletons for proposed max reservoir level - intermittent	WA25200300		X	
stream skeletons				
skeleton for two-sided river	WA25200400		X	
skeleton for two-sided canal	WA25200500		X	
DEM				
DEM point				
DEM point	HA90100000	X		

Appendix C - POOR MAN'S EXAMPLE OF TRIM SOURCE FEATURES

It is usually difficult to visualize in three dimensions the actual surface expression of the topography and the associated hydrographic features that make up the source data used to build this database. This page provides a poor man's example. A more modern means of visualizing the resulting datasets is to browse 3D renderings of the dataset.



Appendix D - CREATION OF THE TRIM HOL DATABASE

The height-of-land delineation algorithms define, with optimal accuracy, the watershed boundaries and catchment regions for most hydrological features of the TRIM data set for British Columbia. These features include lakes, single-line streams, double-sided rivers, and coastlines. The scheme is designed to compute watershed boundaries for most types of terrain (excluding wetlands and man-made waterbodies.

D.1 SOURCE DATA

The TRIM HoL Database was created using topographic and hydrographic information contained in the TRIM dataset. TRIM contains elevation information in two forms:

- DEM information (basically, spot heights in an irregular pattern across the surface);
- Breaklines that contain a series of X,Y,Z triplets. There are three types of breaklines in TRIM:
  - Hypsographic breaklines (prominent land features such as ridges and cliffs);
  - Hydrographic breaklines (the streams, rivers and lake edges);
  - Anthropological breaklines (e.g. manmade features such as roads and railways)

The TRIM HoL boundaries were calculated using all of these features except for the anthropological breaklines. This is because road and railway features have little effect on the determination of watershed boundaries.[4]

D.2 HOL PROCESSING ALGORITHMS

Using the TRIM features as input, the HoL database was created in two main stages: line Voronoi delineation, and full delineation incorporating DEM information. Each stage is described below.[5]

D.2.1.1 Stage 1: Line Voronoi Delineation

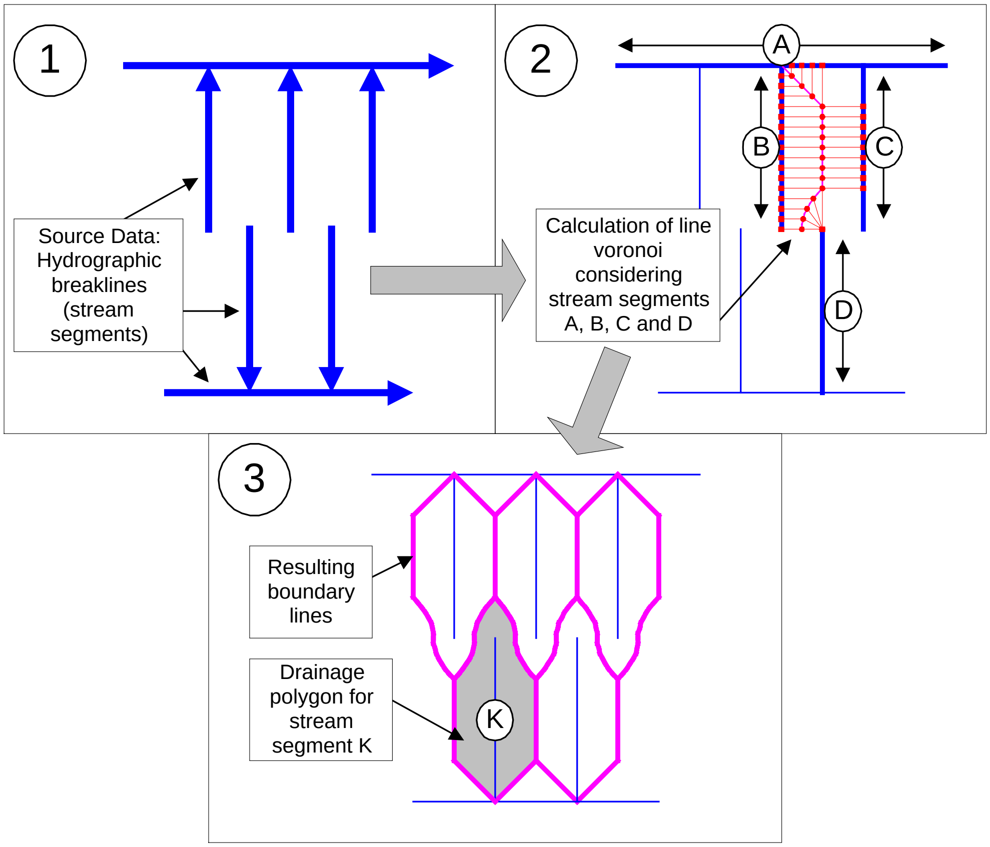
Description: In the first stage, the hydrological linework was used to define an approximation to the line Voronoi boundaries which separate all sets of adjacent hydrological features. These boundaries define regions within which all the points are closer to one particular waterbody than to any other waterbody. In the absence of DEM information, this line Voronoi boundary delineation provides an optimal estimate of the watershed boundaries.

Example: The figure on the next page shows how the hydrological linework is used to develop the line Voronoi. The first panel shows a collection of hydrographic features which drain to the North or South, and then to the East. The second panel shows how one part of the line Voronoi is calculated based upon the surrounding stream features. The third panel shows the resulting boundary lines, and one of the drainage polygons that be derived from this linework.

4 Appendix C provides an example of the source data features.

5 Appendix D provides additional technical information about the TRIM HoL Database.

Figure 14 – Example of the Calculation of a Line Voronoi



D.2.1.2 Stage 2: Full Delineation Incorporating DEM Information

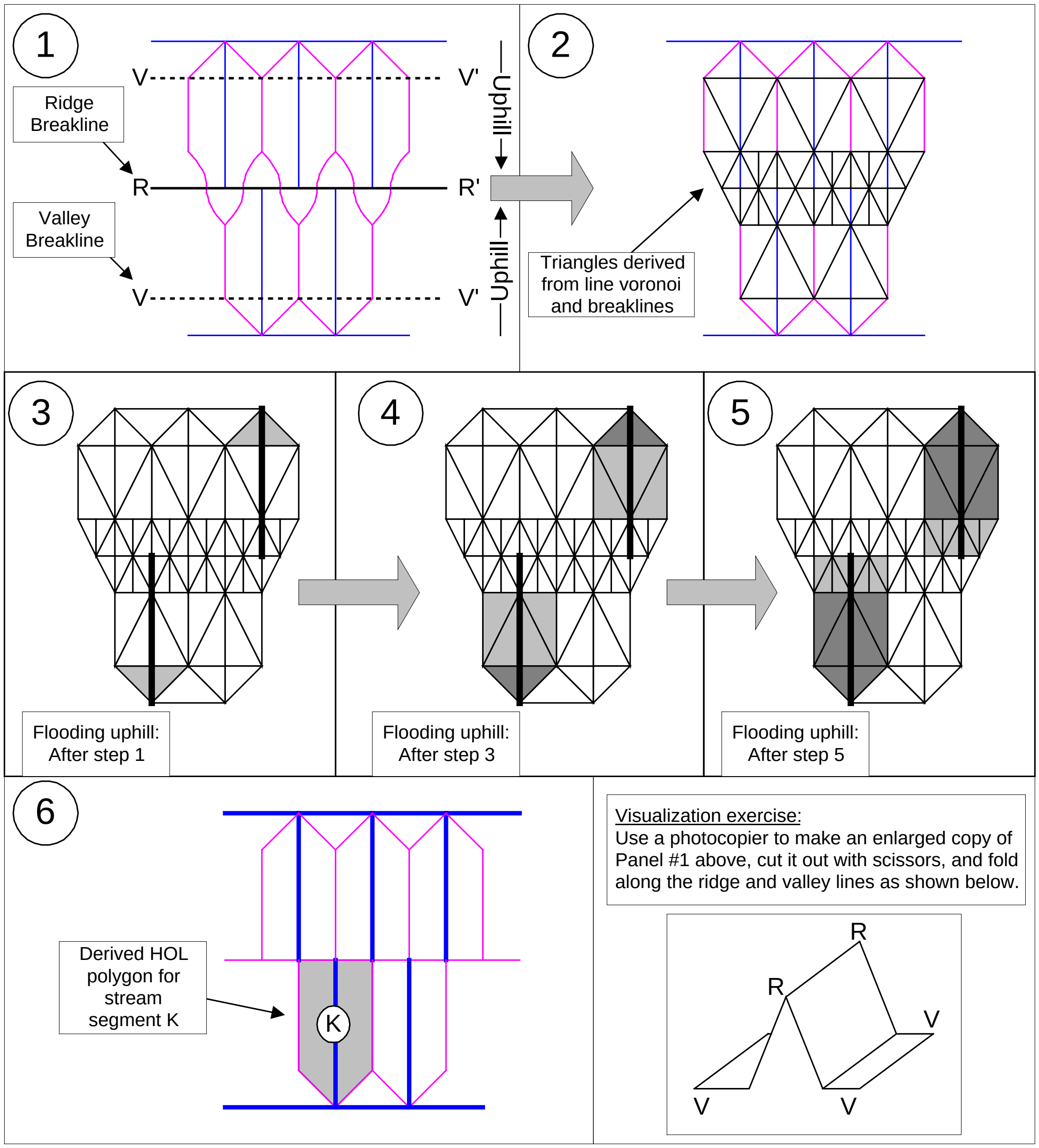
Description: In the second stage, the TRIM DEM is used to generate watershed boundaries that are fully consistent with the terrain information provided by the DEM. The overall approach involves the line Voronoi boundaries, the development of a triangulated model of the topographic surface, and a "flooding" algorithm which determines the flow direction of all of the triangles.

Example: The first panel in Figure 15 on the next page shows the same example as above, but with three east-west breaklines introduced to define the topography of the area, one ridge line (line RR') and two valley breaklines (lines VV').

Panel 2 shows a possible set of triangles that could be derived from the hydrographic breaklines (water features), line Voronoi, and hypsographic breaklines. Panels 3, 4 and 5 show how the flooding algorithm "climbs" the slope in a series of steps for two of the streams. Eventually, all of the triangles will be flooded and the drainage area for each stream segment is determined. Panel 6 shows what the resulting HoL boundaries, and the watershed polygon for one stream segment.

Why use a flooding algorithm? It makes sense to calculate the HoL boundary starting from the stream segment because that is where the water is going to end up. Using the streams as a starting point, the algorithm searches uphill for the area draining into each stream until it encounters the influence of another stream. At that point, the search stops for that stream segment. The common line between the two polygons is the height of land boundary.

Figure 15 - Example of Full Delineation Using DEM Information



D.2.2 Discussion

It is instructive to compare the resulting HoL lines on this page to those shown on the previous page. If the area of the earth shown in Figure 14 was almost flat, the HoL lines would be optimal. If the area has high relief such as in Figure 15, the breaklines become very important determinants as to which way the water will drain. In this example, the small areas at the tips of each stream segment get "clipped" by the ridgeline because the water actually drains the other way.

In reality, the TRIM HoL database actually balances both methods. In low-relief areas, the line Voronoi almost exclusively determines the HoL boundary. As the relief expression gets higher, the full delineation using the DEM is the key determining factor.

Appendix E - VERSION MANAGEMENT PROCEDURES

E.1 INTRODUCTION

E.1.1 Background

The TRIM Watershed Atlas Heights of Land (TWA HoL) database is derived from *Terrain Resource Information Management* (TRIM) data. Geographic Data BC is the custodian for the TWA HoL Database.

New mapping and detection of error and natural or man-made changes may trigger updates to the TWA HoL.

E.1.2 Purpose

The TWA HoL requires a version management scheme that will enable re-computation of watershed boundaries as new and update mapping is received. This procedure outlines a version management scheme for the TWA HoL Database.

E.1.3 Administration

A group comprised of selected user representatives will administer these procedures.

E.2 FEATURE LEVEL VERSION MANAGEMENT

To support all types of user groups the TWA HoL database will manage version information at the feature level. Every feature in the TWA HoL database (stream segment, lake, watershed, etc.) will carry information about its accuracy and its update history.

E.2.1 Update History

A feature's update history has two dates:

- date of admission (when the feature was added to the database), and
- date of retirement (when the feature was removed from the database).

When features are modified the old feature or changed portion thereof is retired and the new feature or portion thereof is admitted into the database.

- Features are never deleted from the database; only marked as retired (non-active) as of a given date.

Tracking basic history components at the feature level allows users to query the database for a dataset in any given epoch (time period). Additionally, the tracking of accuracy class and specification release allows users to generate a scale-consistent dataset.

E.2.1.1 Adding New Features

New features are created when:

- a new feature is added to the database, and
- an existing feature is updated to accommodate a new feature.

Example: If a new first order stream is added to an existing stream network, the new stream will break an existing stream segment into two parts at the confluence point. These two parts are added as new features.

E.2.1.2 Updating Existing Features

When a feature is updated (e.g., the path of a river moved) the existing feature is retired and a new feature is added. This occurs with any update in the features including updates in attribute information.

Example: When a new survey finds that a stream previously identified as intermittent is free flowing, (possibly from lower level photography), the update in attribute value retires the old feature and adds a new feature, even though the new feature has the exact same geometry as the old one.

E.2.2 States of Features

Any line segment in the TWA HoL Database may co-exist in any of four states:

- present version (province wide computation and interpretation of the HoL database)
- updated view (local stream geometry only)
- current view (re-computation of local watershed only)
- retired feature $_{(n),}$ retired feature $_{(n-1)}$ … (superseded data features from previous versions)

E.2.2.1 Present Version

The Present Version reflects a province-wide computation and interpretation of the HoL database. The Present Version is the most stable and internally consistent representation of the data.

Version updates will most likely be initiated by an external need to re-describe boundaries, rights or interests defined by heights of land. A version update would involve the following activities:

- re-computation of all watersheds containing “pending update” flags
- retirement of all superseded data elements
- re-labeling of all current view as Version n.0 would current view watersheds be re-processed under a version re-computation? This implies not.
- notification of update

The date of the most recent pending update flag removed becomes the new version date.

E.2.2.2 Updated View

The Updated View reflects the addition of new TRIM-compliant stream mapping data (local stream geometry only).

The updated view is **not** propagated through either the single line stream network definition or the height of land interpretation. The updated view of the stream geometry will be inconsistent with both the present version and the current view of the single line stream network and the height of land interpretation. The updated view contains data that has not been incorporated in either the stream network analysis of the height of land determination and cannot be used for either stream network analysis or height of land depiction.

E.2.2.3 Current View

When new mapping has been completed in a specified area (i.e., TRIM quarter block, SHIM watershed, or specific project), a ***local*** re-computation may be done to ensure that the current updated local geometry, network definition, and height of land interpretations, are all consistent. This current view reflects a re-computation of local watershed data only. Current view date may be inconsistent with upstream, downstream and adjacent data. Current view data should only be used for very localised analysis.

E.2.2.4 Retired Feature

The Retired Feature state indicates that the data feature has been superseded by an updated version (retired feature $_{(n),}$ $_{retired}$ feature $_{(n-1)}$ …). There may be many retired instances of a particular feature. Care must be exercised in using retired features to ensure that all retired features used are of a similar epoch.

E.3 UPDATING THE TWA HOL DATABASE

E.3.1 New Mapping Data

As new TRIM-compliant stream mapping data is added to the TWA HoL Database it is tagged with the effective date of admission and creates an updated view of the local stream geometry. The **effective date of admission** serves to flag a **pending update** (i.e., the effective date of admission is more recent than the present version date).

When new mapping has been completed in a specified area a *local re-computation* may be done to create a **current view** of the local watershed that reflects the current updated local geometry, network definition, and height of land interpretations, are consistent.

E.3.2 Data Errors or Changes

Major changes (either error correction or changes resulting from natural or man-made processes) are added to the TWA HoL Database and tagged with an effective date in the same manner as new mapping updates. All replacement data must be TRIM compliant.

A user group will assess the severity, permanence, and impact of the error or update, and recommend:

- immediately re-computing the local single line stream network and height of land interpretation (i.e. current view); or
- maintain the flags and await an update re-computation (i.e. update view).

E.3.3 Algorithmic Updates

Correction, enhancements and extensions to the analytical algorithms will trigger an immediate re-computation and new version (i.e. the entire province will be re-computed).

E.4 REPORTING AND TRACKING ERRORS AND DEFECTS

Geographic Data BC Defect Tracker:

Geographic Data BC has established a problem tracking application on its website at http://home.gdbc.gov.bc.ca/tmtrack/tmtrack.dll .

An authorised user of TWA HoL data may be licensed to access this application and submit error and defect reports. To obtain a license to use the Geographic Data BC Problem Tracker contact the TWA HoL Data Custodian – David Skea at David.Skea@gems8.gov.bc.ca.

Training will be provided by Geographic Data BC staff.

A licensed user can submit error and defect reports and view error and defect reports that have been submitted by others. A licensed user will be notified whenever the status of a report they submitted changes.

Unlicensed users may also log on as guest and submit and view error and defect reports, but they will receive no notification of status changes to these reports. Use of guest accounts by unlicensed staff and contractors is not recommended and should be discouraged.

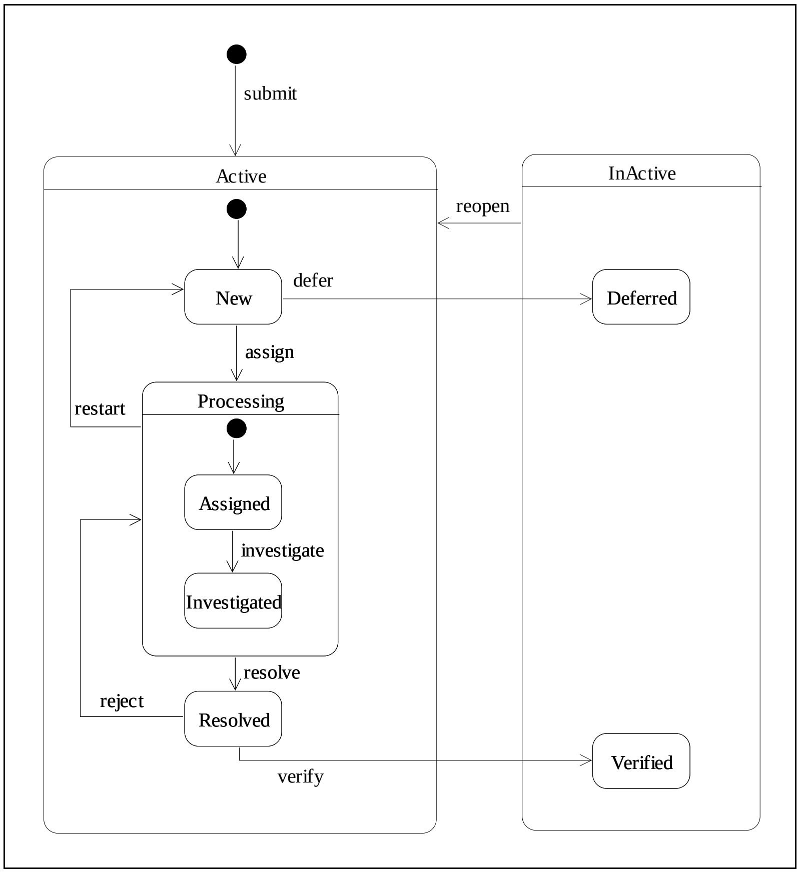
Within two business days of submission, a new report will be assigned for investigation and resolution. At this time the status will change from **NEW** to **ASSIGNED**.

A duplicate report of an error or a defect or an incomplete or inaccurate report may be **DEFERRED**.

Within three business days of being assigned, a plan and schedule for resolution will be established (**ASSIGNED** to **INVESTIGATED**) or the problem will have been resolved (**ASSIGNED** to **RESOLVED**).

The resolution will be **VERIFIED** by a quality assurance tester.

Figure 16 - Geographic Data BC Defect Tracker



Defect reports can be submitted by users and staff.

A manager handles defects in the New, Deferred, and Verified states.

An engineer handles defects in the Processing state.

A tester handles defects in the Resolved state.

Users (except guest) are notified by email of changes to defect reports they submitted.

Users (except guest) can make changes to a defect report they submitted. All changes are logged.