Freshwater Atlas

Watershed Boundary Generation Process Flow

Prepared for

Base Mapping & Geomatic Services
Integrated Land Management Bureau
Ministry of Agriculture and Lands

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Document Tracking

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REVISION HISTORY

Date	Version	Author	Description of Changes
July 06, 2007	1	Refractions Research	Initial draft.
July 16, 2007	2	Refractions Research	Added overview diagrams; minor edits, updated formatting.

CONTENTS

1 INTRODUCTION

1.1 PURPOSE

This document is intended to give an overview of the process used to generate watershed boundaries and provide a description for each step in the process. The approximate processing times are indicated as part of the description for each step.

The intended audience is primarily personnel from Base Mapping and Geomatic Services (BMGS) from the Integrated Land Management Bureau of the Ministry of Agriculture. The technical reader can get an understanding of the data processing and QA review conducted during the generation of the watershed boundaries. The management reader can gain an understanding of the overall process, the number of different steps involved and the approximate processing times required to generate the data.

The secondary audience is personnel from Refractions Research Inc. and the document will be used when the next version of watershed boundaries is generated to plan the processing schedule, review the possible software improvements that could be developed, and understand the process (in the event that there are new team members).

1.2 SCOPE

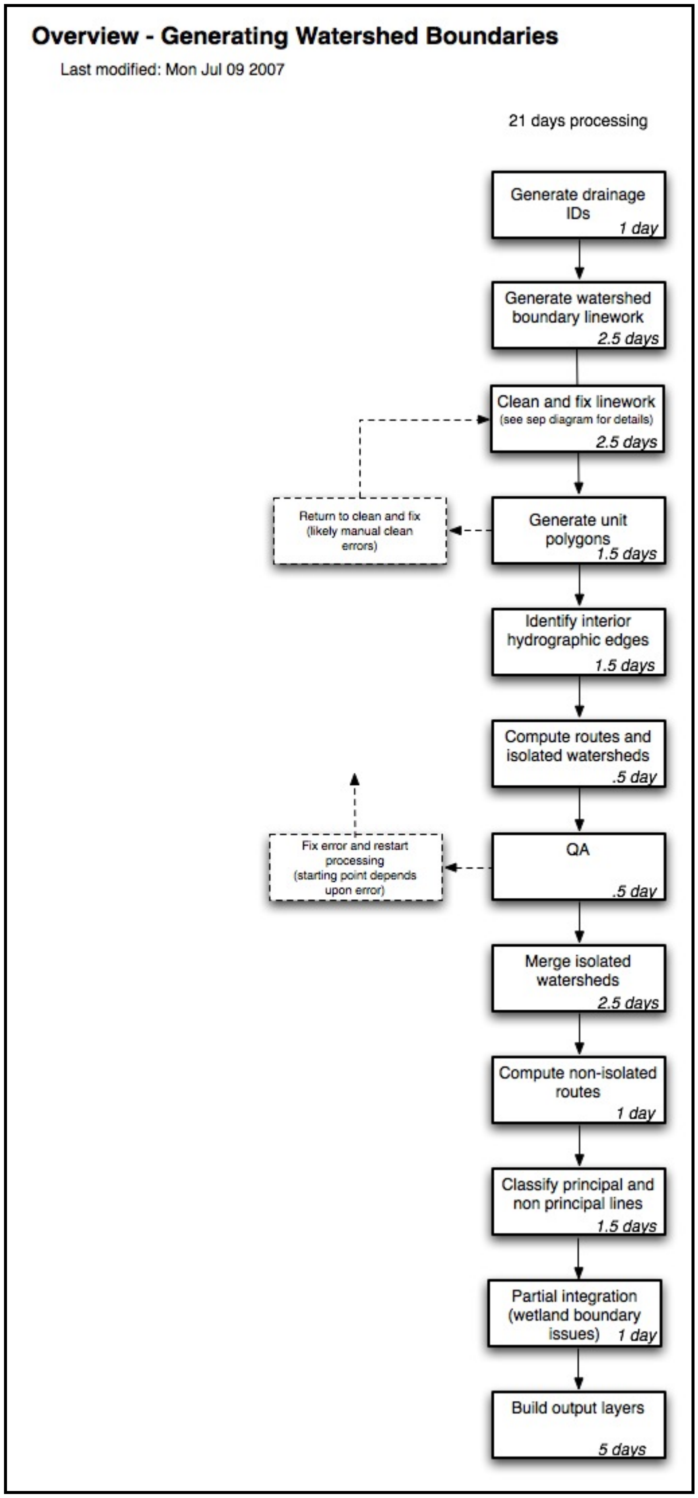
The process description in this document is limited to the generation of watershed boundaries as specified for version 1.2 of the FWA.

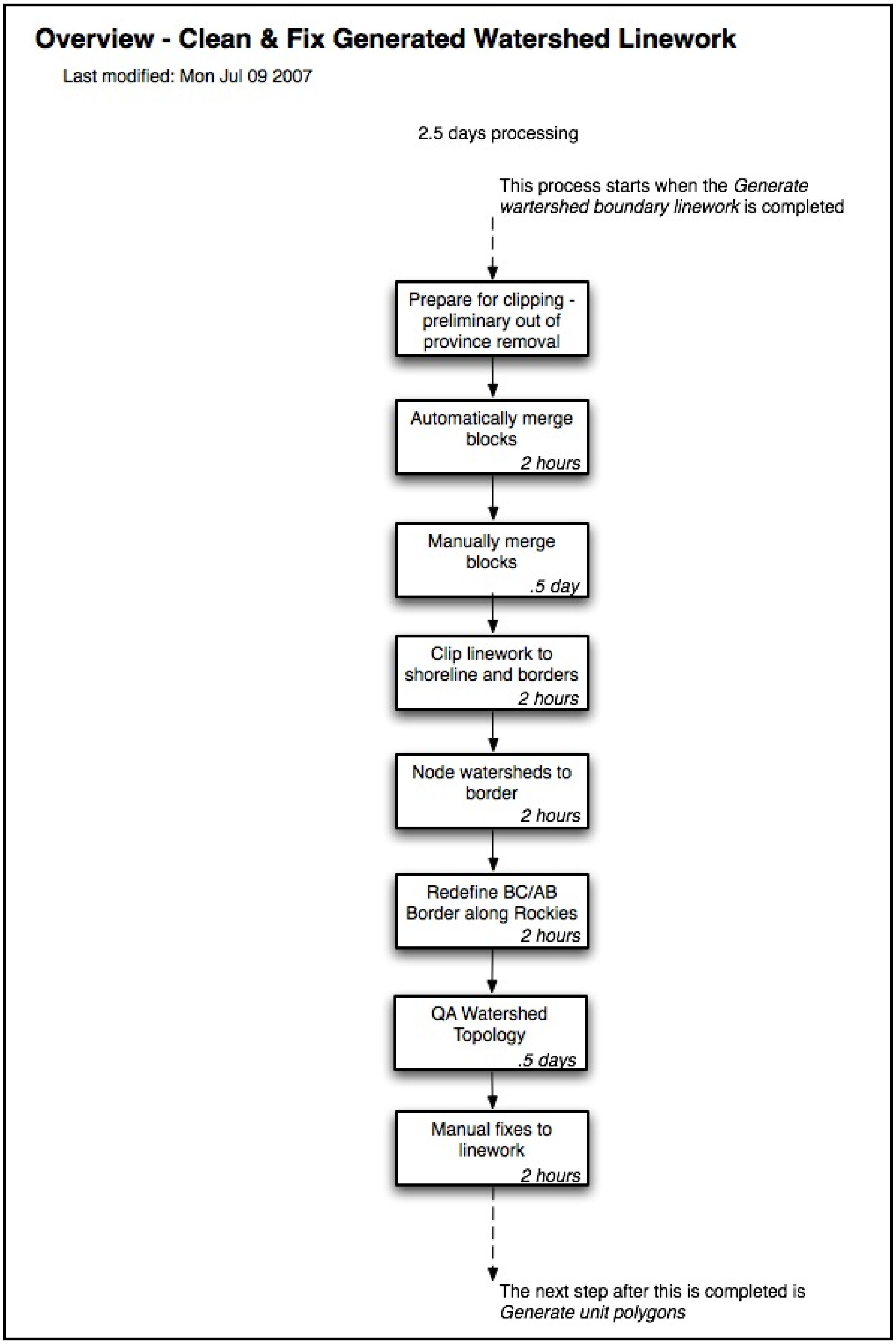
This document does not provide detailed design specification for the generation of watershed boundary linework, which is provided in a separate document, *FWA-HOL Design 0.3.doc.*

This document does not provide detailed requirements for FWA watershed boundaries, which is provided in a separate document, *Watershed Boundary Requirements.doc.*

This document does not provide any information on the FWA stream network.

2 PROCESS OVERVIEW




Overview - Clean & Fix Generated Watershed Linework
Last modified: Mon Jul 09 2007
2.5 days processing
This process starts when the *Generate wartershed boundary linework* is completed
Prepare for clipping - preliminary out of province removal
Automatically merge blocks
2 hours
Manually merge blocks
.5 day
Clip linework to shoreline and borders
2 hours
Node watersheds to border
2 hours
Redefine BC/AB Border along Rockies
2 hours
QA Watershed Topology
.5 days
Manual fixes to linework
2 hours
The next step after this is completed is *Generate unit polygons*

3 PROCESSING STEPS

The following sections provide descriptions and approximate processing times for each of the steps required to generate the watershed boundary linework and polygonal watershed layers for Version 1.2 of the FWA.

3.1 GENERATE DRAINAGE IDS

This step prepares the input data for the watershed generator. It involves running the drainage id software and performing some manual QA.

The drainage id software prepares the input data for the watershed generator (and unit polygon generation). It determines which edges from the FWA hydrographic edges are to be provided as input to the watershed generator and applies a drainage id to each of these edges that determines what drainage each edge should be contained within. In addition a side attribute (for determining the water side of bank edges) and a type attribute (bank, flow, etc.) are populated. Further information on what edges are included and how drainage ids are assigned can be found in the *Watershed Boundary Requirements* documentation.

Some basic QA checks are performed automatically. These include:

- ensuring each edge is assigned only a single drainage id
- all drainage ids are valid (>0)
- all bank edges have a side attribute.

In addition a manual QA check was preformed that involves reviewing the drainage id assignment at specific locations that correspond to each requirements in the *Watershed Boundary Requirements* documentation.

Approximate Processing Time: Six (6) hours

3.2 GENERATE WATERSHED BOUNDARY LINEWORK

This step generates the watershed boundary linework. For further information on linework generation see the *FWA-HOL Design 0.3.doc.*

Approximate Processing Time: 2.5 days on 20 processors (46 cpu days)

3.3 CLEAN AND FIX LINEWORK

The following collection of software applications prepares the generated watersheds for polygonization. At a high level, the linework is cleaned (that is, duplicate lines within some tolerance are removed), clipped to the BC border, and verified for correct topology.

3.3.1 Automatic Block Merging

This application attempts to automatically flag duplicate watershed lines that occur on TRIM mapsheet boundaries. Starting in the southwest and working towards the northeast, this process iterates through all 7027 mapsheets in BC identifying lines within a meter tolerance of each other.

Approximate Processing Time: Two (2) hours

3.3.2 Manual Block Merging

This application provides a tool in the JUMP (Java Unified Mapping Platform) editing environment that enables quick manual flagging of duplicate watershed edges that the automatic process could not resolve. Such situations are typically cases where duplicate or overlapping lines differ at endpoint locations. The last run of the automatic block merging process left about 520 issues that needed to be resolved.

Approximate Manual Time: Four (4) hours

3.3.3 Clip Watersheds at BC Border

This application automatically removes all watershed linework that lie completely outside of BC and further clips remaining linework to the BC border. A large exception that this program deals with is that no clipping is performed along the Rockies on the BC-Alberta border.

Approximate Processing Time: Two (2) hours

3.3.4 Node Watersheds to BC Border

This application automatically nodes FWA features to the clip locations identified in the previous "Clip Watersheds at BC Border" step. Care is taken to ensure references to clipped features in the FWA data model are updated appropriately. For example, the provincial border often acts as lake, river, wetland, or island banks where hydrographic features span into extra-jurisdictional areas.

Approximate Processing Time: Two (2) hours

3.3.5 Redefine BC-Alberta Border Along the Rockies

This task is the manual process of panning along the Rockies at the BC – Alberta border, manually flagging edges that should define the new BC border. Using the JUMP tool created for the manual merging process, this task can be resolved fairly quickly.

Approximate Manual Time: Two (2) hours

3.3.6 QA Watershed Topology

This application iterates over the entire province, ensuring correct watershed topology. Checks include:

- watershed lines are never shorter than 10^−5^ meters
- watershed lines only intersect at endpoints - ensuring lines are properly noded.
- watershed lines never cross hydrographic features.
- watershed lines never cross the BC Border (except along the Rockies)
- watershed lines are completely contained within BC
- dangling watershed lines never occur
- watershed lines never occur inside of rivers or lakes.

Approximate Processing Time: Four (4) hours

3.3.7 Manual Watershed Fix

This task is a manual step to fix any issues that arise during the QA process. Typically there are not any items that need addressing, except that the watershed generator does not currently remove all generated watersheds that occur inside of lakes or rivers (around 450 cases).

Approximate Manual Time: Two (2) hours

3.4 GENERATE UNIT POLYGONS

This step uses Java software to generate unit polygons for the entire province. As input the software takes the newly generated unit polygons, existing delimiter and administrative boundary edges, and drainage id information generated from the drainage id software. As output it creates unit polygons as well as a relationship between the polygons and edges that make up each polygon. The unit polygon processing is completed in three steps:

- Pre-Processing - a table is created in the database with all edges required to form polygons for each drainage id.

- Generation - unit polygons are generated for each drainage id

- Post-Processing – adding indexes and cleaning up database table

This software runs on a single processor.

A manual QA check was performed to ensure that all bank edges bound two unit polygons; all watershed boundary lines bound one unit polygons (exception is the BC-Alberta Rockies Border); all coast edges bound one unit polygon. Any issues were dealt with manually and the unit polygons were regenerated for the specific drainage id in error. Issues that arose from Version 1.2 processing include:

- One case in the province where a lake exists on an island in another lake. The pre-processing step of this software does not properly assign drainage ids to these lake bank edges. This was resolved manually for Version 1.2.

- A single case where a watershed boundary line was not properly noded to other watershed boundary lines.

- A single cases where the administrative boundary did not correctly node to the new watershed boundary lines.

- A few cases where watershed boundary lines were flagged incorrectly during the merging process.

- A few cases where the left and right drainage ids associated with the watershed boundary lines were incorrect.

- A single case where a watershed boundary line was missing (not generated by the watershed generator). This was dealt with by fixing the data error that caused the issue, reprocessing the block, and inserting the required edge.

Approximate Processing Time: Nine (9) hours
Approximate Manual Time (resolving issues): Two (2) hours

3.5 IDENTIFY INTERIOR HYDROGRAPHIC EDGES

This software identifies which stream network edges are contained within each unit polygon. This software is comprised of three steps:

- Pre-processing - This step is run once on a single processor. It sets up a block processing table to track processing status.

- Processing - This step computes what stream network edges are contained within each unit polygons. It is designed to run on block-by-block basis on multiple processors using the block processing table.

- Post-Processing - This step is run once on a single processor. This step cleans up the output table and creates required indexes.

No manual or automated QA checks are performed with this software.

Approximate Processing Time: Twelve (12) hours on 4 processors (2 cpu days)

3.6 COMPUTE ROUTES AND ISOLATED WATERSHEDS

This software assigns attributes to each unit polygons. The attributes computed (in order) include:

- waterbody id (wb_id) - the waterbody the unit polygon contains

- route id (route_id) - the route associated with the unit polygon

- isolated (is_iso) - if the unit polygon forms an isolated watershed

Outstanding Data Issue: Routes are assigned based on the edges contained within the unit polygon. Observed features are used first, then 1410s, and then non-isolated constructions lines, and then isolated construction lines. In many cases there are multiple non-isolated construction lines within a single unit polygon. This is a result of the drainage id requirements (see *Watershed Boundary Requirements* documentation). For Version 1.2 of processing the non-isolated construction line with the minimum route id was used.

Approximate Processing Time: Four (4) hours

3.7 QA

This step is designed to QA the Unit Polygons, Interior Hydrographic Edges, and Attribution Steps. The automated QA software checks the following:

- every coastline edge and coastline delimiter edge bounds exactly 1 unit polygon

- every non-coastline and non-watershed boundary lines that bounds a unit polygons bound exactly 2 unit polygons

- every watershed boundary line bounds exactly 2 unit polygons

- every bank edge and delimiter edge (except wetland bank edges) bounds some unit polygon

- every included watershed edge bounds some unit polygon
- each lake, river, and manmade waterbody is a unit polygon
- each lake, river, and manmade waterbody is associated with exactly 1 unit polygon
- every flow arc is contained within some unit polygon
- all non-wetland skeleton flow arcs are contained within exactly one unit polygon
- no unit polygons have area < 0.000001
- no unit polygons that are associated with a wb have a null route_id

Any errors that resulted from this QA are dealt with manually. For Version 1.2 of processing issues dealt with included:

- edges incorrectly flagged as included/not-included
- edges assigned incorrect drainage ids

Approximate Processing Time: One (1) hour (per run)
Approximate Manual Time (resolving issues): Two (2) hours

3.8 MERGE ISOLATED WATERSHEDS

This stage determines which non-isolated unit polygons the isolated unit polygons *drain* into. A combination of Java, Perl, C, and Terrain Server was used for processing.

There are three main steps in this software process:

- Pre-Processing (single processor) - Software (Java) process that generates and populates the required tables for the Processing step.
- Processing (multi-processor) - The processing software is a combination of Perl wrapper script and a C program that access a Terrain Server instance hosted at Refractions. Processing is done in groups of connected isolated watersheds. The results of the software is a list of edges that should be 'removed to merge the isolated watersheds with non-isolated watersheds.
- Post-Processing (single processor) - Software (Java) process that takes the output from the processing software and updates the required tables in our database.

Manual QA is performed to ensure that each group of connected unit polygons has been processed. In addition an automated QA is included in the post-processing to ensure that each isolated unit polygon has been processed.

For Version 1.2 processing various issues occurred surrounding the software. Generally these were resolved manually by providing slightly different input to the C isolated software program. However a few of these required further research that resulted in the manual determination of the results. This occurred in two cases where there were a large collection of connected isolated watersheds. The manual determination was made using a existing watershed boundary lines.

Software Issues: There are some bugs in the C processing software. For the purposes of this processing these were worked around (see above), however future use of this software may require further investigation of the bugs for it to work as expected.

Approximate Processing Time: Twelve (12) hours using 3 processors (1.5 cpu days)
Approximate Manual Time (resolving issues): Eight (8) hours

3.9 COMPUTE NON-ISOLATED ROUTES

This software uses the results of the Isolated Watershed Processing to compute a non-isolated route for each unit polygons.

Approximate Processing Time: Eight (8) hours

3.10 CLASSIFY PRINCIPAL/NON-PRINCIPAL LINES

This software takes each watershed boundary lines and classifies it as principal, isolated, or non-principal.

Approximate Processing Time: Twelve (12) hours

3.11 PARTIAL INTEGRATION

Partial integration processing includes the following steps:

- Updating the new watershed boundary lines that defined the BC-Alberta border along the rockies to administrative boundary edges.
- Converting all old watershed boundary lines that bounded wetland polygons to 1701 so wetland polygons can still be closed when the old watershed boundary lines are removed.
- Replacing the old watershed boundary lines with the new watershed boundary lines.
- Assigning a best-guess watershed group code to all watershed boundary lines. This done spatially by determining what old watershed group polygon the mid-point of the first segment of the watershed boundary line lied within.

Some of this processing was automated (assigning group codes to watershed boundary lines), other was done manually. All results were reviewed manually.

Approximate Processing Time: Eight (8) hours

3.12 BUILD OUTPUT LAYERS

3.12.1 Named Watersheds Polygons

This software generates a watershed polygon for each named stream. For each named stream it uses the hierarchical keys to determine what flows into that stream, and merges together all the unit polygons associated with these streams.

The output geometry type is a multi-polygon. Most named watersheds form a single polygon however for named streams whose mainstem or tributaries flow in and out of the province multiple polygons are generated, one for each part of the watershed that is inside BC.

Some manual QA was performed to verify the results look reasonable.

Approximate Processing Time: Four (4) hours

3.12.2 Principal Watershed Polygons

This software generates watershed polygons from all principal watershed boundary linework. This is similar to what was generated for the 1:50K.

Although most of this processing was automated some manual work was required to identify the watersheds lines required as input to break out large polygons at watershed group boundaries. By definition these watershed lines are non-principal thus not being provided as input; however because of the need to break out large rivers at watershed group boundaries these lines need to be included. Once a full integration has been completed and each feature has an accurate watershed group code this step can be automated.

As well there is one case in the province where a secondary flow has no associated primary flow or coastline; thus no principal polygon was built automatically for this area. A polygon was generated manually and added to the dataset with the route id of the secondary flow.

Watershed group codes are assigned to each principal polygon automatically by the software. This is done by assigning the watershed group associated with the route if the route is only associated with a single watershed group. For principal polygons with routes associated with multiple watershed groups a spatial overlay was done with the old watershed groups and the group with the largest intersecting area was associated.

Approximate Processing Time: Twenty (28) hours on 3 processors

Approximate Manual Time: Two (2) hours

4 WATERSHED BOUNDARY RELATED DEFINITIONS

blue line key (bl_key)

The route. A connected collection of stream edges for a route. For example the Fraser River has a bl_key (route), and each distinct side channel of the Fraser River has a distinct bl_key (route).

watershed key (ws_key)

An integer key used to identify a river. There is a 1:1 relationship between the ws_key and the watershed code (ws_code) for all non-isolated streams. For example the Fraser River and each of it's side channels have the same watershed key.

unit polygon

Unit polygons are generated by polygonizing all watershed boundary linework (principal and non-principal), all lake, river, manmade waterbody banks, coastline edges, delimiter edges and administrative boundaries. Wetland bank edges are not used to generate unit polygons.

isolated unit polygon

A unit polygon is considered isolated if has no connection to the stream network and has no observed flow arcs within the watershed.

isolated (dissolvable) edges

A watershed boundary line is flagged as isolated if it is part of as isolated unit polygon and the edge has been selected for dissolving inorder to merge the isolated watershed with a non-isolated watershed.

principal watershed boundary line

A watershed boundary line is principal if

it is not isolated

AND

the right face ws_key differs from the left face ws_key

non-principal watershed boundary line

A watershed boundary line is non-principal if

it is isolated

OR

the ws_key associated with the left unit polygons is the same as the ws_key associated with the right unit polygon

principal watershed polygon

Principal watershed polygons are polygons derived from all principal watershed boundary linework, coastline edges, delimiter edges and administrative boundaries. See the Build Output Layers – Principal Watershed Polygons step for description of the few exceptions to this definition for Version 1.2.