DELEGATION REQUEST

Name of person speaking: Dave Weaver

Organization you are representing: Beaufort Watershed Stewards

Primary purpose of the organization: To promote the health and resilience of local watersheds in the Beaufort Range & to ensure the quality & quantity of fresh water

Number of members: 30

Mailing address:
PO Box 253
Union Bay, BC V0R 3B0

Contact name: Dave Weaver Vice President

Subject matter: Title: Presentation of the key findings from the recently completed Beaufort Watershed Stewards 2021 Hydrological Health Report Card on Four Watersheds. This assessment project of four watersheds in the Fanny Bay area (within the CVRD) and its report results, shows potential issues with watershed health - specific to the elevated risk of high peak flows in the associated creeks. The assessment was performed by BWS volunteers and a retired professional forester. The implications to water quality and quantity within the Comox Valley is felt to be of interest to the CVRD board and we would be pleased as a community group to share those outcomes with your members.

Requested meeting date: Dec, 7, 2021

Audio-visual equipment needed: If by Zoom no equipment needed, if in person a projector to hook up to laptop

Beaufort Watershed Stewards - 2021

Hydrological Health Report Card on Four Watersheds

Nov. 4, 2021

by Dave Weaver - Retired Professional Forester
Vice President Beaufort Watershed Stewards

Statement of intent and disclaimer – The author of this report is a retired non-practicing professional forester and received no remuneration for preparing this report. The author is not a professional hydrologist and was not a practicing hydrologist during his paid working career. All of the findings and conclusions presented in this report are empirically based on the data and observations, relative to the papers, publications and guides cited in this report and are not a result of any interpretation of the data as a practicing forest hydrologist. In fact, the intent of this report is to coarsely identify watersheds that maybe trending in unhealthy directions and to therefore seek further qualified professional assessments.

Credits: All of the work performed for this report was completed by Beaufort Watershed Stewards (BWS) volunteers, and all photos and images were generated by the author.

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Obtain from: www.beaufortwater.org
Contact: vicepresident@beaufortwater.org

Land Acknowledgement: We respectfully acknowledge that the watersheds we depend on are on the unceded traditional territory of the K'ómoks, Pentlatch and Qualicum First Nations, the traditional keepers of this land

Table of Contents:

1.0 Executive Summary

Background: The 2021 Beaufort Watershed Stewards (BWS) Hydrological Health Report Card project was initiated in response to the 2020 BC Forest Practices Board's watershed report (5). In this report they found that sediment from forest harvesting roads presented a high risk to fish habitat in 3 of the 5 watersheds that they assessed. Only 3 of the 5 watersheds had an Equivalent Clearcut Area percentage (ECA%) determined. Therefore, the Board recommended an ECA% review process as a good first step in assessing overall watershed health and specific vulnerabilities to extreme peak flow changes. In addition, BWS stream sampling data obtained during recent peak flow runoff events (>10 mm rain per day), found very high turbidity in several streams, prompting BWS to conduct this Hydrological Health Report Card project, that included ECA%.

Methods: Four watersheds were assessed in this project: Mud Bay Creek, Waterloo Creek, Wilfred Creek, and Cowie Creek. To optimize the field opportunity data were obtained on *five quantifiable metrics*: ECA%, Total Area Harvested, Road Density, Number of Stream Crossings, Total Number of Landslides, and *two qualitative observations:* Riparian Protection, and Road Maintenance and Practices. The primary measurement ECA%, is a methodology that has been used in the USA since 1974 and in BC extensively since 1995. ECA% is basically a "snapshot in time" of the percent of the watershed area still in a "clearcut state". Clearcut state is defined as all disturbed, denuded, and clearcut harvested forest areas, that have had the vegetation cover removed and the resultant regenerating vegetation has not yet achieved "*hydrological recovery"*. Hydrological recovery is defined as achieving an ability to intercept precipitation to the same rate prior to the disturbance – this is usually a certain height and crown closure of regenerated plantations in managed forests (2,7).

Results: The findings were compiled to produce a ***Hydrological Watershed Health Report Card***:

Mud Bay Creek	Waterloo Creek	Wilfred Creek	Cowie Creek
B+	B-	C-	D

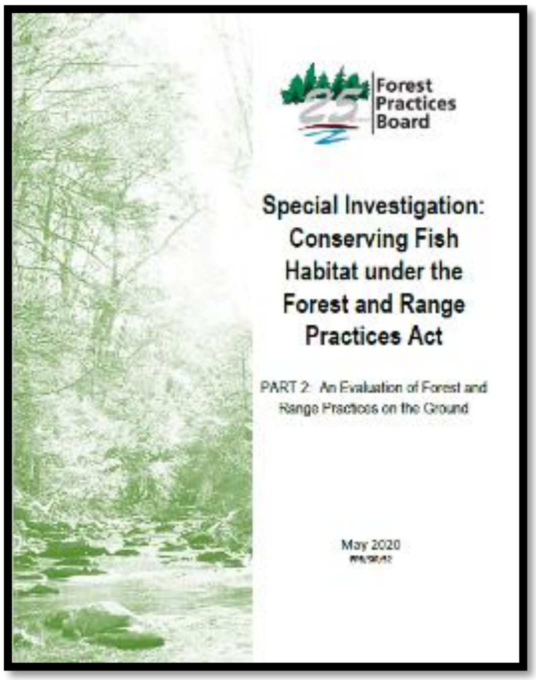
The value for each letter grade has the following descriptions:
A – excellent; **B** – good; **C** – satisfactory; **D** – unsatisfactory; **F** – failure

Recommendations: Based on these findings, the next steps recommended for BWS are:

1. *Cowie Creek (lowest rating of D) - more study is required*: Data on the natural substrate stream bank material is required. This will aid in determining the potential contribution of natural stream banks versus the potential of road development contribution to higher documented sediment and turbidity values in Cowie Creek.
2. *Institute a water quantity monitoring program*: To document fluctuations above normal peak flow levels, the quantity of water discharged per watershed needs to be monitored as well. BWS volunteers are well on their way in completing water quantity measurement infrastructure in 2021.
3. *Plan and perform Hydrological Health Report Cards on other watersheds*: Due to the significant initial findings of this study, it is recommended BWS assess neighbouring watersheds that are currently showing higher sediment levels in their measurements.
4. *Advocate for reform of the Private Managed Forest Land Act (PMFLA) to control rates of harvest:* The elevated levels of harvesting on the private land portions of the watersheds documented in this study, has raised concern for the potential impact on watershed health. It is recommended that BWS engage with the local licensees to review their process for determining the rates of harvest.

2.0 General Outline of Project

This project was conceived primarily due to the implications and impacts resulting from the recent 2020 BC Forest Practices Board (FPB) watershed report (5). Within this report, 5 randomly selected watersheds province wide were assessed, and they found sediment from forest harvesting roads presented a high risk to fish habitat in 3 of the 5 watersheds assessed. Notably, only 3 of the 5 watersheds had an Equivalent Clearcut Area percent (ECA%) determined previously and the report recommended an ECA% review as a first step in assessing watershed health and vulnerabilities to extreme peak flow changes.



The full report can be found at:
https://www.bcfpb.ca/wp-content/uploads/2020/05/SIR52-Fish-Habitat-Conservation-Part2.pdf

In addition to these key findings by the FPB, the Beaufort Watershed Stewards (BWS) stream sampling data from fall 2020 found high sediment/turbidity levels during peak flow runoff events, which raised the following questions:

1) *Does this high turbidity infiltrate our local water supply?*
2) *Are these high turbidity events caused naturally by stream bank substrates? or*
3) *By poor harvesting road design? and/or*
4) *By high watershed harvest rates?*

Question 1 was addressed by reviewing data from the Ships Point Improvement District (SPID) community aquifer wells. Vancouver Island Health Authority samples SPID wells monthly for turbidity levels using the same turbidity metric that BWS uses for stream samples. SPID wells never exceeded 1 Nephelometric Turbidity Units **(**NTU) of turbidity—a metric for sediment and a threshold for a boil water advisory. Whereas BWS field stream samples have exceeded 6 NTU in the past 2 years. To date, elevated stream turbidity has not infiltrated into SPID water supply.

Question 2 may be answered through an Aquifer Mapping project proposed by BWS. During data collection for this Aquifer project, exposed stream substrates and field data around streams will be documented and interpreted by qualified geomorphologists and/or geo-scientists.

Question 3 requires the expertise of a forest road engineer or hydrologist, to conduct field assessments of road design and their effects on sediment run off. Due to potential high cost, this project would be more applicable in the future, possibly targeting high risk watersheds resulting from the ECA data and other observed metrics tabled in this report.

Question 4 is addressed with some of the data outcomes in this report. Watershed harvest rate impacts are fairly inexpensive to assess using the Equivalent Clearcut Area (ECA) method to rank the general hydrological health for BWS Watersheds. During field assessments, it was evident that other metrics recommended by the BC Government watershed assessment procedures, could be observed and quantified using Google Earth measurement techniques. Therefore, the scope of this project was expanded to produce a "Watershed Hydrological Report Card" for the 4 watersheds assessed in this project. The report card addresses 5 quantitative metrics: ECA%, Total Area Harvested, Road Density, Number of Stream Crossings, Total Number of Landslides, and 2 qualitative observations based on observations: Riparian Protection and Road Maintenance and Practices.

3.0 Timeline and Volunteer Hours

The following are the actual timelines per methodology for this report and the volunteer hours accrued.
Winter 2020-21 – Mapping of Watersheds and Identifying Disturbance Units per Watershed (all Google Earth Pro exercises). Total volunteer hours - 67 hours.
Spring 2021 – Field reconnaissance of specific Disturbance Units and metrics within each watershed. Total volunteer hours - 33 hours of field reconnaissance.
Fall 2021 – Final Report on hydrologic health report card per watershed. Total volunteer hours - 45 hours.

4.0 Scope

Four watersheds within the sampling area of the BWS were chosen for this study: Mud Bay Creek, Waterloo Creek, Wilfred Creek, and Cowie Creek.

Figure 1 below is an oblique Google Earth image showing all four watersheds located on the east side of the Beaufort Range peaks. The caption explains boundaries and public/private land ownership.
It is important to note that the Mud Bay Creek watershed is less that 500 ha in size. This is technically too small of a drainage area to perform a meaningful ECA assessment hydrologically (as recommended in the BC Coastal Watershed Assessment Procedure Guidebook (2)). Therefore, the Mud Bay Creek assessment data in this report are only for comparative value and not absolute value. The Report Card scores for Mud Bay Creek are also only presented for comparative reasons.

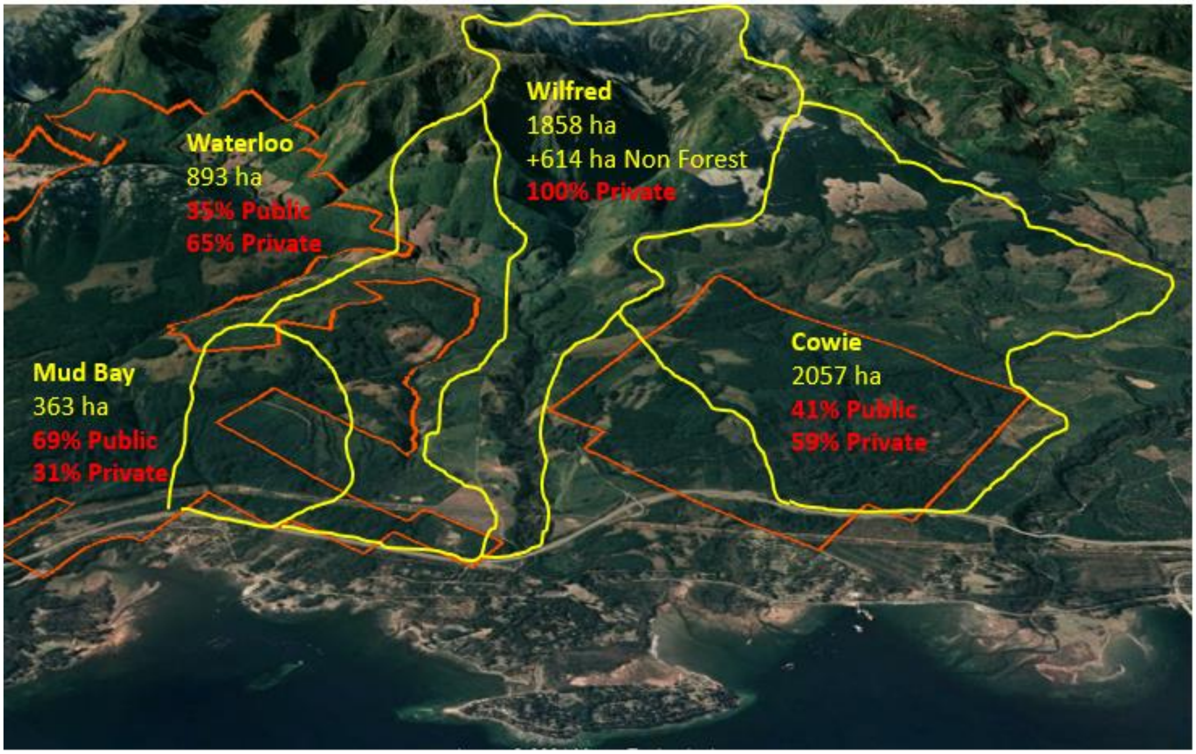


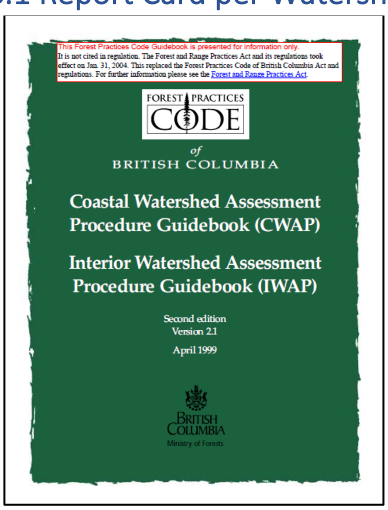
Figure 1: Oblique 2020 Google Earth image of the 4 studied watersheds (Watershed boundaries and areas are in yellow; public land boundary is in **orange**; percent public and private land are in red).

5.0 Costs

There were no accrued costs to BWS for this project. Google Earth Pro Free software provided all of the 2020 imagery, mapping and area calculations to the project manager.
All of the labour in mapping, field work and final report writing and editing was performed by the BWS project manager and other BWS volunteers.

6.0 Data Collection Methodology per Watershed

6.1 Report Card per Watershed Concept



As described in the project outline section, the Watershed Health Report Card approach was embraced for this project, using the guidance provided for metrics outlined in the BC Coastal Watershed Assessment Procedure Guidebook, 2001 (2).

Seven of the 9 basic metrics described in the guidebook were achievable in this project:

<u>Quantitative:</u>

1. Equivalent Clearcut Area percent (ECA%)
2. Total Area Harvested
3. Road Density (km/km^2)
4. Number of Stream Crossings
5. Total Number of Landslides

<u>Qualitative Observations</u>

1. Riparian Protection
2. Road Maintenance and Practices

6.2 Equivalent Clearcut Area (ECA) Methodology

6.2.1 Description

The ECA methodology has been used in the USA since 1974, and in BC extensively since 1995. ECA provides a "relative impression" of the condition of watersheds. However, the use of the ECA method has not been legally required in any watersheds in BC since 2003. It is still considered a best practice to use ECA as a general indication of watershed health relative to changes in peak flows (2). But most literature (2, 3, 4, 5, 9) recommends the use of ECA in conjunction with other watershed measurements to assess total watershed health, and most reports recommend ECA as an effective and inexpensive screening tool to identify watersheds that may be at risk.

6.2.2 Definitions

<u>Equivalent Clearcut Area (ECA)</u> is basically a "*snap shot in time*" (specific to an assessment date) of the:

- Percentage of the Watershed Area still in a "*clearcut state*";
- Significant changes to *"peak flow"* run offs (or watersheds with high risk of elevated peak flows) have been suggested for the following ECA thresholds (Winkler 2017, BC Government (9)):
    - > 20% ECA in designated community watersheds;
    - > 25% ECA in fisheries sensitive watersheds; and
    - > 30% ECA in all other watersheds.

<u>Clearcut State</u> is defined as:

- All disturbed, denuded, and clearcut harvested forest areas, that have had the vegetation cover removed and the resultant regenerating vegetation has not yet achieved "*hydrological recovery*". Hydrological recovery is defined as achieving an ability to intercept precipitation to the same rate prior to the disturbance – this is usually a certain height and crown closure of regenerated plantations in managed forests (2,7).

<u>Peak Flow</u> is defined as:

- The maximum flow rate that occurs within a specified period of time. It usually occurs on an event basis, primarily fall flush or spring melt.

6.2.3 ECA Methodology

The following ECA methodology (2) steps were performed for this project, based on disturbances observed per watershed up to April 1, 2021:

1. Exact Watershed boundaries and areas were defined:
   - Using Topographic Maps, Google Earth Pro and Project Watershed Maps, heights of land between watersheds were located and entire watersheds accurately mapped;
   - Area in hectares for each watershed were calculated, using Google Earth Pro polygon calculator.
2. All disturbances and clearcuts in each watershed were determined and classed to a hydrological recovery factor by:
   - Using recent imagery from Google Earth Pro, identified all the Disturbance Units (DU) per watershed, and labelled and numbered them consecutively per watershed;
   - Each DU was determined if it was either:
     a. Still in a clearcut state as visible from the imagery and therefore given a *hydrological recovery factor* of 1, *or*
     b. Required a field assessment to determine the state of *clearcut equivalency* (basically assessing the vegetation/tree height and then assigning a *hydrological recovery factor),* using the factor tables per tree height assessed in the field*,* as outlined below:
        - The Coastal Watershed Assessment Guidebook 1999 (2), recommends the separation of ECA units in a watershed into 3 elevation precipitation zones for the east side of Vancouver Island – the *rain zone* from 0 to 300 meters elevation; the *transition zone* of mixed precipitation from >300 to 800 meters elevation; and the *snow zone* >800 meters elevation. For the purposes of this project, the two lower elevation zones were combined, as recommended by Brayshaw (3) and Hudson (6). The figure below shows the table used in this project for determining *hydrological recovery factors* in these two lower elevation zone DUs assessed.

Average Height Regeneration	Recovery Factor Rain & Transition Zones
0 - < 3 m	1
3 - < 5 m	0.75
5 - < 7m	0.5
7 - < 9 m	0.25
≥ 9 m	0.1

Figure 2: *Hydrological Recovery Factor* table relative to regeneration height, used in this project for the rain and transition precipitation zones (originating from the criteria listed in the Coastal Watershed Assessment Guidebook - 2001 (2)).

- For the higher elevation snow zone DUs above 800 meters, a translation of the graph of results produced by Hudson (6) was used, rather than just using the factors listed in Figure 2 above. It was felt by the author and in conversation with other groups currently attempting to calculate ECA (specifically the Comox Valley Regional District - CVRD), that this translation graph would better addresses the snow melt conditions locally on the coast, using the most current science available. Below is that original graph (Figure 3) of Hudson's research findings (page 6, figure 7 graph in Hudson's paper). Therefore Figure 4 below, is the author's translated table used for determining *hydrological recovery factors* for the higher *snow zone* DUs assessed in this project.

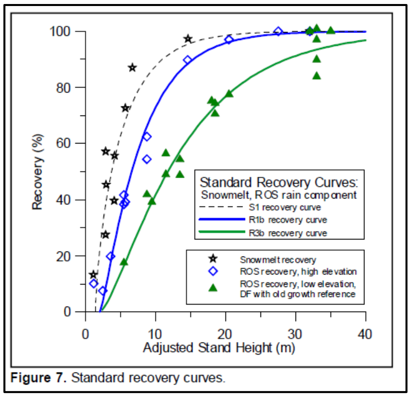


Figure 3: From Hudson 2007 (6), "Standard Recovery Curves" describing snow melt recovery under average conditions on Vancouver Island.

Average Height Regeneration	Recovery Factor Snow Zone
0 - < 3 m	1.2
3 - < 5 m	1
5 - < 7m	0.6
7 - < 9 m	0.4
9 - < 12 m	0.25
≥ 12 m	0.1

Figure 4: Translated from Hudson above (Figure 3), the *Hydrological Recovery Factor* table relative to regeneration height, used for this project for DUs in the *snow zone*.

3. The ECA % of each Watershed was calculated using the cumulative DU ECA areas in hectares, divided by the total productive area of the watershed (2).
4. The final *Hydrological Hazard Rating* categories were determined for each of the 4 watersheds, by using the ECA range thresholds – found in the Powell River Community Forest Watershed Assessment 2020 (3). This was the most applicable (BC Coast) and current (2020), hazard rating found in the literature.

ECA Range (percent of total watershed)	Hydrologic Hazard	Qualitative Interpretation
0% to 15%	Very low	Detectable **changes to peak, mean & low flow will not occur.**
15% to 20%	Very low to low	
20% to 25%	Low	Detectable **changes to peak or flow are unlikely to occur.** Small variations might be detectable using statistical analysis.
25% to 30%	Low to moderate	
30% to 35%	Moderate	Detectable **changes to peak flow might occur** for some flow magnitudes and return periods. Flow durations might be altered.
35% to 40%	Moderate to high	
40% to 45%	High	Detectable **changes to peak flow frequency and magnitude will occur.** Floods will become larger and more frequent. Low flows might increase or decrease. Mean annual flow might change.
45% to 50%	High to very high	
50% or higher	Very high	**Watershed hydrology will be significantly changed**. Peak flow frequency and magnitude will undergo large changes. Floods will be much larger and much more frequent. Low flow and mean annual flow frequency and duration will change.

Figure 5: Hydrologic Hazard by ECA % - from Powell River Community Forest Watershed Assessment 2020 (3), used for this project.

6.3 Total Area Harvested

All watersheds had already been harvested and their primary growth completely removed (except for a few narrow steep gullies) via extensive clearcuts in the 1930s and 1940s.
Therefore, the percent of harvesting value per watershed was calculated by dividing the area of second growth harvested since the 1940s, up to April 2021, by the total productive forest area for each watershed. *Productive forest* is defined as the total watershed area minus non-productive areas such as: large mappable rock outcrops, large contiguous wetlands and lakes, sub-alpine forests, alpine and snow / ice fields.

All of these areas were determined and calculated using Google Earth Pro and verified in the field. However, no credible source was available in the literature, to demonstrate what threshold level of harvest rate would be acceptable or unacceptable for BC coastal harvesting practices.

6.4 Road Density

Existing forest road networks for each watershed were identified and their length measured using the tools available in Google Earth Pro.
The total length in kilometres of forest road per watershed was tallied and divided by the total productive area for each watershed and a metric of km/km^2 value was produced.

This value was compared to the threshold values found in a publication from Alberta for acceptable levels of forest road density $_{(1)}$. The author notes this is not the best reference threshold to use for BC, however no other reference table could be sourced in the literature.

Road density in Km /Km2	Rating
≤ 2	Good
2 – 3	Fair
> 3	Poor

Figure 6: Road Density Thresholds used in this report – from the Guide to Reporting on Common Indicators Used in State of the Watershed Reports - Alberta 2012 $_{(1)}$

6.5 Number of Stream Crossings

While assessing DUs tree heights in the field, the number of creek crossing were tallied and located on the DU maps per watershed. Only the 4 main creeks per watershed and their direct tributaries were assessed. No road ditch culverts intended to move primarily road surface runoff, were included in this tally. The tally included the following 5 categories of crossings: bridges; deactivated bridge sites; single culverts; multiple side by side culverts; and deactivated culvert sites. Several higher elevation crossings were not accessible during field work and had to be interpolated from current Google Earth images and verified as best as possible from remote binocular viewing.

6.6 Total Number of Landslides

All 4 of the watersheds assessed were interpolated using Google Earth Pro images to locate and tally all natural and unnatural slides and soil exposure events that were identifiable. All tallied disturbances were field verified with photos and are presented in the results section.

6.7 Qualitative Observations

6.7.1 Riparian Protection

General observations were made regarding riparian protection measures practiced in each watershed. The authors familiarity with the BC Acts that govern riparian protection (required standards for public land within the Forest Range and Practices Act [FRPA] and for private forest land within the Private Managed Forest land Act [PMFLA]), guided the context for the practices observed and the comments tabled.

These observational comments are listed by land ownership (public and private) in the results section.

6.7.2 Road Maintenance and Practices

As well, general observations were made regarding road maintenance, grading practices, surface upkeep and any practice that appeared noteworthy. Observations were made relative to the highlighted positive and potentially negative practices presented in the FPB report on road sedimentation (5).

These observational comments are listed by land ownership (public and private) in the results section.

7.0 Results

7.1 Product Examples

All of the Disturbance Unit Maps produced for each Watershed assessed, and are posted in **Appendix 11.1**:

List of Disturbance Unit Maps:

- 1 Map for Mud Bay Creek
- 2 Maps for Waterloo Creek
- 4 Maps for Wilfred Creek
- 4 Maps for Cowie Creek

All of the Report Card Health Quantitative data metrics are contained on Excel Spreadsheets produced for each Watershed assessed, and are posted in **Appendix 11.2**:

List of ECA per Zone Percentages:

- 1 Total Spreadsheet for Mud Bay Creek
- 3 Spreadsheets for Waterloo Creek (Rain Zone, Transition and Snow Zone, and Total)
- 3 Spreadsheets for Wilfred Creek (Rain Zone, Transition and Snow Zone, and Total)
- 4 Spreadsheets for Cowie Creek (2 Rain Zone, Transition and Snow Zone and Total)

List of Road Density and Crossings Tallies per Watershed:

- 1 Spreadsheet per Watershed

7.1.1 Example Map

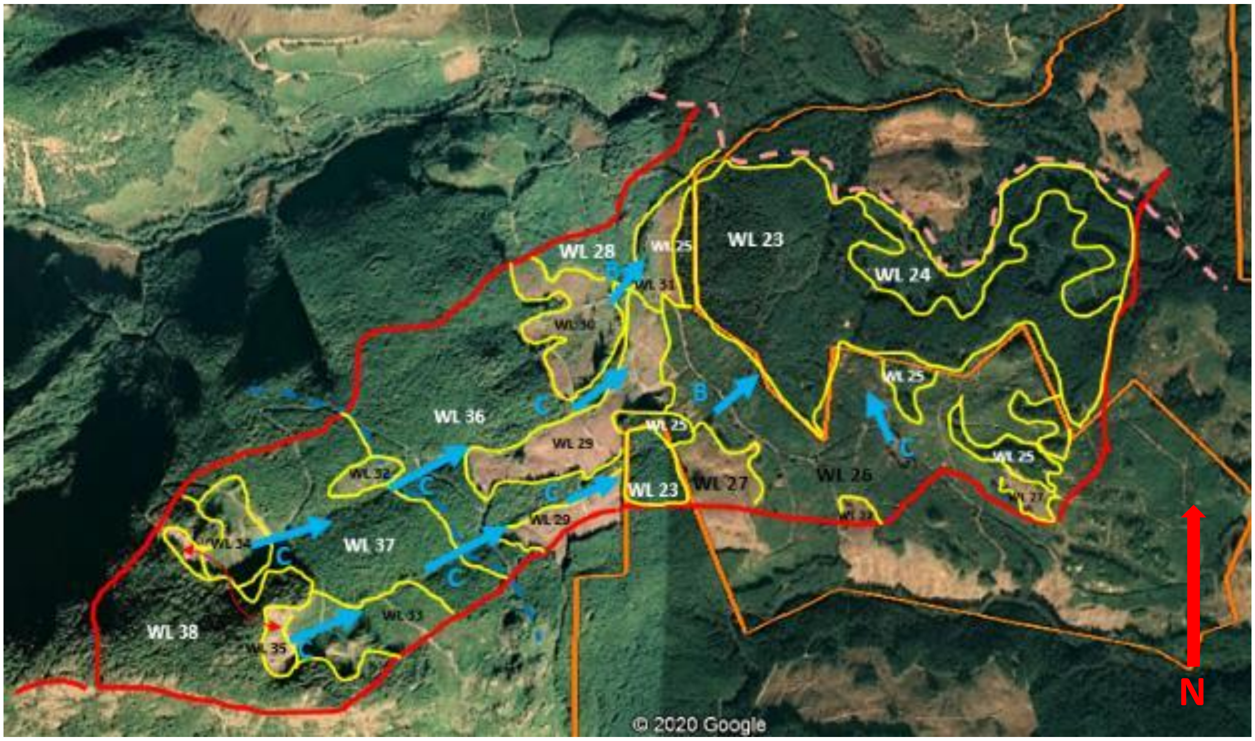


Figure 7: Waterloo Creek Disturbance Unit Map Transition and Snow Zone – Example Map

DU MAP LEGEND

Boundaries		
	Watershed	
	Ownership	
	Transition Zone	
	Snow Zone	
	Disturbance Unit	
Titles	DU Identification	**WL 29**
	Stream Crossing	B
	B- Bridge; C - Culvert	

7.1.2 Example Data Package

ECA per Zone per Watershed

BWS Watershed ECA Calculations				**2021**									
Waterloo	Trans &	Snow	(WL)				Ave Ht regen	Recovery Factor	Recovery Factor	Snow		ECA % for Watershed	
							0 - < 3 m	1	1.2	0 - < 3 m			29.50743
							3 - < 5m	0.75	1	3 - < 5m			
				Crown(C)	Private(P)	Private(P)	5 - < 7 m	0.5	0.6	5 - < 7 m			
	Watershed	Total Area	538	141	280	117	7 - < 9 m	0.25	0.4	7 - < 9 m			
	(For Mgmt area to hwy 19)						9 + m	0.1	0.25	9 -< 12m			
									0.1	12+ m			
				Elev Zone (Ha)					Adj Ha / Zone				
MB DU#		Descript		Trans	Snow		Regen Ht	R Factor	Trans		Snow		
C	P												
WL 23		CC 2nd Gr		109			>9	0.1	10.9				
WL 24		CC Part U		32			8	0.25	8				
	WL 25	CC		15.4			>9	0.1	1.54				
	WL 26	CC		76			6	0.5	38				
	WL 27	CC		17.3			<3	1	17.3				
	WL 28	CC		15.4			8	0.25	3.85				
	WL 29	CC		27.9			<3	1	27.9				
	WL 30	CC		14.6			4	0.75	10.95				
	WL 31	CC		6.5			5	0.5	3.25				
	WL 32	CC			2.6		5	0.6			1.56		
	WL 33	CC			14.9		5	0.6			8.94		
	WL 34	CC			6.4		4	1			6.4		
	WL 35	CC			4.2		<3	1.2			5.04		
	WL 36	CC 2nd Gr		106.9			>9	0.1	10.69				
	WL 37	CC 2nd Gr			44.3		>12	0.1			4.43		
	WL 38	OG			44.6		>9 OG	0			0		
			0	421	117				132.38	0	26.37	158.75	FINAL ECA Ha's

Figure 8: Waterloo Transition and Snow Zone Spreadsheet

Road Density and Crossings Tallies per Watershed

Waterloo Watershed								
Road Tallies								
Crown		**Main Roads**		**Secondary (spurs - recent and active)**	**Tertiary (inactive , partly grown over, still passable)**	**Watershed Creek Crossing**		**Crossing Comments**
		Name	**Length(Km)**	**Length(Km)**	**Length(Km)**	**Crossing #**		
		Rosewall FSR	0.3	0.8	0.6			
				0.6				
				1.2				*one bridge on FSR*
				1.7				*but outside sample*
	Totals		**0.3 Km**	**4.3 Km**	**0.6 Km**	**0 Crossings**		
Crown Grand Total			**5.2 Km**					
		Crn Watershed Area	**3.11 Km2**					
		Ratio	1.67 **Km of Road per Km2**					
Private		**Main Roads**		**Secondary (spurs - recent and active)**	**Tertiary (inactive , partly grown over, still passable)**	**Watershed Creek Crossing**		**Crossing Comments**
		Name	**Length(Km)**	**Length(Km)**	**Length(Km)**	**Crossing #**		
		Hasting Main	0.8	1.1	0.4	1	North WL Fork	Bridge Good shape
		Rosewall FSR	1	0.7	0.5	1	South WL Fork	Bridge Good shape
		Hastings S Branch	2.4	0.8	0.3	3	North WL Fork	Culvert
				1	0.3	4	South WL Fork	Culvert
				1.2	0.3			
				2				
				0.7				
				1.5				
				1				
				1.2				
				1.2				
				0.2				
	Totals		**4.2 Km**	**12.6 Km**	**1.8 Km**	**9 Crossings**		
Private Grand Total			**18.6 Km**					
		Priv Watershed Area	5.86 **Km2**					
		Ratio	3.17 **Km of Road per Km2**					
Waterloo Watershed Grand Total			23.8 **Km**			9 **Crossings**		
		Watershed Area	8.98 **Km2**					
		Ratio	2.65 **Km of Road per Km2**					
Background Data								
		Crown(C)	Private(P)					
Area Ha.	898	311.8	586.2					

Road Density Thresholds – Alberta 2012

Road density in Km /Km2	Rating
≤ 2	Good
2 – 3	Fair
> 3	Poor

Figure 9: Waterloo Road Densities and Crossing Tally Spreadsheet

7.2 Data Summaries

7.2.1 Summary Table of Quantitative Metrics of Watershed Hydrologic Health

The following is a Summary Table listing all of the Watershed Health quantitative metrics resulting from this study, separated by ownership.

Watershed Assessed April 2021	Watershed Total Area (Hectares)	Total Area Harvested (%)	ECA (%)	Road Density (km/km^{2})	No. of Creek Crossings	No. of Land Slides **
Mud Bay	366 ha	24%	21%	2.07	2	0
% public	69%		20%	1.8	2	
% private	31%		23%	2.7	0	
Waterloo	893 ha	45%	28%	2.65	9	0
% public	35%		22%	1.7	0	
% private	65%		**32%**	**3.7**	9	
Wilfred	1858 ha	37%	30%	2.5	21	**3**
% public	0%		0%	0	0	
% private	100%		30%	2.5	21	
Cowie	2057 ha	**49%**	**31%**	3.4	**29**	0
% public	41%		14%	1.4	3	
% private	59%		**43%**	**4.8**	26	

Table 1: Quantitative Metrics of Hydrological Health per Watershed assessed up to April 1, 2021. Bold and highlighted in **red** are values with moderate or high health risk. Values in bold **orange**, are the highest values quantified in this assessment.

**The following are photos of natural landslides – two identified outside productive forest land in rock bluff terrain and one newer one (circa 2017) above a constructed road in productive forest.
Several other slide disturbances were observed on satellite images, but these appear to be avalanche tracks at a very high elevation on steep subalpine slopes. This tree cover removal and resultant exposed parent materials appear more likely due to snow avalanches.

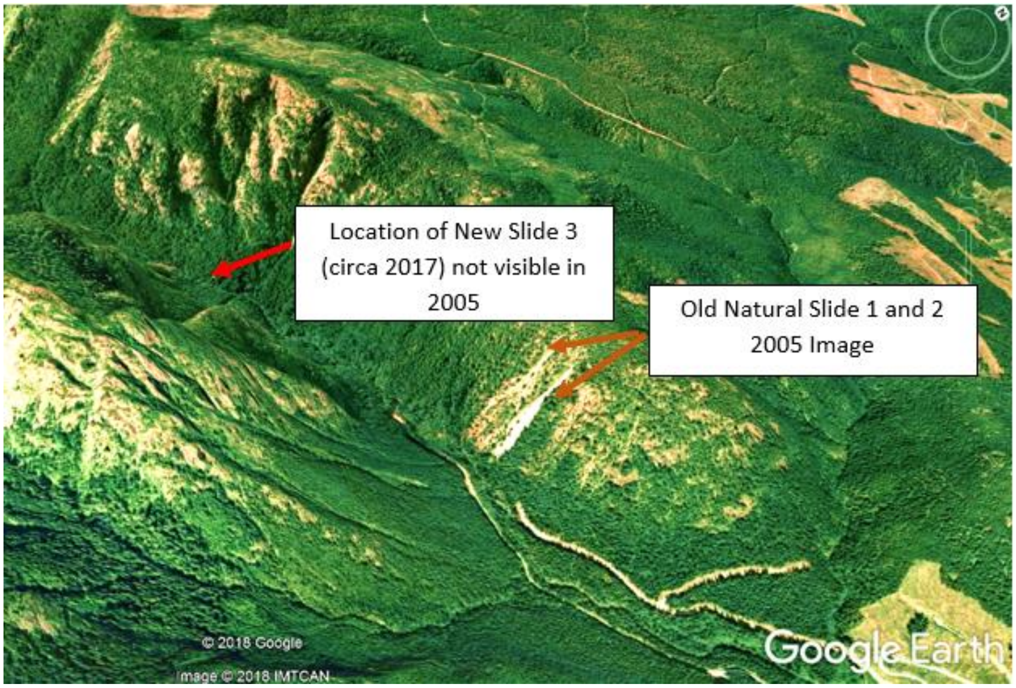


Photo 1: Location of slides from Google Earth Image about 2005.

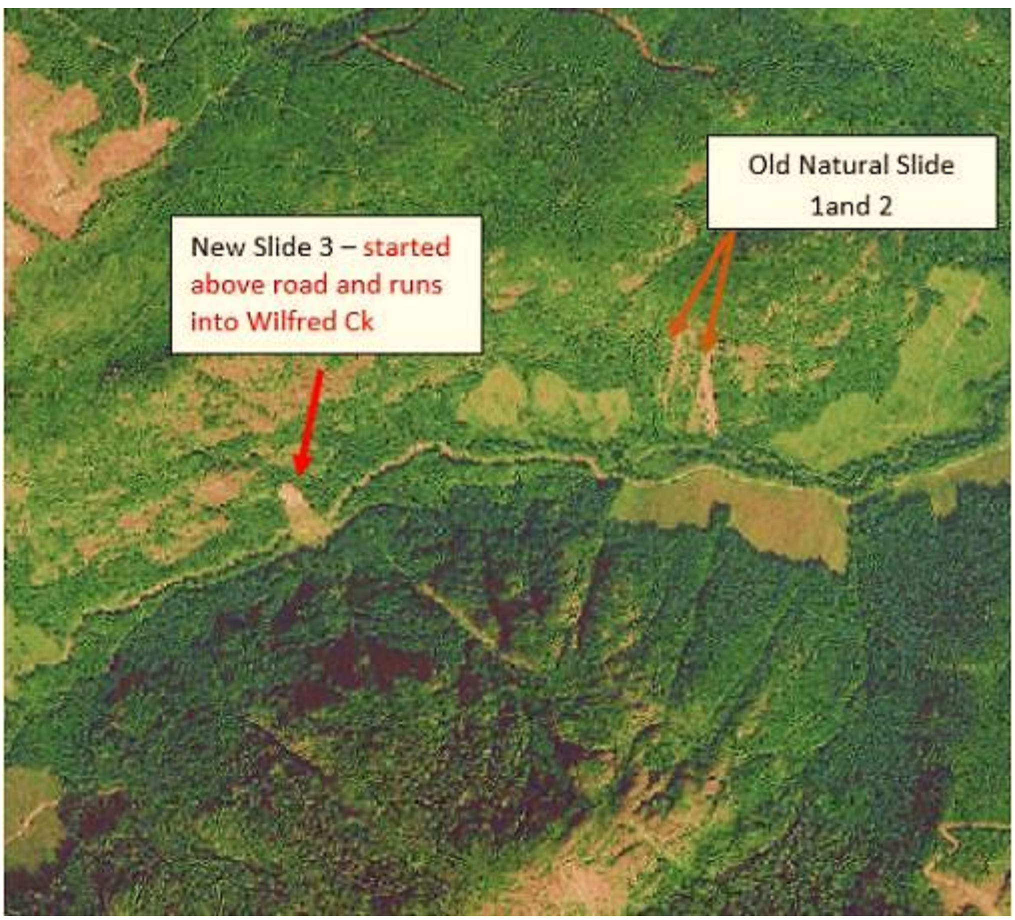


Photo 2: Location of slides from Landsat Image Sept 2017

Photo 3: Older natural slides 1 and 2 (slide 2 is behind the tree cover to the left)**.**

Photo 4: Newer slide 3 (circa 2017) which has its headwall above the road, and the slide was observed to have crossed Wilfred Creek during the failure event.

7.2.2 Summary of Qualitative Observations

7.2.2.1 Riparian Protection

- Generally, all of the riparian protection observed in all harvested blocks on public and private land appeared to comply with FRPA and PMFLA, respectively.
- Notably it appeared that on the private land areas, primary creek channel protection exceeded the legislative requirements - with at times very large gullies being well protected with very wide intact unlogged buffers (see Photo 5 below).
- Minor cases of harvesting within the riparian protection zone were observed on 2 occasions on private land, but these appeared to be isolated incidents. Under the PMFLA, some removal of specific trees is permitted under that Act (see Photo 6 below).

Photo 5: Example of adequate Riparian protection.

Photo 6: Example of harvesting within Riparian protection, with cut stumps circled in red.

7.2.2.2 Road Maintenance and Practices

- In field observations there was a consistent clear difference between public road maintenance and private road maintenance.
- Private roads were much better maintained – relative to the following aspects of good road maintenance and were designed to minimize sedimentation (relative to points outlined by the FPB report (5) and within the FPB webinar presentation by D. Tripp 2020).

Road Aspects Observed	Private Forest Roads	Public Forest Roads
Road grade condition	• All active roads well graded. • Good crown on road to drain runoff.	• Only recent harvested block roads graded, many roads heavily potholed. • Poor crown development on current and old roads.
Road side sediment run off measures	• Long steep stretches of active roads all had side *diversions drains* regularly graded into the side cast (see Photo 7 below)	• Very few if not any observed *diversions drains* graded into the side cast.
Road deactivation after use	• Majority of inactive roads were deactivated well. • One bridge removal on Cowie Creek appeared to expose high amounts of side cast soil which could contribute to sediment runoff (see Photo 8 below).	• Majority of inactive roads were deactivated well.

Table 2: Road maintenance and practices observations per land ownership.

Photo 7: Example of good road maintenance practice in making *diversions drains* graded into the side cast, on private roads – Hastings Main.

Photo 8: Cowie Creek deactivated bridge site with exposed side banks.

8.0 Data Outcomes

8.1 Graphic Comparisons of the Assessment Results

The following are graphic comparisons of quantitative metrics tallied for this project, as presented above in tabular form in section ***7.2.1 Summary Table.***

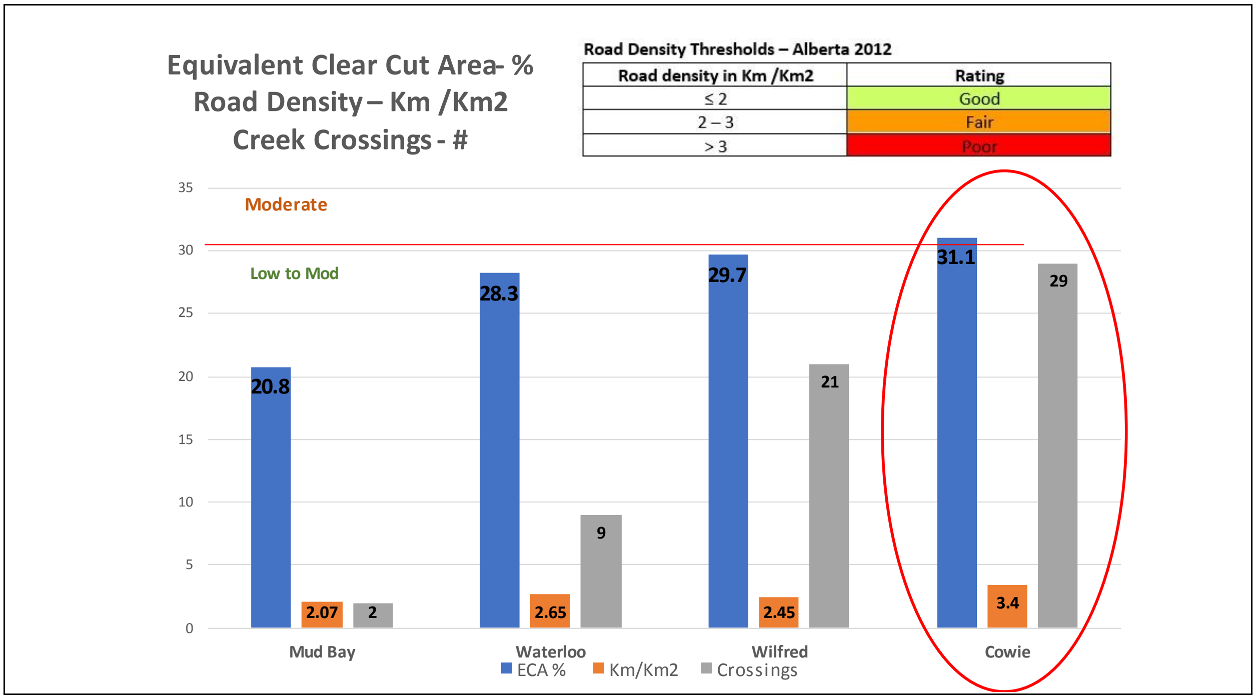


Figure 10: ECA %, Road Density, number of Road Crossings per Watershed

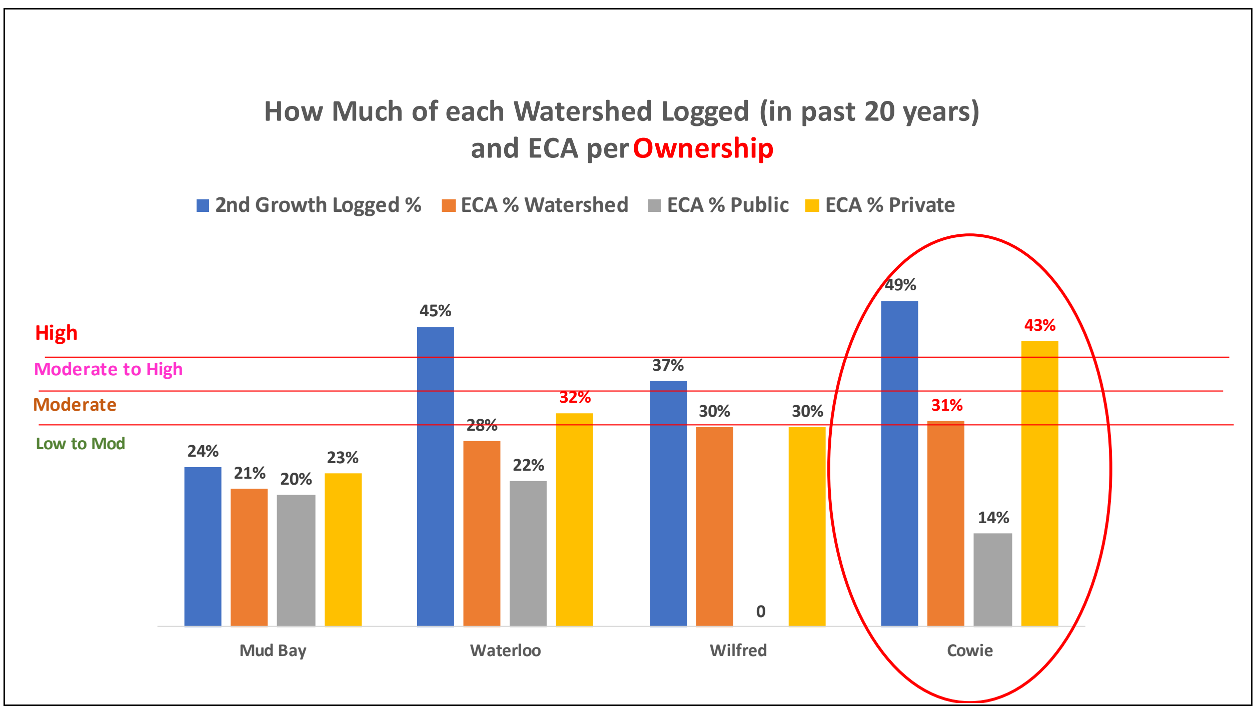


Figure 11: Amount each watershed that has been logged in the past 20 years and ECA% per ownership per watershed.

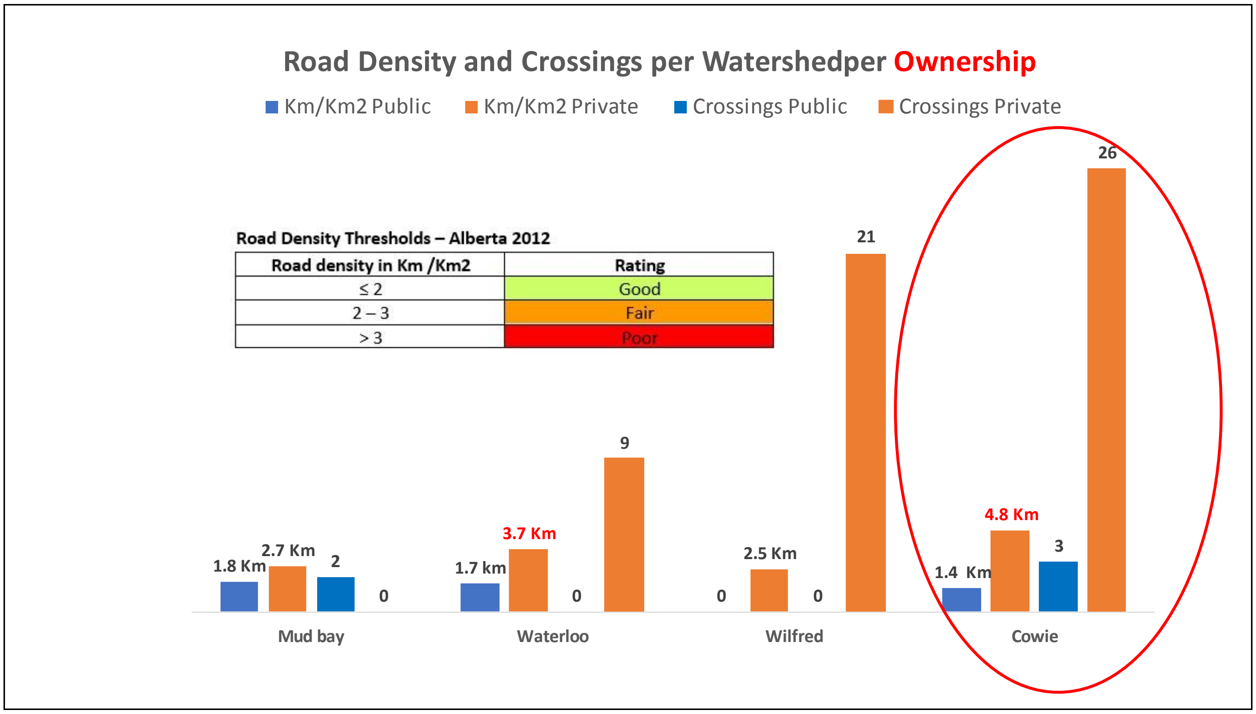


Figure 12: Road density and number of road crossings per watershed per land ownership.

Overall, two trends are evident from these Figure graphics:

1. **Risk ratings vary according to land ownership.** Most private land metrics had greater risk ratings than public lands. Land ownership was the most predictive metric. This difference may be due to FRPA and PMFLA having very different requirements/restrictions for rate of harvest.
2. **Cowie Creek watershed had the highest risk for elevated peak flows**. This is primarily due to ECA% levels being in the moderate to high-risk category, and higher road densities in the poor rating.

The last Figure below documents BWS's watershed water quality measurements, specifically turbidity during elevated rain events for the past 3 years, in each watershed. The graph illustrates that the Cowie Creek watershed has shown the highest turbidity during these events – well above thresholds for human water quality and fish egg survival thresholds.

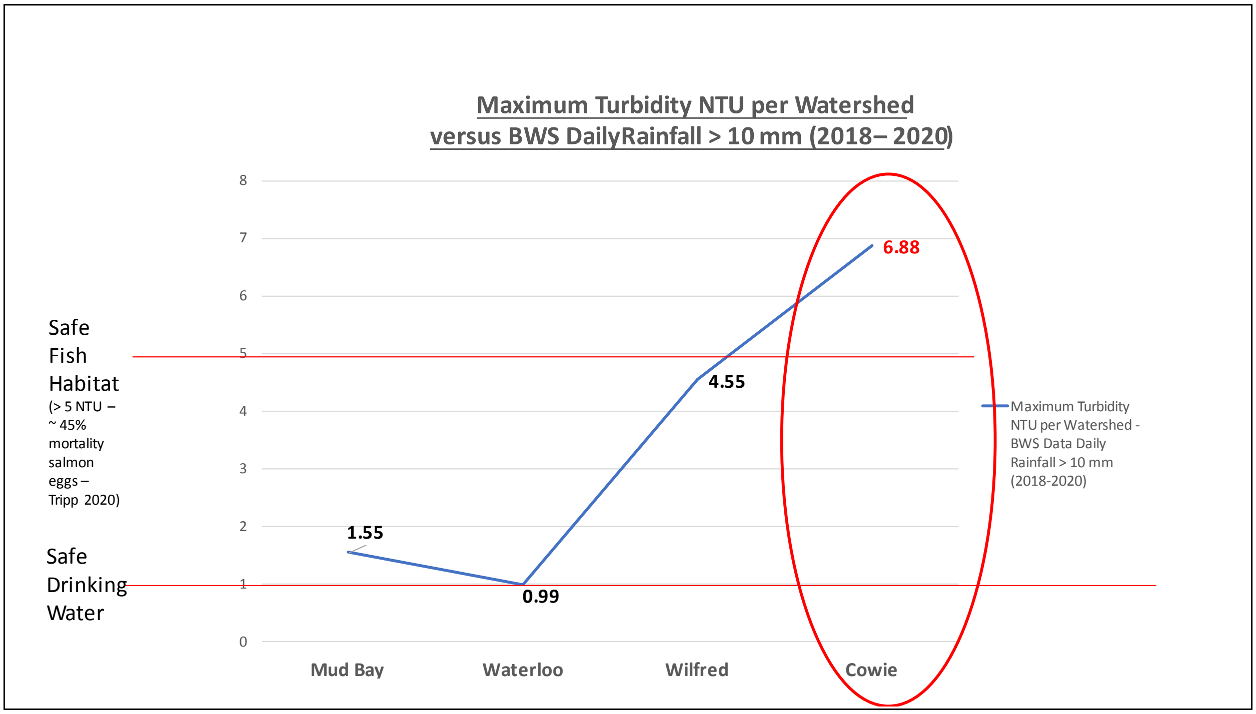


Figure 13: Maximum Turbidity NTU during rainfall events > 10 mm, per Watershed relative to Human and Fish Health thresholds.

Refer to **Appendix 11.3** for the sources of the data for this graph.

8.2 Report Card Scores regarding current Hydrological Health per Watershed

The following are "*comparative"* Report Cards. They are meant to solely summarize the project findings into alphabetical values and therefore allow for the reader to compare the 4 watersheds studied in a relative context of a "*Hydrological Health Snap Shot in 2021*".

Hydrological Metrics	Mud Bay Creek **	Waterloo Creek	Wilfred Creek	Cowie Creek
QUANTITATIVE				
Total Area Harvested	B	C	C	D
Equivalent Clearcut Area	A	B	B	D
Road Density	B	C	C	D
Number of Creek Crossings	A	B	C	D
Number of Landslides	B	B	D	B
QUALITATIVE OBSERVATIONS				
Riparian Protection	B	B	B	B
Road Maintenance and Practices	C	C	B	C
FINAL GRADE	B+	B-	C-	D

Table 3: Relative Watershed Report Card - Hydrological Health Snap Shot in 2021. The value for each letter grade uses the following relative description:

- **A** – excellent
- **B** – good
- **C** – satisfactory
- **D** – unsatisfactory
- **F** – failure

** **Note**: Mud Bay Creek is too small (<500 ha) to assess effective hydrological metrics, therefore it is rated here only for purposes of comparison.

9.0 Next Steps: Recommendations for BWS

1. **Cowie Creek - more study required**: The low score for Cowie Creek Watershed Hydrological Health suggests an elevated risk of peak flows and in addition, has the highest turbidity measurements over the 3 years. Therefore, the next step for BWS is to obtain data on natural substrate stream bank material, in order to determine the potential contribution of natural stream bank material versus the potential road development contribution, to higher sediment and turbidity values. These steps should be paired with the Aquifer Mapping project (2022-2023) and be part of the substrate mapping process, performed by professionals.

2. **Institute a water quantity monitoring program:** Poorer watershed health elevates the risk of higher peak flows. Therefore, to document these fluctuations above normal flow levels, the quantity of water discharge per watershed needs to be monitored as well. This objective is well established in BWS's mission statement and the efforts made are well on their way in completing water quantity measurement infrastructure in 2021.

3. **Plan and perform Hydrological Health Report Cards on other watersheds**: Due to the significant initial findings of this study, it is recommended that BWS initiate additional; assessments on neighbouring watersheds currently being monitored for water quality and quantity - prioritizing those that are showing higher sediment levels in their measurements

4. **Advocate for reform of the Private Managed Forest Land Act (PMFLA) to control/lower rates of harvest:** The elevated levels of harvesting on the private land portions of the watersheds documented in this study, have raised concern for the potential impact on watershed health. It is encouraged that the BWS engage with the local licensees to review their process for determining the rates of harvest. As well, to advocate to the regulatory body (BC Ministry of Forests) to bring about changes to legislation to include watershed health assessment and a process to modify forest practices to mitigate elevating the risk of peak flows and possibly peak droughts.

10.0 Works Cited and Referenced

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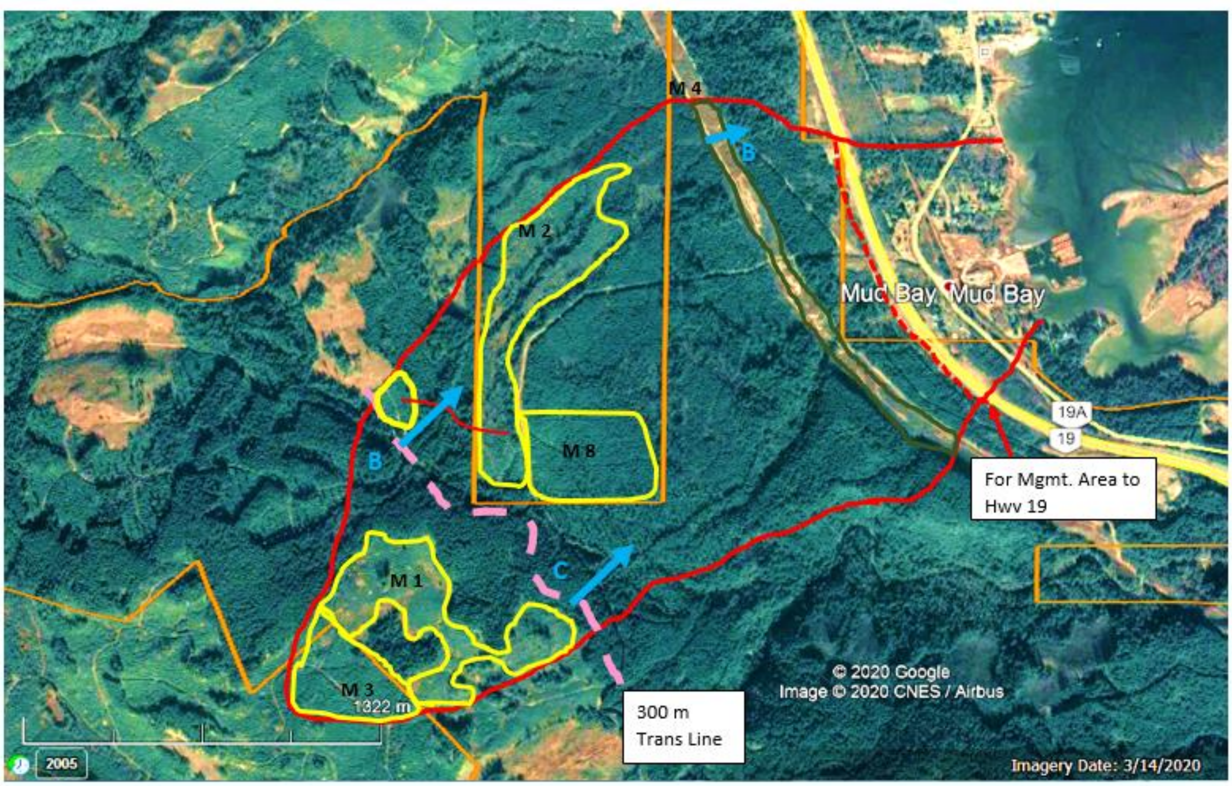
11.0 Appendix – Data

11.1 Disturbance Unit Maps per Watershed

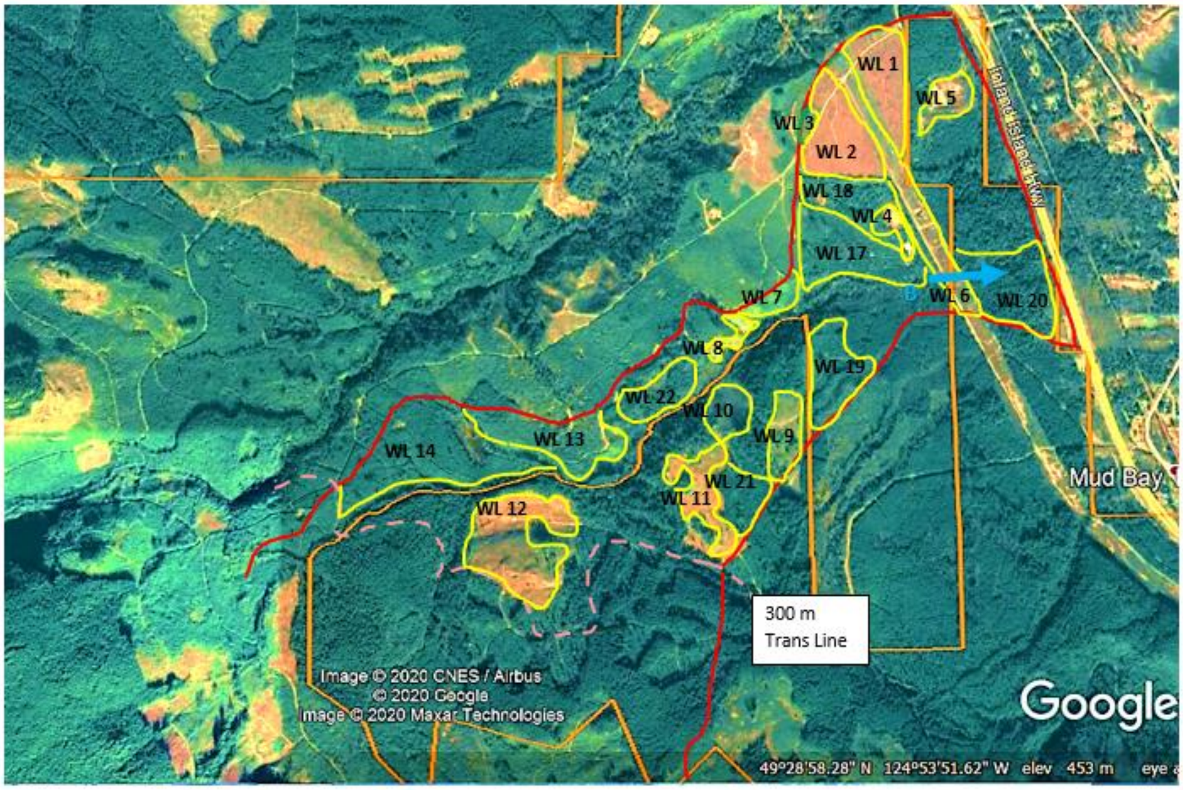
DU MAP LEGEND

Boundaries		
	Watershed	
	Ownership	
	Transition Zone	
	Snow Zone	
	Disturbance Unit	
Titles	DU Identification	**WL 29**
	Stream Crossing	B
	B- Bridge; C - Culvert	

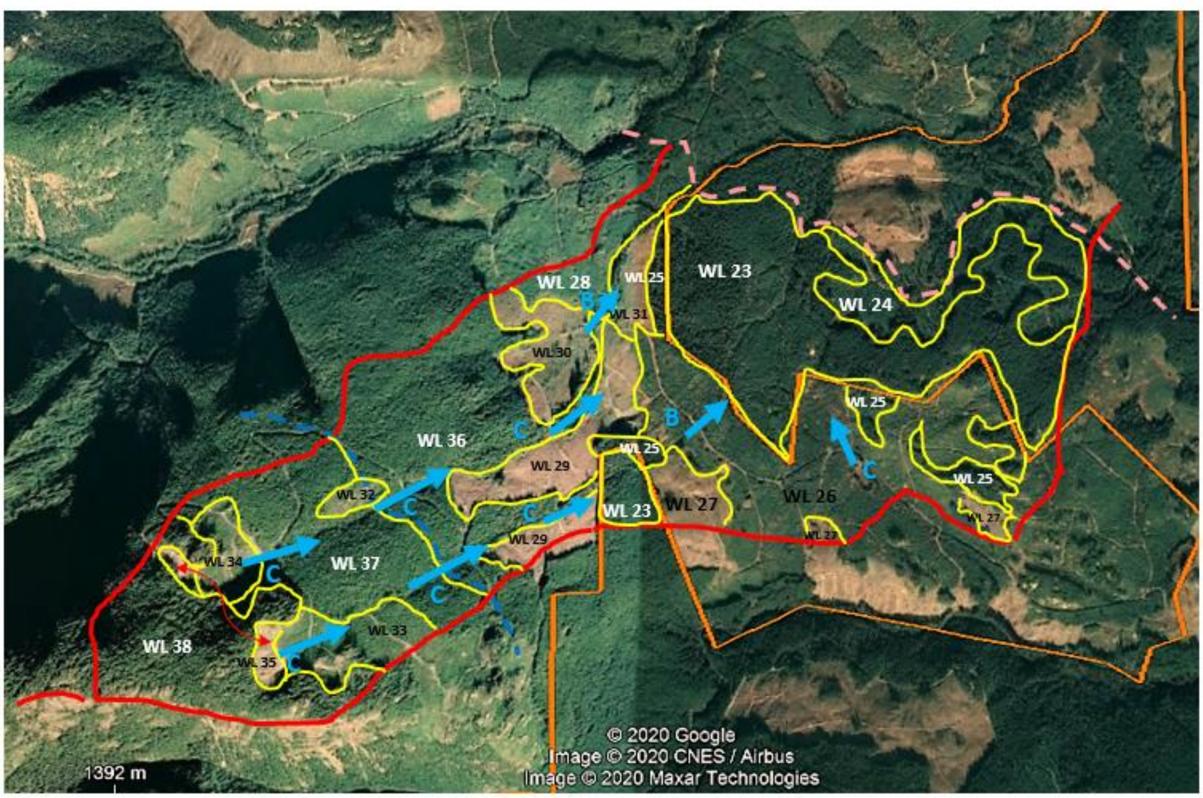
Mud Bay Creek Watershed



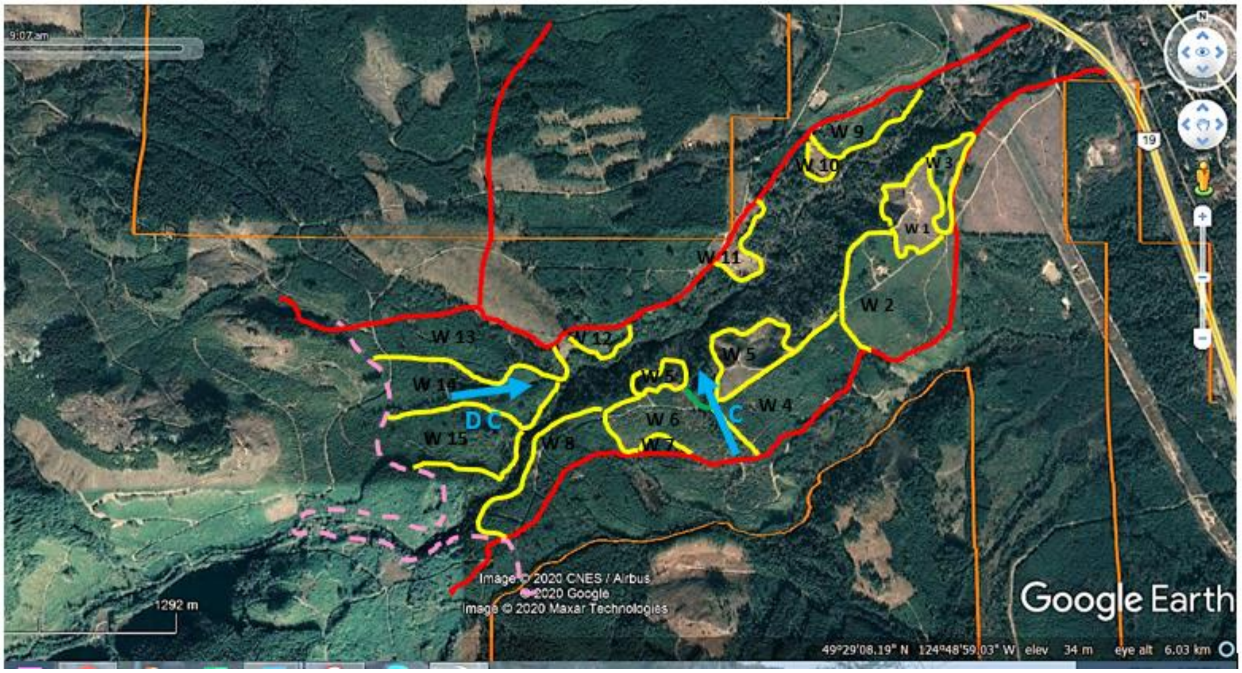
Waterloo Creek Watershed – Rain Zone



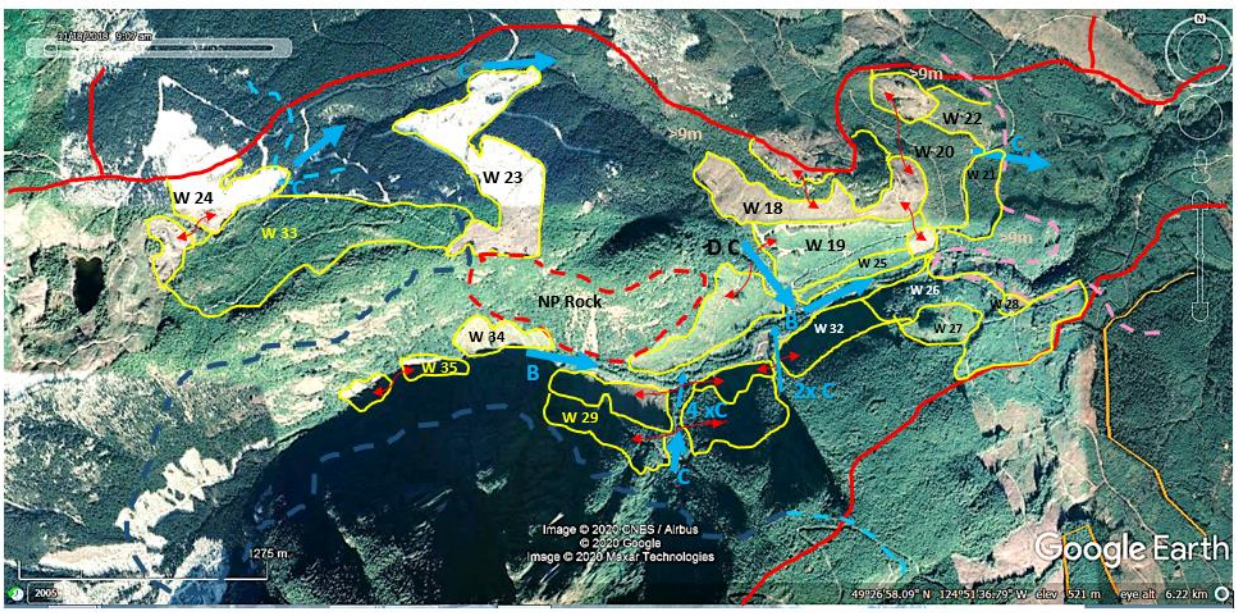
Waterloo Creek Watershed – Transition and Snow Zone



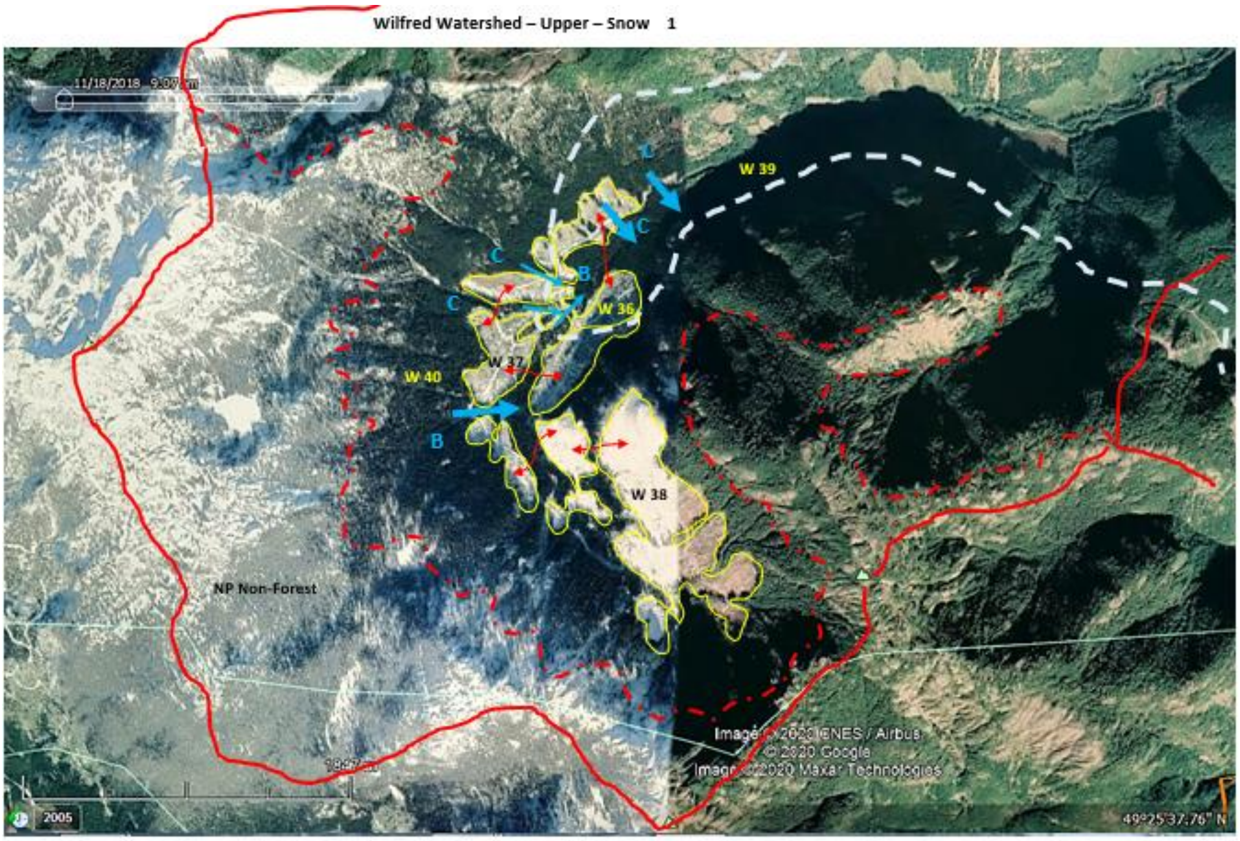
Wilfred Watershed – Rain Zone



Wilfred Watershed – Mid – Trans & Snow

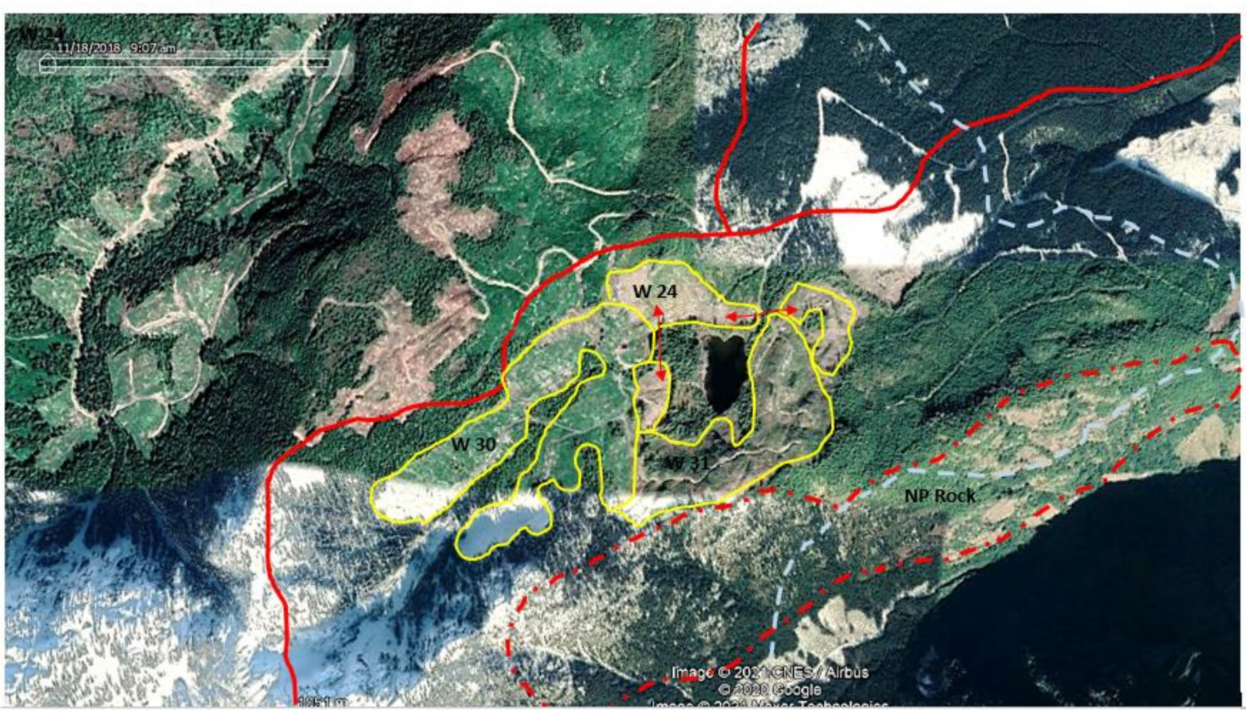


Wilfred Watershed – Upper – Snow 1

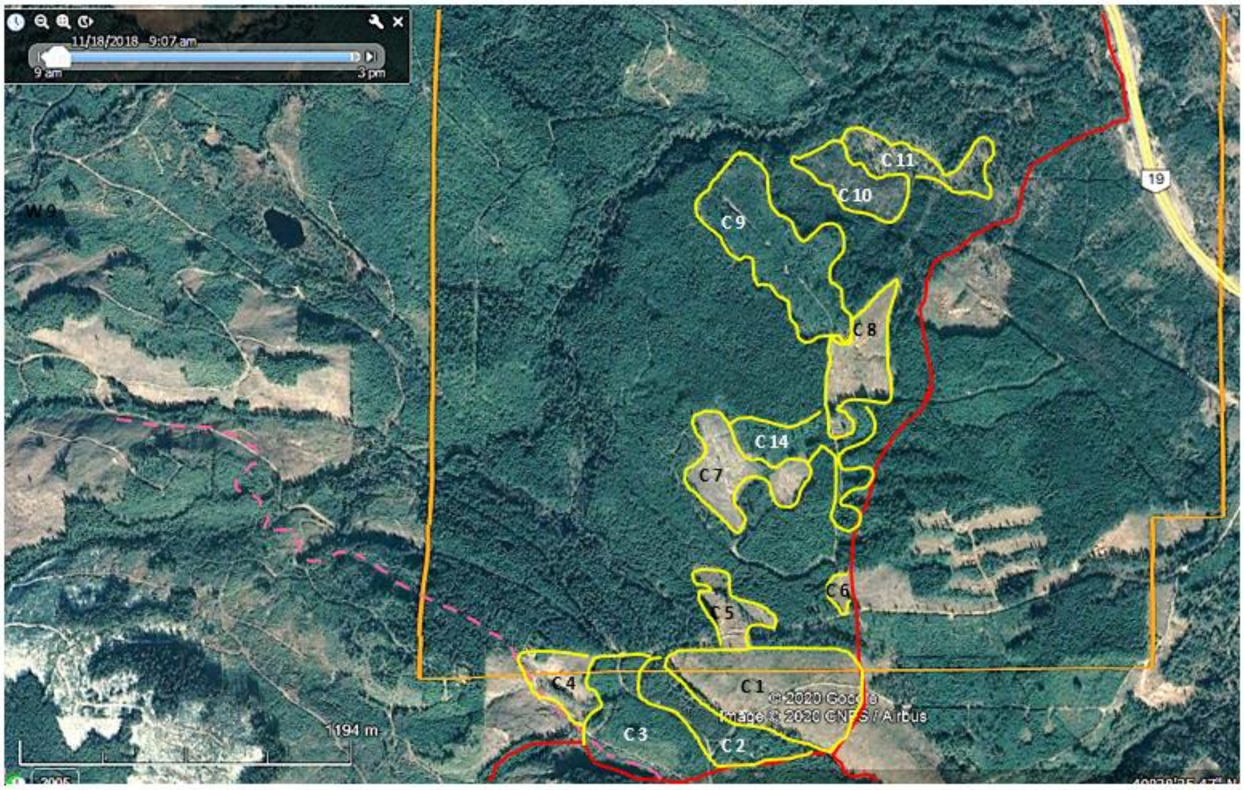


Net out Non-Forest Type line – Alpine, Sub – Alpine, High Elev. Rock:

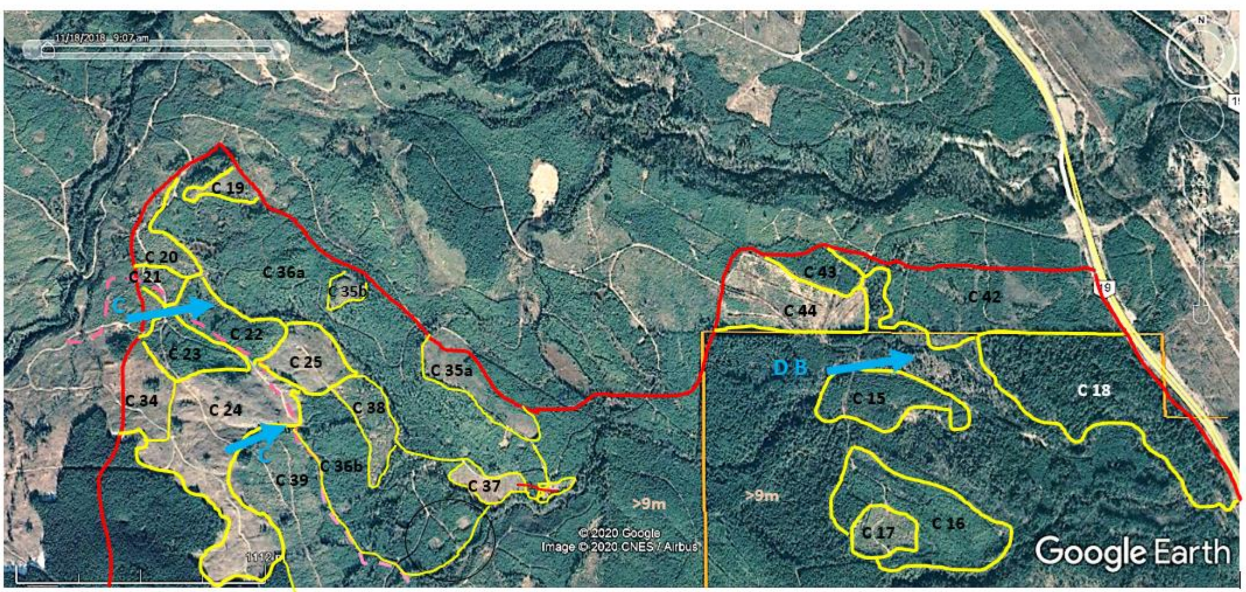
Wilfred Watershed – Upper Snow – 2



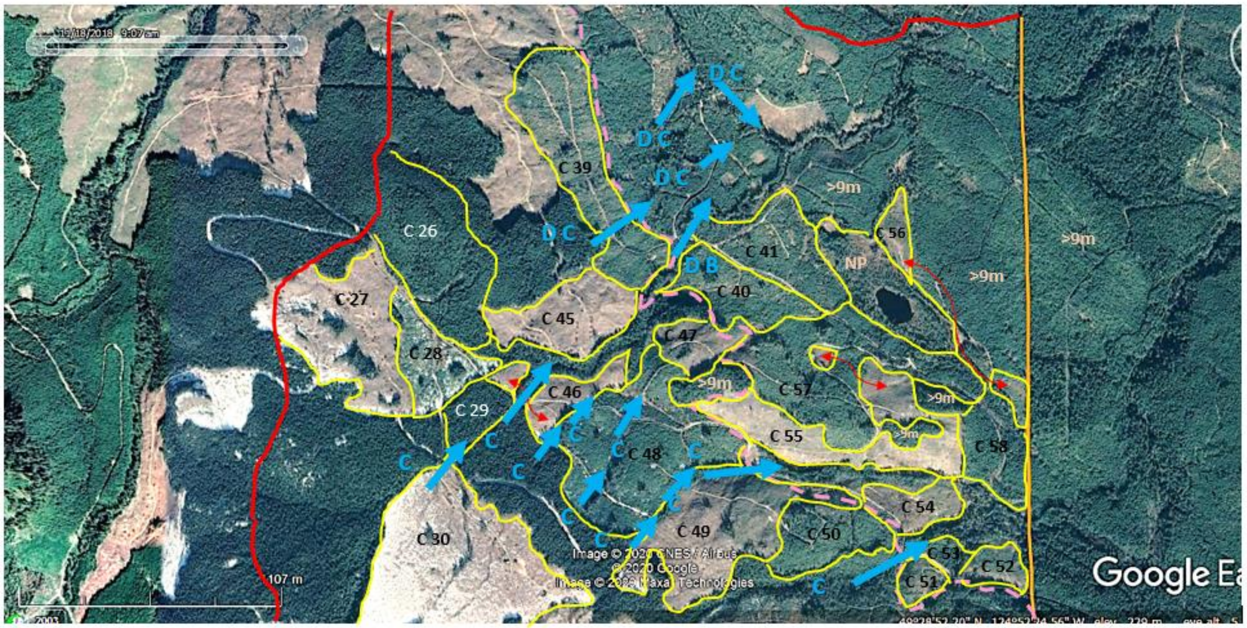
Cowie Watershed – Cougar Rain



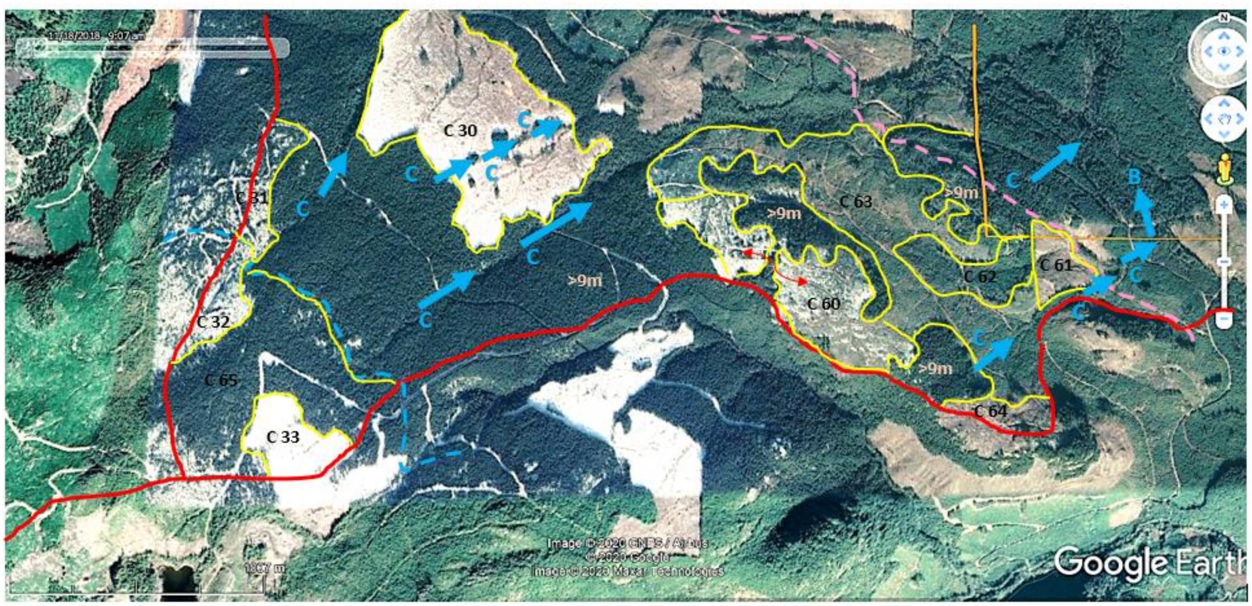
Cowie – Cowie North Rain



Cowie – Cowie North Trans



Cowie Watershed – Cougar Trans & Snow



11.2 Excel Spreadsheet Summaries per Watershed

BWS Watershed ECA Calculations 2021 Data Checked √

Mud Bay (M)

Ave Ht regen	Recovery Factor
0 - < 3 m	1
3 - < 5m	0.75
5 - < 7 m	0.5
7 - < 9 m	0.25
9 + m	0.1

ECA % for Watershed		
	20.8099	%
Crown	19.8401	
Private	22.961	

	Total Area	Crown(C)	Private(P)
Watershed Total Area	363	250.2	112.8
(For Mgmt area to hwy 19)		68.90%	31.10%

MB DU# C	P	Descript	Elev Zone (Ha) Rain	Trans	Snow	Regen Ht	Recovery Factor	Adj Ha / Zone Rain	Trans	Snow	Crown(C)	Private(P)
M1		CC		24.5		5	0.5		12.25		12.25	
	M2	CC	22			5	0.5	11				11
	M3	CC		12.4		<9	0.25		3.1			3.1
M4		Hydro Line	14.2			0	1	14.2			14.2	
M5		Recover CC		35.1		> 9	0.1		3.51		3.51	
	M6	Recover CC	43			>9	0.1	4.3				4.3
M7		Recover CC	196.8			> 9	0.1	19.68			19.68	
	M8	CC	15			6	0.5	7.5				7.5
			291	72	0			56.68	18.86	0	49.64	25.9

75.54 FINAL ECA Ha's Zones

BWS Watershed ECA Calculations 2021 Data Checked √

Vaterloo Rain Zone (WL)

Ht regen	verg Facto
0 - < 3 m	1
3 - < 5m	0.75
5 - < 7 m	0.5
7 - < 9 m	0.25
9 + m	0.1

ECA % for Watershed		
Zones	26.428	%
ha		

	Total Area	Crown(C	Private(P)
Vatershed Total Area	360	169.8	190.2
(For Mgmt area to hwy 19)			

MB DU# C	P	Descript	Elev Zone (Ha) Rain			Regen Ht	R Facto	Adj Ha / Zone Rain		
	WL1	CC	11.5			< 2	1	11.5		
	WL2	CC	14.3			2	1	14.3		
	WL3	CC	1.2			4	0.75	0.9		
	WL4	PIT	1.7			0	1	1.7		
	WL5	PIT	4.4			0	1	4.4		
WL6		Hydro	9.8			0	1	9.8		
	WL7	CC	3.6			4.5	0.75	2.7		
	WL8	CC	2			<1	1	2		
WL9		CC Dr	5.8			16	0.1	0.58		
WL10		CC Dr	3.5			12	0.1	0.35		
WL11		CC	8			1	1	8		
WL12		CC	18			1	1	18		
	WL13	CC	17			9	0.1	1.7		
	WL 14	CC	26.9			9	0.1	2.69		
WL 15		Recover CC	100.9			> 9	0.1	10.09		
	WL 16	Recover CC	64.3			> 9	0.1	6.43		
	WL 17	CC	16.2			4	0.75	12.15		
	WL 18 o	PC Overstorey	5.7			12	0.1	0.57		
	WL 18 u	PC Understorey	3.8			4	0.75	2.85		
	WL 19	CC	12.6			7	0.25	3.15		
WL 20		OGMA	15.7			>9	0	0		
WL 21		CC	8.1			8	0.25	2.025		
	WL22GUESS H	CC Log2021	5			0	1	5		
			360		0			95.14	0	0

0

FINAL ECA Ha's

BWS Watershed ECA Calculations				2021	Data Checked √												
Waterlo	Trans &	Snow	(WL)				Ave Ht regen	ery Factor	ery Factor	Snow					ECA % for Watershed		
							0 - < 3 m	1	1.2	0 - < 3 m						29.507	
							3 - < 5m	0.75	1	3 - < 5m							
				Crown(C)	Private(P	Private(P	5 - < 7 m	0.5	0.6	5 - < 7 m							
Watershed		Total Are	538	141	280	117	7 - < 9 m	0.25	0.4	7 - < 9 m							
	(For Mgmt area to hwy 19)						9 + m	0.1	0.25	9 -< 12m							
									0.1	12+ m							
				Elev Zone (Ha)					Adj Ha / Zone								
MB DU#		Descript		Trans	Snow		Regen Ht	R Factor	Trans		Snow						
C	P																
WL 23		CC 2nd Gr		109			>9	0.1	10.9								
WL 24		CC Part U		32			8	0.25	8								
	WL 25	CC		15.4			>9	0.1	1.54								
	WL 26	CC		76			6	0.5	38								
	WL 27	CC		17.3			<3	1	17.3								
	WL 28	CC		15.4			8	0.25	3.85								
	WL 29	CC		27.9			<3	1	27.9								
	WL 30	CC		14.6			4	0.75	10.95								
	WL 31	CC		6.5			5	0.5	3.25								
	WL 32	CC			2.6		5	0.6			1.56						
	WL 33	CC			14.9		5	0.6			8.94						
	WL 34	CC			6.4		4	1			6.4						
	WL 35	CC			4.2		<3	1.2			5.04						
	WL 36	CC 2nd Gr		106.9			>9	0.1	10.69								
	WL 37	CC 2nd Gr			44.3		>12	0.1			4.43						
	WL 38	OG			44.6		>9 OG	0			0						
			0	421	117				132.38	0	26.37		158.75	FINAL ECA Ha's			

BWS Watershed ECA Calculations			2021		Data Checked √												
Waterloo	Total	(WL)					Ave Ht regen	Recovery Factor							ECA % for Watershed		
							0 - < 3 m	1								28.2762	%
							3 - < 5m	0.75							Crown	21.7271	
				Crown(C)	Private(P)		5 - < 7 m	0.5							Private	31.7545	
	Watershed	Total Area	898	311.8	586.2		7 - < 9 m	0.25									
	(For Mgmt area to hwy 19)			35.00%	65.00%		9 + m	0.1									
										Adj Ha / Zone			FINAL ECA Ha's				
							Regen Ht	R Factor							Crown(C)	Private(P)	
									95.14	132.38	26.4		253.92		48.845	46.295	95.14
															18.9	113.48	132.38
																26.37	26.37
													253.89		67.745	186.145	
			0	0	0				0	0	0						

BWS Watershed ECA Calculations 2021 **Data Checked √**

Wilfred Rain

Ave Ht regen	Recovery Factor
0 - < 3 m	1
3 - < 5m	0.75
5 - < 7 m	0.5
7 - < 9 m	0.25
9 + m	0.1

ECA % for Watershed		
No Zones	39.748	%

		Crown(C)	Private(P)
Watershed Total Are	333	0	333
(For Mgmt area to hwy 19)			100.00%

MB DU# C	P	Descript	Elev Zone (Ha) Rain			Regen Ht	Recovery Fact	Adj Ha / Zone Rain		
	W1	CC	10.4			<1	1	10.4		
	W2a	CC	19			2.5	1	19		
	W2b	CC	11.1			4	0.75	8.325		
	W3	CC	5.7			4	0.75	4.275		
	W4	CC	21.6			6	0.5	10.8		
	W5	CC	12.3			2.5	1	12.3		
	W6	CC	14.7			5 to 6	0.5	7.35		
	W7	CC	2.1			9	0.1	0.21		
	W8	CC	13.6			9	0.1	1.36		
	W9	CC	8.9			6 to7	0.5	4.45		
	W 10	CC	1.5			< 1	1	1.5		
	W 11	CC	4.6			< 1	1	4.6		
	W 12	CC	2			6	0.5	1		
	W 13	CC	14.8			7	0.25	3.7		
	W 14	CC	20.4			8 to 9	0.25	5.1		
	W15	CC	16.4			7	0.5	8.2		
	W 16	RiparOG	36			> 9	0	18		
	W 17	Recover CC	117.9			> 9	0.1	11.79		
			333	0	0			132.36	0	0

132.36 Total Fall Peak Flow

BWS Watershed ECA Calculations 2021 **Data Checked √**

Wilfred (T&S)

Ht regen	Recovery Factor	Recovery Factor	Snow
0 - < 3 m	1	1.2	0 - < 3 m
3 - < 5m	0.75	1	3 - < 5m
5 - < 7 m	0.5	0.6	5 - < 7 m
7 - < 9 m	0.25	0.4	7 - < 9 m
9 + m	0.1	0.25	9 -< 12m
		0.1	12+ m

ECA % for Watershed	
27.519	%

		All	Private(P)
Watershed Total A	1525	772	753
(For Mgmt area to hwy 19)		minus 614 Non Fc (already deducted)	

IB DU# C	P	Descript		Elev Zone (Ha) Trans	Snow	Regen Ht	Recovery Factor		Adj Ha / Zone Trans	Snow
	W18	CC		31.8		0	1		31.8	
	W19	CC		39		4 to5	0.75		29.25	
	W20	CC		27.4		6	0.5		13.7	
	W21	CC		8.4		8	0.25		2.1	
	W22	CC		9		7	0.25		2.25	
	W23	CC		30		< 3	1		30	
	W24	CC			26.1	< 3	1			26.1
	W25	CC		5.5		7	0.25		1.375	
	W26	CC		27.3		7 to 9	0.25		6.825	
	W27	CC		10.4		4	0.75		7.8	
	W28	CC		2.9		3	0.75		2.175	
	W29	CC		22.6		0	1		22.6	
	W30	CC			35	5	0.6			21
	W 31	CC			22	4	0.82			18.04
	W32	CC		28.6		3 to 4	0.75		21.45	
	W33	CC			46.4	7 to 9	0.4			18.56
	W34	CC		7.9		4 to 5	0.75		5.925	
	W35	CC		5.9		<3	1		5.9	
	W36	CC		17.9		4	0.75		13.425	
	W37	CC			34.2	4	0.82			28.044
	W38	CC			61.6	<3	1			61.6
	W39	CC 2nd		497.4		>9	0.1		49.74	
	W40	OG			527.7	>12	0			0
				772	753				246.32	173.34

419.66 FINAL ECA Ha's Zones

BWS Watershed ECA Calculations				**2021**	Data Checked √												
Wilfred	**Total**	**(W)**					**Ave Ht regen**	**Recovery Factor**							**ECA % for Watershed**		
							0 - < 3 m	1								29.7104	%
							3 - < 5m	0.75									
				Crown(C)	Private(P)		5 - < 7 m	0.5									
	Watershed	**Total Area**	1858		1858		7 - < 9 m	0.25									
	(For Mgmt area to hwy 19)				100.00%		9 + m	0.1									
										Adj Ha / Zone			FINAL ECA Ha's				
							Regen Ht	**R Factor**									
									132.36	246.32	173.34		**552.02**				
			0	0	0				0	0	0						

BWS Watershed ECA Calculations				**2021**	Data Checked √												
Cowie	**Rain Zone**	**C**					**Ave Ht regen**	**Recovery Factor**							**ECA % for Watershed**		
Cougar							0 - < 3 m	1							Zones	17.5192	
							3 - < 5m	0.75						ha			
				Crown(C)	Private(P)		5 - < 7 m	0.5									
	Watershed	**Total Area**	780.7	736	44.7		7 - < 9 m	0.25									
	(For Mgmt area to hwy 19)						9 + m	0.1									
			Elev Zone (Ha)						**Adj Ha / Zone**								
MB DU#		**Descript**	**Rain**				Regen Ht	R Factor	**Rain**								
C	**P**																
	C 1	CC	22.2				< 1	1	22.2								
	C 2	CC	10.85				7	0.25	2.7125								
	C 3	CC	13.5				8	0.25	3.375								
	C 4	CC	4.7				< 1	1	4.7								
C 5		CC	4.3				< 1	1	4.3								
C 6		CC	1.3				< 1	1	1.3								
C 7		CC	9.7				< 1	1	9.7								
C 8		CC	9.75				< 1	1	9.75								
C 9		CC	21				6	0.5	10.5								
C 10		Dr (Ac)	8.8				> 20	0.15	1.32								
C 11		Low STK	10.9				> 20	0.25	2.725								
C12		RiparOG	35				>9	0	0								
C13		RecoverCC	619.9				> 9	0.1	61.99								
C14		Strip Log	8.8				8	0.25	2.2								
			780.7		0				136.773	0	0				0		
									FINAL ECA Ha's								

BWS Watershed ECA Calculations 2021 **Data Checked √**

Cowie **Rain Z** C

Cowie North

Ave Ht regen	verg Factor
0 - < 3 m	1
3 - < 5m	0.75
5 - < 7 m	0.5
7 - < 9 m	0.25
9 + m	0.1

ECA % for Watershed		
Zones	22.494	

ha

	Total A	Crown(C	Private(P)
Watershed	467.1	100.3	366.8

(For Mgmt area to hwy 19)

IB DU# C	P	Descrip	Elev Zone (Ha) Rain			Regen Ht	R Factor	Adj Ha / Zone Rain		
	C 42	CC	41			7 to 8	0.25	10.25		
	C 43	CC	8			> 9	0.1	0.8		
	C 44	CC	22.2			< 3	1	22.2		
C 15		CC	12.2			> 9	0.1	1.22		
C 16		CC	27.9			< 9	0.25	6.975		
C 17		CC	6.9			4 (6)	0.75	5.175		
C 18		OGMA	53.3			> 9	0	0		
	C19	CC	2.5			4	0.75	1.875		
	C20	CC	7.7			5	0.5	3.85		
	C21	CC	5.9			5	0.5	2.95		
	C22	CC	13.8			6	0.5	6.9		
	C25	CC	8.4			4	0.75	6.3		
	C35ab	CC	9.7			4	0.75	7.275		
	C36ab	CC	117.2			8	0.25	29.3		
	C37	CC	5.1			2	1	5.1		
	C38	CC	8.4			6	0.5	4.2		
	C40	CC	13.3			4	0.75	9.975		
	C41	CC	14.7			6	0.5	7.35		
	C51	CC	3			5	0.5	1.5		
	C52	CC	4			3	0.75	3		
	C53	CC	2			8	0.25	0.5		
	C54	CC	8.2			4	0.75	6.15		
	C55	CC	23.5			2	1	23.5		
	C56	CC	6.4			4	0.75	4.8		
	C57	CC	30			6	0.5	15		
	C58	CC	11.8			8	0.25	2.95		
			467.1		0			105.07	0	0

FINAL ECA Ha's

0

BWS Watershed ECA Calculations 2021 **Data Checked √**

Cowie N **(T&S)**

Ave Ht regen	Recovery Factor Rain & Trans	Recovery Factor Snow	Ave Ht regen
0 - < 3 m	1	1.2	0 - < 3 m
3 - < 5m	0.75	1	3 - < 5m
5 - < 7 m	0.5	0.6	5 - < 7 m
7 - < 9 m	0.25	0.4	7 - < 9 m
9 + m	0.1	0.25	9 -< 12m
		0.1	12+ m

ECA % for Watershed		
	49.285538	%

	Total Ar	Crown®	Private(P)
Watershed	809	6	803

(For Mgmt area to hwy 19)

MB DU# C	P	Descript		Elev Zone (Ha) Trans	Snow	Regen Ht	Recovery Factor		Adj Ha / Zone Trans	Snow
			6 haCrown	749	54					
	C23	CC		8.7		6	0.5		4.35	
	C24	CC		42.9		<3	1		42.9	
	C26	CC 2020		29		<3	1		29	
	C27	CC		26		<1	1		26	
	C28	CC		10.4		5	0.5		5.2	
	C29	CC 2020		5.7		<3	1		5.7	
	C30	CC		60		1 to 2	1		60	
	C31	CC		4.3		5	0.5		2.15	
	C32	CC			7.1	5	0.6			4.26
	C33	CC			8.8	< 3	1.2			10.56
	C34	CC		8.5		4	0.75		6.375	
	C39	CC		21		4	0.75		15.75	
	C45	CC		14.2		<1	1		14.2	
	C46	CC		7.3		<3	1		7.3	
	C47	CC		6.4		<3	1		6.4	
	C48	CC		33.2		6	0.5		16.6	
	C49	CC		26.7		<3	1		26.7	
	C50	CC		10.4		6	0.5		5.2	
	C60	CC		30.3		3	0.75		22.725	
	C61	CC		6.8		0	1		6.8	
	C62	CC		10.6		8	0.25		2.65	
	C63	CC		73.8		5	0.5		36.9	
	C64	CC		5.9		0	1		5.9	
	C65	CC 2nd			38.1	>12	0.1			3.81
	C66	CC 2nd		312.9		>9	0.1		31.29	
				755	54				380.09	18.63

398.72 FINAL ECA Ha's

BWS Watershed ECA Calculations				2021		Data Checked √											
Cowie	Total	(C)					Ave Ht regen	Recovery Factor							ECA % for Watershed		
							0 - < 3 m	1								31.1469	%
							3 - < 5m	0.75							Crown	13.909	%
				Crown(C)	Private(P)		5 - < 7 m	0.5							Private	43.0967	%
	Watershed Total Area		2056.8	842.3	1214.5		7 - < 9 m	0.25									
	(For Mgmt area to hwy 19)			41.00%	59.00%		9 + m	0.1									
									Adj Ha / Zone								
							Regen Ht	R Factor							Crown(C)	Private(P)	
									136.8	380.1	18.63				103.786	32.99	136.776
									105.1						13.37	91.7	105.07
			0	0	0				241.9	380.1	18.63	640.63				380.09	380.09
												FINAL ECA Ha's				18.63	18.63
												640.566			117.156	523.41	

Mud Bay Watershed Data Checked √
Road Tallies

Crown		Main Roads		Secondary (spurs – recent and		Tertiary (inactive , partly grown over, still passable)			Watershed Creek Crossing		Crossing Comments
		Name	Length(Km)		Length(Km)		Length(Km)		Crossing #		
					0.5						
		Rosewall FSR	1.5		0.8				1	0.8 spur off Rosewall - Bridge	Good conditon
			0.7		0.5				1	At end of Rosewall - Culvert	
					0.5						*1bridge on FSR*
											outside sampling
	Totals		2.2	Km	2.3	Km	0	Km	2	Crossings	
Crown Grand Total			4.5	Km							
		Crn Watershed Area	2.5	Km2							
		Ratio	1.80	Km of Road per Km2							
Private		Main Roads		Secondary (spurs – recent and		Tertiary (inactive , partly grown over, still passable)			Watershed Creek Crossing		Crossing Comments
		Name	Length(Km)		Length(Km)		Length(Km)		Crossing #		
					0.4		0.6				
		Rosewall FSR	1.2		0.8						
	Totals		1.2	Km	1.2	Km	0.6	Km	0	Crossings	
Private Grand Total			3	Km							
		Priv Watershed Area	1.1	Km2							
		Ratio	2.73	Km of Road per Km2							
Mud Bay Watershed											
Grand Total			7.5	Km					2	Crossings	
		Watershed Area	3.63	Km2							
		Ratio	2.07	Km of Road per Km2							

Road Density Thresholds – Alberta 2012

Road density in Km /Km2	Rating
≤ 2	Good
2 – 3	Fair
> 3	Poor

Waterloo Watershed Data Checked √

Road Tallies

Crown

Main Roads: Name	Main Roads: Length(Km)	Secondary (spurs - recent and: Length(Km)	Tertiary (inactive , partly grown over, still passab: Length(Km)	Watershed Creek Cro: Crossing #		Crossing Comments
Rosewall FSR	0.3	0.8	0.6			
		0.6				
		1.2				*one bridge on FSR*
		1.7				*but outside sample*
Totals	**0.3 Km**	**4.3 Km**	**0.6 Km**	**0 Crossings**		

Crown Grand Total	**5.2**	**Km**
Crn Watershed Area	**3.11**	**Km2**
Ratio	1.67	**Km of Road per Km2**

Private

Main Roads: Name	Main Roads: Length(Km)	Secondary (spurs - recent and: Length(Km)	Tertiary (inactive , partly grown over, still passab: Length(Km)	Watershed Creek Cro: Crossing #		Crossing Comments
Hasting Main	0.8	1.1	0.4	1	North WL Fork	Bridge Good shape
Rosewall FSR	1	0.7	0.5	1	South WL Fork	Bridge Good shape
Hastings S Branch	2.4	0.8	0.3	3	North WL Fork	Culvert
		1	0.3	4	South WL Fork	Culvert
		1.2	0.3			
		2				
		0.7				
		1.5				
		1				
		1.2				
		1.2				
		0.2				
Totals	**4.2 Km**	**12.6 Km**	**1.8 Km**	**9 Crossings**		

Private Grand Total	**18.6**	**Km**
Priv Watershed Area	5.86	**Km2**
Ratio	3.17	**Km of Road per Km2**

Waterloo Watershed Grand Total	23.8	**Km**	9 **Crossings**
Watershed Area	8.98	**Km2**	
Ratio	2.65	**Km of Road per Km2**	

Road Density Thresholds – Alberta 2012

Road density in Km /Km2	Rating
≤ 2	Good
2 – 3	Fair
> 3	Poor

Background Data

		Crown(C)	Private(P)
Area Ha	898	311.8	586.2

Wilfred Watershed Data Checked √

Road Tallies

Crown

Main Roads: Name	Main Roads: Length(Km)	Secondary (spurs - recent an: Length(Km)	Tertiary (inactive , partly grown over, still pass: Length(Km)	Watershed Creek Cro: Crossing #		Crossing Comments
Totals	**0 Km**	**0 Km**	**0 Km**	**0 Crossings**		

Crown Grand Total	**0**	**Km**
Crn Watershed Area	**0**	**Km2**
Ratio	#DIV/0!	**Km of Road per Km2**

Private

Main Roads: Name	Main Roads: Length(Km)	Secondary (spurs - recent an: Length(Km)	Tertiary (inactive , partly grown over, still pass: Length(Km)	Watershed Creek Cro: Crossing #		Crossing Comments
Hastings Main	4.1	1.7	0.6	15	Culverts	
Hastings North Br	3.3	0.7	0.5	2	Deactivated Culverts	
Hastings Alpine Br	7.5	0.2	3.3	4	Bridges	
		0.6	1			
		1.1	1.5			
		2.1	2.5			
		1.3	1.5			
		1.4				
		0.8				
		0.9				
		0.6				
		1				
		0.6				
		1.7				
		1.3				
		0.4				
		1				
		0.6				
		0.8				
		0.6				
		0.4				
Totals	**14.9 Km**	**19.8 Km**	**10.9 Km**	**21 Crossings**		

Private Grand Total	**45.6**	**Km**
Priv Watershed Area	18.58	**Km2**
Ratio	2.45	**Km of Road per Km2**

Wilfred Watershed Grand Total	45.6	**Km**	21 **Crossings**
Watershed Area	18.58	**Km2**	
Ratio	2.45	**Km of Road per Km2**	

Background Data

		Crown(C)	Private(P)
Area Ha	1858	0	1858

Cowie Watershed **Data Checked √**

Road Tallies

Crown

Main Roads		Secondary (spurs - recent a	Tertiary (inactive , partly grown over, still pas:	Watershed Creek Cro:		Crossing Comm
Name	**ength(Km)**	**Length(Km)**	**Length(Km)**	**Crossing #**		
Jacob Main	2	1.2	0.7	1	Bridge	
		1.4	1	1	Culvert	
		1.4	1.6	1	Deactivated Bridge	
			2.2			
Totals	**2 Km**	**4 Km**	**5.5 Km**	**3 Crossings**		

Crown Grand Total	**11.5**	**Km**
Crn Watershed Ar	**8.42**	**Km2**
Ratio	1.37	**Km of Road per Km2**

Private

Main Roads		Secondary (spurs - recent a	Tertiary (inactive , partly grown over, still pas:	Watershed Creek Cro:		Crossing Comm
Name	**ength(Km)**	**Length(Km)**	**Length(Km)**	**Crossing #**		
Hoilday Main	6.1	0.4	0.4	21	Culvert	
Tsable Main	2.5	1.9	0.3	4	Deactived Culvert	
Connector Main	3.7	0.9	0.3		Bridge	
Hastings North Br	0.6	0.8	0.2	1	Deactivated Bridge	
Jacob Main	0.8	2.3	0.9			
		1.1	2.5			
		0.5	0.4			
		0.9	1.5			
		1.7	0.4			
		0.6	0.5			
		0.7	0.4			
		1	1.4			
		0.5	1.9			
		0.7	2.9			
		1.4	1.5			
		0.8	0.4			
		1.4	1.2			
		1.1				
		2				
		1.1				
		1.3				
		2.3				
		1.3				
		0.9				
Totals	**13.7 Km**	**27.6 Km**	**17.1 Km**	**26 Crossings**		

Private Grand Total	**58.4**	**Km**
Priv Watershed Ar	12.145	**Km2**
Ratio	4.81	**Km of Road per Km2**

Cowie Watershed

Grand Total	69.9 **Km**		29 **Crossings**
Watershed Are	20.57 **Km2**		
Ratio	3.40 **Km of Road per Km2**		

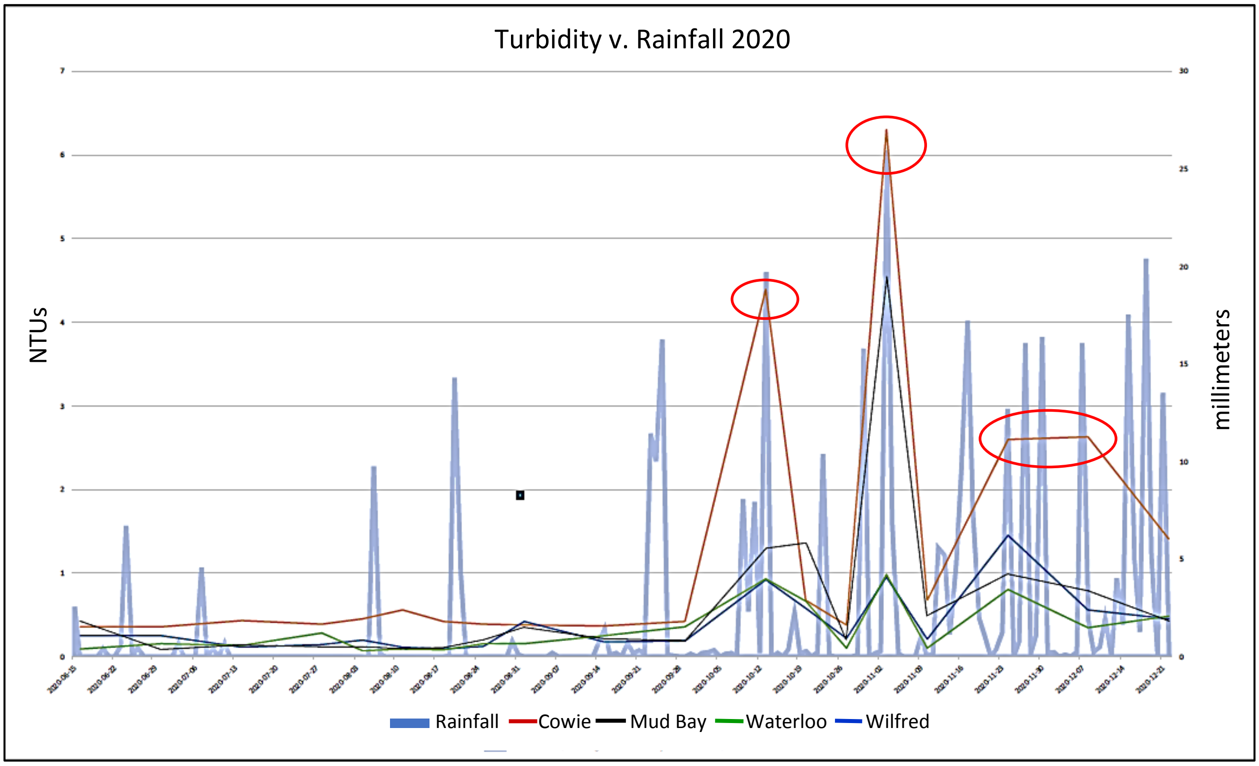
Background Data

		Crown(C)	Private(P)
Area Ha	2056.8	842.3	1214.5

Road Density Thresholds – Alberta 2012

Road density in Km /Km2	Rating
≤ 2	Good
2 – 3	Fair
> 3	Poor

11.3 Graphs of Turbidity per Watershed versus Rainfall



Turbidity v. Rainfall per Watershed 2020: Turbidity measurements are from BWS data (Turbidity is in NTUs on the left axis of graph) and Rainfall measurements are from the BC Forest Service fire weather station in Bowser, BC (Rainfall is in millimeters on the right axis of the graph).
Cowie Creek data is highlighted with **red circles**.

Join us

Memberships are $10 per person annually. This ensures that you are on our mailing list for updates and activities.

Volunteer

Everything Beaufort Watershed Stewards does is through the work of community volunteers.

As our activities expand, we continue to seek volunteers. One opportunity is for people to help with stream sampling—do you love a walk in the woods and time around streams? We provide approved training for our sampling techniques.

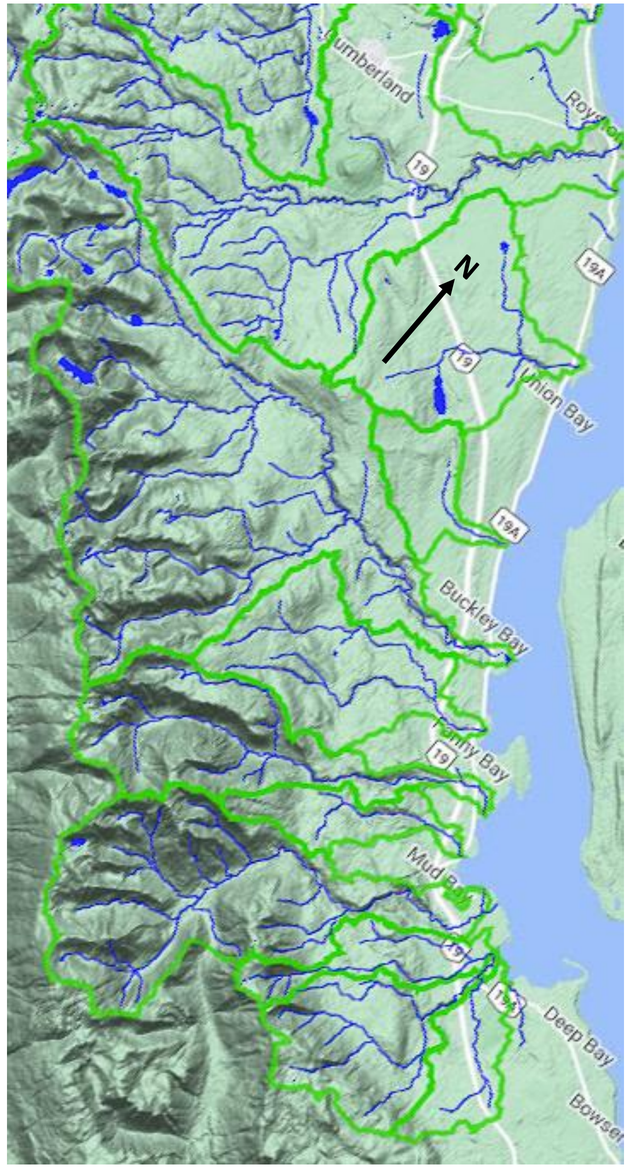
Our work benefits from a wide range of expertise among our members: conservation, forestry, biology, hydrogeology, accounting, administration, grant writing, fisheries and graphic design are examples. You might be surprised to learn how we could use your talents!

Contribute

In addition to monetary contributions, we collect refundables as one of our main sources of support. Please email us at info@beaufortwater.org or check the website for information on how to donate your refundables.

Charitable Registration No.: 726608680 RR0001

We respectfully acknowledge that the watersheds we depend on are on the unceded traditional territory of the K'ómoks, Pentlatch and Qualicum First Nations, the traditional keepers of this land.



Creeks and watersheds in the Beaufort Mountain Range
Image credit: K'ómoks Estuary Water Map, Project Watershed

Wilfred Creek *Photo credit: L. Ray*

Beaufort Watershed Stewards

www.beaufortwater.org

info@beaufortwater.org

Mission

The Beaufort Watershed Stewards work to promote the health and resilience of local watersheds in the Beaufort Range and to ensure the quality and quantity of fresh water for the future.

Stream Monitoring

Stream monitoring is a core component of our activities. It provides baseline and ongoing data on the health of streams in the Beaufort watersheds.

We have recently expanded our stream monitoring to include 11 streams that originate within the Beaufort watersheds. For most of the year we sample biweekly and weekly during summer low flow and fall flush periods.

Stream temperature is critical for fish bearing streams to ensure salmonid survival. Turbidity gives information related to contaminants and erosion from human or natural causes. Dissolved oxygen is required to support aquatic life and is an indicator of stream health.

Specific conductivity provides a warning of possible salt water intrusion.

Our data are included in the provincial database that tracks the health of streams and watersheds throughout British Columbia.

Streams BWS Monitors

- Mud Bay Creek
- Waterloo Creek
- Wilfred Creek
- Apple Cherry Creek
- Cowie Creek
- Tsable River
- Emily Creek
- Hindoo Creek
- Hart Creek
- Spence Creek
- Trent River

Stream Flow Measurement

While our monitoring program is about the quality of the water, flow measurement is about the quantity. It is critical to know trends in surface water flow as climate warming continues.

We have flow gauges on a select set of streams at this time, but hope to expand this program as we welcome more volunteers.

Well Level Monitoring

A large proportion of residents within the Beaufort watersheds rely on well water. Beaufort Watershed Stewards monitors a small selection of wells, both community and private. This monitoring equipment provides ongoing data on the quantity and selected quality indices of well water.

For private wells, the data and graphs of trends over time are shared with owners.

Hydrological Mapping

We are very excited to be starting a new project to map the aquifers that provide water for those of us residing east of the Beaufort Mountain Range. This will be accomplished using geophysical techniques.

This initiative will be the first time any assessment of our aquifers has been conducted. We currently have limited knowledge of the size and status of the aquifers that we rely on.

Community Outreach and Education

The Fanny Bay Flyer, our website and Facebook page are our main forms of contact.

We look forward to hosting educational sessions, activities such as watershed walks and town hall meetings.