

Trent River Watershed Cumulative Effects Assessment - 2025

**An application of BC's Cumulative
Effects Framework at a Local
Watershed Scale**

July 2025

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Land Acknowledgement: The Beaufort Watershed Stewards 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.

Statement of intent: The author of this report is a retired non-practicing forest worker. All the findings presented by the author in this report are based on the data collected relative to following the requirements the BC provincial government's Interim Assessment Protocol for Aquatic Ecosystems in British Columbia (2020).

Registered Professional Forester Supervision: This report was peer-reviewed by registered professionals and was supervised and signed off by the following Registered Professional Foresters.

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Credits: All the photos and images in this report were generated by the author and/or by Beaufort Watershed Stewards' volunteers.

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Mission statement: *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.*

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1.0 Executive Summary

Background:

The Trent River Watershed Cumulative Effects (CE) Assessment project is the third in a planned series of watershed health assessment projects undertaken by the Beaufort Watershed Stewards (BWS). The first BWS watershed assessment project in 2021 involved four local watersheds ⁽⁶⁾, which used the existing older protocol - the 2001 BC Coastal Watershed Assessment Procedure Guidebook ⁽⁴⁾.

In 2023, the second BWS watershed assessment project was completed for the Tsuble River ⁽⁷⁾.

This report used the new watershed assessment protocol published by the BC Government, titled:

Interim Assessment Protocol for Aquatic Ecosystems in British Columbia – Dec 2020⁽³⁾ (further referred to in this report as the “Protocol”). This is a very comprehensive, made in BC procedure, that includes complete thresholds for six core watershed health indicators.

The BWS have continued to use the procedures of the Protocol for this 2025 CE Assessment of the Trent River’s aquatic and hydrological function.

Methods:

The procedures and thresholds listed in the Protocol for the six Core Indicators (listed below in the table), were followed in this report, and were determined by using primarily Geographic Information Systems (GIS) technology, augmented with vegetation interpretation of 2023 satellite images. A percentage of selected Core Indicator metrics were ground verified- 64% of tree heights for Peak Flow, 17% of GIS identified Stream Crossing and 15% for imagery identified Riparian Disturbances.

Results:

The following is a Summary Table, listing the six Core Indicators’ final values for this Report.

Core Indicators	Road Density	Road Density < 100 m Stream		Road Density Unstable Slopes	Stream Crossing Density	Riparian Disturbance	Peak Flow
		Aquatic Habitat	Water Quality				
Core Indicator Values	3.8 km/km ² HIGH	0.7 km/km ² HIGH	0.2 km/km ² MOD	0.01 km/km ² LOW	1.41 #/km ² HIGH	0.11 km/km LOW	0.61 HIGH

Table 1: The six Core Indicators’ final values assessed in this report. High values are shown in red.

Using the hierarchy process of the Protocol and the six Core indicator values identified above, the overall Trent River watershed risk rating was determined as having a **HIGH** potential of negative impacts to hydrological and aquatic ecosystem function due to the cumulative effects of industrial development⁽³⁾. The Protocol suggests that assessed watersheds with a resultant high-risk rating should further be assessed via a more rigorous analysis by qualified professionals – which is consistent with recommendations made by Dr Alila^(1,2) and also by the Joint Professional Watershed Practice Guidelines document, published by the Forest Professionals of BC (FPBC) and the Engineers and Geoscientists BC in 2020⁽⁸⁾.

Recommendation:

Therefore, due to the high-risk rating of the cumulative effects potential impacts within the Trent River Watershed, further professional assessment is recommended to be undertaken.

2.0 Introduction

The Trent River Watershed Cumulative Effects (CE) Assessment project is the third in a planned series of watershed health assessment projects undertaken by the Beaufort Watershed Stewards (BWS). The first BWS watershed assessment project in 2021 involved four local watersheds⁽⁶⁾, using the existing older protocol - the 2001 BC Coastal Watershed Assessment Procedure Guidebook⁽⁴⁾.

In 2023, the second BWS watershed assessment project was completed for the Tsable River⁽⁷⁾. This report used the new watershed assessment protocol published by the BC Government, titled: ***Interim Assessment Protocol for Aquatic Ecosystems in British Columbia – Dec 2020***⁽³⁾ (referred to in this report as the “Protocol”).

This is a very comprehensive, made-in-BC Protocol, that includes complete thresholds for six core watershed health indicators. It was also designed to generate a conclusive rating for a watershed’s overall risk of negative impacts to hydrological processes, due to the cumulative effects of industrial development activities – which includes logging. The Protocol was designed primarily as a coarse scale Geographic Information Systems (GIS) based assessment tool but also recommends that finer scaled watershed specific data can be used for targeted regional applications of the thresholds, which producing a finer resolution assessment report.

The BWS have used this same rigorous Protocol for this assessment of the Trent River’s aquatic and hydrological function. Also, more detailed GIS data and ground verified metrics were added to assessing the six core indicators for this report, as encouraged within the Protocol.

2.1 Oblique Google Earth Map of the Trent River Watershed

Figure 1 below is an oblique Google Earth image showing the Trent River watershed located on the east side of the Beaufort Range. The Trent River watershed is classed as a Coastal Snow Transient Hydro-Climatology – or wet snow / rain on snow hydrology, as described by Dr Alila in his webinar presentation (2023). These are watersheds that “*start at sea level and rise to over 1100 meters*”⁽¹⁾. Their hydrology is very different from others in BC; they rely on the input of wet snow melting from a forest canopy to recharge ground water⁽¹⁾.

The total watershed area was mapped by GIS and confirmed at 8,203 ha or 82.03 km². The watershed is a blend of land ownership:

- 84% Corporate owned private forest management lands;
- 8% Publicly owned forest management lands;
- 3% Village of Cumberland;
- 3% Civic and community forest lands;
- 2% Private lands and aggregate pit lands (mostly north of Cumberland).

In the case of this assessment of the Trent River watershed, industrial development has been and continues to be primarily privately managed forest harvesting.

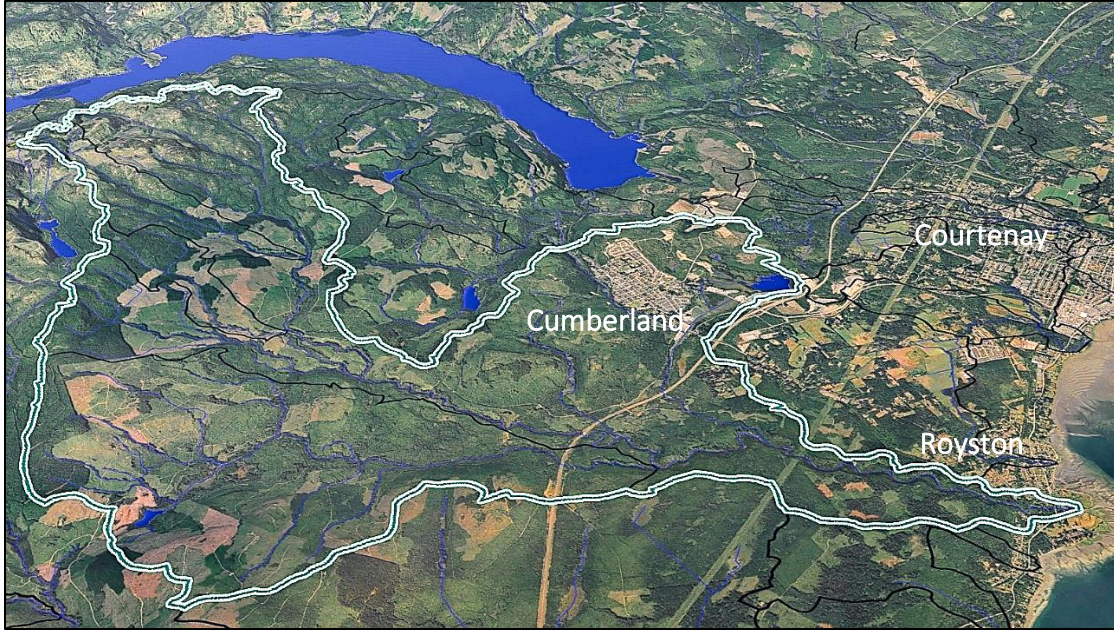


Figure 1: Oblique 2023 Google Earth image of the Trent River Watershed – looking from the east (right side of the image), to the west (left side of the image).

The total watershed area boundary above is in white.

3.0 Objectives of the Report

The prime objectives of this Trent River Watershed CE Assessment Report (referred to in this document as the “Report”) are:

- To assess hydrological health of the Trent River watershed and to quantify the risk rating of potential negative impacts relative to watershed function and resilience, utilizing the most current approved assessment methodologies contained within the 2020 CE Protocol.
- To disseminate the Report’s findings to local communities and other interested parties – specifically the K’ómoks and Qualicum First Nations, local and provincial governments, and all landowners affected and responsible for the Trent River watershed lands, assessed within this Report.
- To present in the recommendation section of this Report, the appropriate next steps (as outlined within the Protocol), relative to the final overall risk rating value for the Trent River watershed.

4.0 Cumulative Effects Protocol Assessment Model

The Protocol describes a set of watershed indicators that can be calculated using GIS data layers. The initial set of indicators capture different aspects of watershed functions and are designed to inform watershed development and management decisions relating to mitigating the impacts.

The Protocol's conceptual model links selected watershed indicators to identified aquatic ecosystem components, functions, processes, and factors within a nested hierarchy. A complete graphic explanation of the conceptual model hierarchy is in Appendix 10.1, from the original Protocol ⁽³⁾. For this report, the process has been simplified graphically to reflect the targeted regional application of the Protocol to the conditions of the Trent River and the metrics available to be assessed by BWS.

Each of the components of the conceptual model (i.e., Water Quantity, Water Quality and Ecosystem Function (also referred to as Aquatic Habitat Function)), are illustrated in Figure 2 below. The model identifies the specific six indicators and how they relate to the corresponding Components of the Protocol.

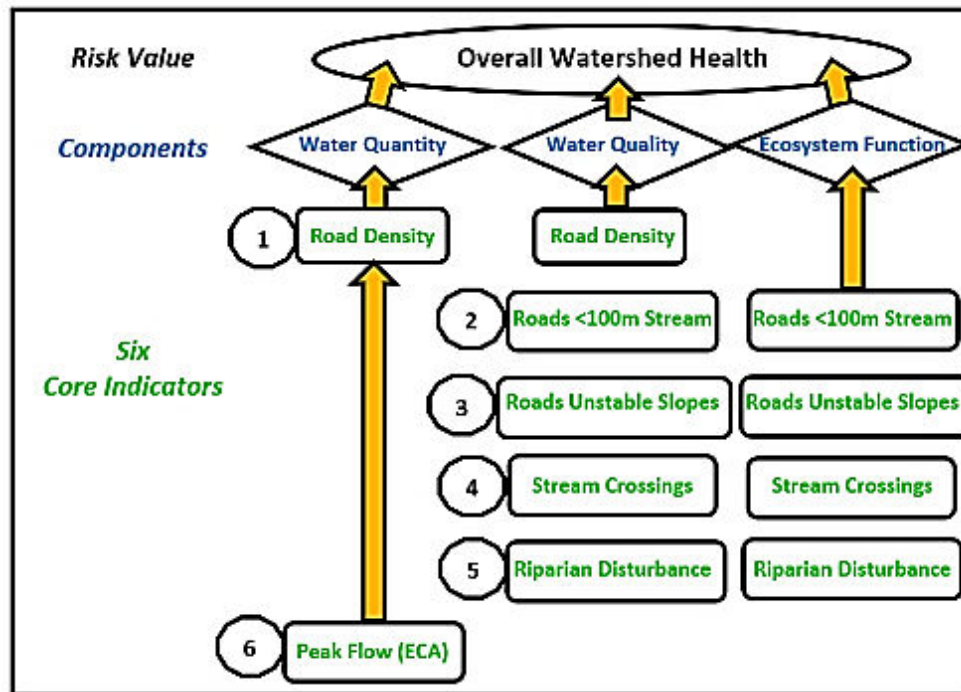


Figure 2: Simplified Protocol Flow Chart: Progressing upward, this figure illustrates which of the six Core Indicators (Identified by a circled number in black), determine the status of the three Watershed Components – Water Quantity, Water Quality and Ecosystem Function - and which in turn determines the Overall Watershed Health Rating at the top.

4.1 Core Indicators Assessed

The Protocol's indicators are divided into two groupings:

Six Core Indicators and **Eight Supplemental Indicators**.

Only the core indicators were assessed as these were the only indicators that have published thresholds within the 2020 Protocol.

Below is a list of the indicators that were assessed, and the metrics tallied.

Core Indicators	Description	Metrics
1	Road Density	km/km ²
2	Road Density < 100 m from a stream	km/km ²
3	Road Density on potentially unstable slopes	km/km ²
4	Stream Crossing Density	#/km ²
5	Riparian Disturbance	km disturbance / km total streams
6	Peak Flow – combination of three factors: a) Natural Runoff Generation Potential considers bio-geoclimatic (BEC) subzone and alpine non-forest areas. b) Surface Flow Attenuation considers drainage density ruggedness and absence of lakes and wetlands. c) Equivalent Clearcut Area (ECA) – considers the influence of forest cover disturbance (i.e., clearcuts) to changes in stream flow.	a) BEC sensitivity and % natural alpine/km² bi) Total stream length per total watershed area (km/km²), times the elevation difference and bii) Area weighted proportion of area of lakes and wetland per lower, mid, and upper thirds of the entire watershed. c) Total ECA area (tallied by Disturbance Unit [DU] per height of trees), divided by the net area of the watershed.

Table 2: The Six Core Indicators assessed in this Report with detailed descriptions and metrics.

4.2 Supplemental Indicators Not Assessed.

The following supplemental indicators were not assessed for this Report as the Protocol did not provide established benchmarks or thresholds to use in the risk rating the of the watershed. However, considering the current varied developments within the Trent River watershed, most of the eight supplemental indicators would have aided in assessing a complete suite of cumulative effects and the impacts.

List of Protocol Supplemental Indicators

- 1) Proportion of Riparian Disturbance (%) for Streams, Lakes, and Wetlands
- 2) Wetland Disturbance (%)
- 3) Total Land Disturbance (Human Disturbance/Land Use/Land Cover and Natural Disturbance combined)
- 4) Land Ownership (%)
- 5) Mines (#/Watershed)
- 6) Permitted Waste Discharge (#/Watershed)
- 7) Water Withdrawals (#/Watershed)
- 8) Dams (#/Watershed)

5.0 Data Collection Methodologies per Core Indicators

5.1 GIS Data Collection Process and Reference Maps Produced.

The majority of the six Core Indicators were determined via GIS analysis. The imagery primarily used for the analysis in this Report, was the July 2023 public Google Earth Pro images.

The following is an example map of the data collected for each of the six indicators. All of the GIS maps produced are presented in Appendix 10.5. This example shows the data collected for roads and road crossings.

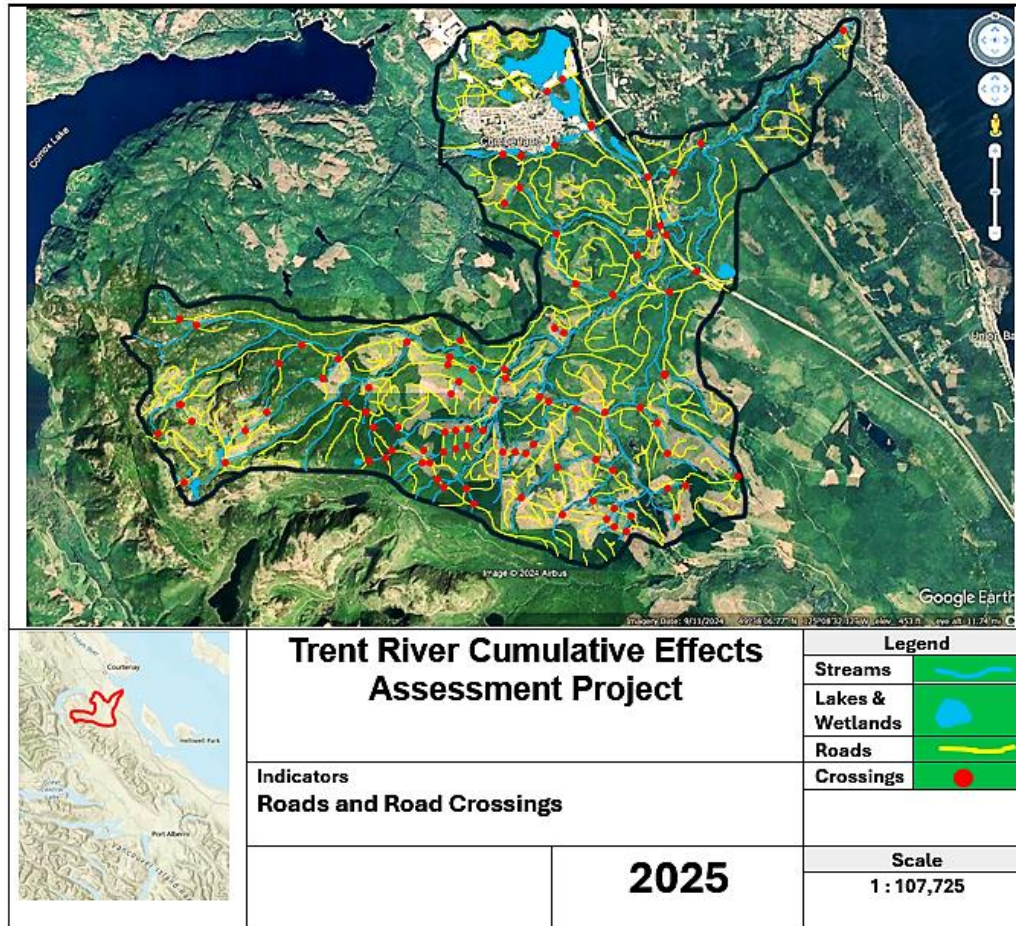


Figure 3: Example of a GIS deliverable map product.

5.2 Detailed Data Collection Methods per Core Indicator

Below are descriptions of the methods used in this Report, sourced directly from the 2020 Protocol⁽³⁾. More information for each Indicator, along with the scientific context and thresholds, are available from the link to the Protocol in the Reference section.

A percentage of selected Core Indicator metrics were ground verified: 64% of tree heights within designated disturbance units for the Peak Flow Indicator; 17% of GIS identified Stream Crossings; and 15% for imagery identified Riparian Disturbances.

1) Road Density (km/km²)

The total length of roads (km) was determined by GIS analysis. Then the total length of roads was divided by the total watershed area (km²).

Note: Only the total road length was used to assess the impacts to water quantity and no weighting by road types was performed (therefore the higher benchmarks were used – as per the procedures in the Protocol).

2) Road Density < 100 m from a stream (km/km²)

The total length of roads < 100 meters from a stream (km) was determined by GIS analysis. For the Aquatic Habitat Component, the total length of roads was divided by the total watershed area (km²). For the Water Quality Component, the weighted total road lengths by road category, divided by the total watershed area was used, as outlined in Table 1 of the Protocol.

3) Road Density on potentially unstable slopes (km/km²)

The total length of roads on slopes > 60% slopes (km) was determined by GIS analysis. Then the total length of roads was divided by the total watershed area (km²).

4) Stream Crossing Density (#/km²)

The total number of stream crossings was determined by GIS analysis. Then the total number (#) was divided by the total watershed area (km²).

5) Riparian Disturbance (km/km Streams) – Linear Based Measurement

The total length (km) of streams with riparian disturbance within 30 m of a stream, was determined by Google Earth image interpretation and were verified on the ground where possible. A complete list and Google Earth screenshots of documented riparian disturbance are located in Appendix 10.4. The total length of streams in the watershed (km) were determined by GIS analysis. Subsequently the total riparian disturbance length was divided by the total length of streams in the watershed (km/km).

Figure 4 below shows two photos of Riparian Disturbance within 30 m of stream channels, identified on Google Earth and verified on the ground (both located in the upper Trent River). The stream on the left is an unclassified stream that had no riparian tree protection and was tallied as disturbed due to logging across the stream channels. The stream on the right is the type of disturbance where reserve trees along stream blew down after a wind event.



Figure 4: Ground verified Riparian Disturbance identified (the blue arrows trace the stream channel)

6) Peak Flow (*the most complex indicator*)

Below is a graphic illustration of how these complex groupings of several metrics are processed:

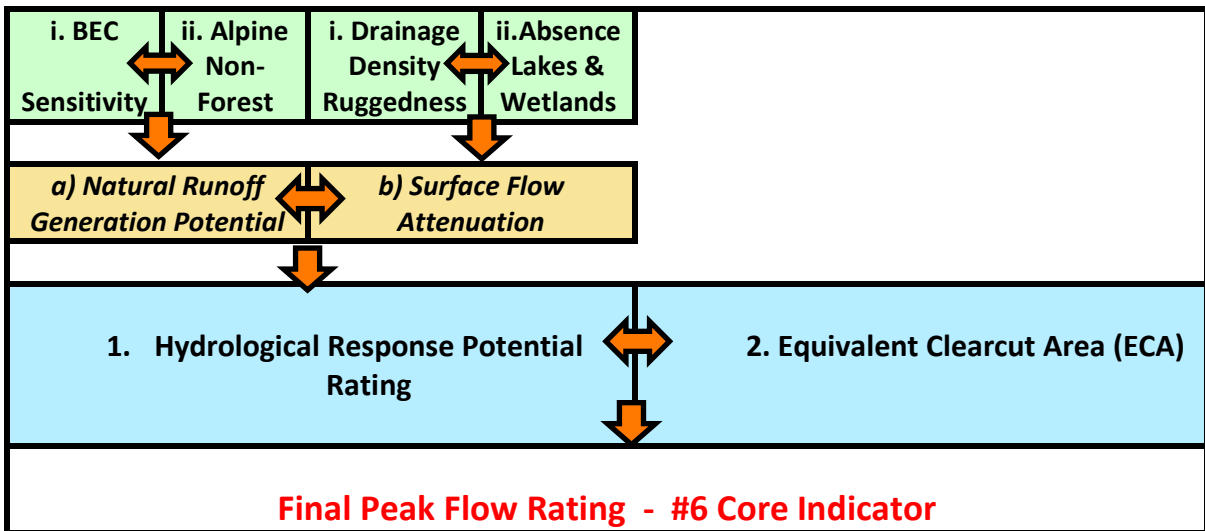


Figure 5: The Peak Flow Graphic illustrates how each micro and sub-metric is processed and subsequently determines each following metric.

Peak Flow Sub-Metric Methodologies

1. **Hydrological Response Potential Rating** This sub-metric is composed of several micro-metrics. Combined, they generate an overall score for this potential rating.

a) Natural Runoff Generation Potential was calculated by using the following two micro-metrics:

- i. Biogeoclimatic Ecosystem Classification (BEC). A relative BEC unit sensitivity ranking is an indicator of average annual precipitation, average snowpack accumulation and persistence (Lewis et al., 2016; Smith et al., 2019)⁽³⁾. The BEC score is coded into 3 numerical classes for the assessment watershed:

1. LOW (0 – 0.5)
2. MODERATE (≥ 0.5 – 1.5)
3. HIGH (≥ 1.5)

Local BEC subzones were determined from the BC Government's BEC website maps⁽⁵⁾. The Protocol's BEC Sensitivity Scores tab in Appendix 2 of the Protocol⁽³⁾ was used to determine these rankings.

- ii. Percent Alpine and Non-Forested Areas. Natural alpine areas and associated features (ice/snow, rock/rubble, moraine) are assessed to estimate the potential for peak flow under natural conditions. The proportion of alpine and non-forested area is coded into 3 numerical classes:

1. $\geq 70\%$
2. 30-70%
3. $< 30\%$

The alpine and non-forested area was identified using Google Earth imagery interpretation of vegetation cover. The total alpine and non-forested area (ha) was divided by the total watershed area (ha) and multiplied by 100 to determine the percentage.

These two micro-metrics scores are combined to give the a) Natural Runoff Generation Potential ranking, using the following table from the Protocol below (Lewis et al, 2016)⁽³⁾:

		BEC Unit Score		
Proportion of Alpine Non-Forested Area (%)		1	2	3
	< 30	Moderate	High	Very High
	31-70	Low	Moderate	High
	> 70	Very Low	Low	Moderate

Table 3: Scoring matrix to derive Natural Runoff Generation Potential ranking⁽³⁾.

- b) Surface Flow Attenuation was calculated by using the following two micro-metrics:

- i. Drainage Density Ruggedness (DDR) (Melton, 1957)⁽³⁾ is the dimensionless product of drainage density (stream length per unit area – km/km²) and total elevation relief (the difference between the highest and lowest points in the watershed relative to watershed length in km) (Schumm 1956)⁽³⁾. DDR is coded into 3 numerical classes:
 1. < 2000
 2. 2001-4000
 3. > 4000

The DDR was determined via GIS analysis using Google Earth.

- ii. Absence of Lakes and Wetlands were calculated using the 1:20,000 lakes and wetlands GIS layers to measure the area of lakes and wetlands within the lower 30%, mid 30% and upper 40% of each watershed. The area-weighted proportion (%) covered by lakes and wetlands was calculated by weighting the lower 30% of the area by 100%, the middle 30% by 75%, and the upper 40% by 25%. This gave greater weight to larger lakes and wetlands situated lower in a watershed, which are more likely to attenuate runoff (Lewis et al, 2016)⁽³⁾. The proportion of lakes and wetlands and the position in the watershed, were scored and coded into 3 numerical classes:
1. >6.1 %
 2. 2.1-6 %
 3. 0-2 %

The lakes and wetland metric was determined by GIS analysis.

These two micro-metric scores are combined to give the b) Surface Flow Attenuation ranking, using the following table from the Protocol (Lewis et al, 2016)⁽³⁾:

		Drainage Density Ruggedness		
Location Weighted Percent Area of Lakes/Wetlands		<2000	2001-4000	>4000
	0-2	Moderate	Low	Very Low
	2.1-6.0	High	Moderate	Low
	>6.1	Very High	High	Moderate

Table 4: Scoring matrix to derive Surface Flow Attenuation ranking⁽³⁾.

Therefore, calculated scores for a) Natural Runoff Generation Potential and b) Surface Flow Attenuation were summed to indicate the final **1) Hydrologic Response Potential Rating** (Lewis et al, 2016)⁽³⁾. These numerical scores range from 4 to 12, and are classified as follows:

VERY LOW: < 6
LOW: ≥ 6 and < 8
MODERATE: ≥ 8 and < 9
HIGH: ≥ 9 and < 11
VERY HIGH: ≥ 11

2) Equivalent Clearcut Area (ECA)

ECA is basically a “snapshot in time” of the percentage of the watershed area that is still in a hydrological clearcut state. A further detailed explanation of ECA is contained in Appendix 10.2 of this Report.

This metric is best suited for the use and interpretation of LiDAR (Light Detection And Ranging) tree height imagery data. However, for the Trent River watershed, no publicly accessible LiDAR was available. Therefore, the methods used were a combination of satellite imagery interpretation and ground height measurements. The final areas per each Disturbance Unit (DU) were tallied by GIS and a *hydrological*

recovery factor was assigned to each DU, using the ECA tables developed by Hudson found in the Appendix of the Protocol ⁽³⁾.

The resulting ECA areas for each DU were tallied and then divided by the total watershed area (minus urban centers contained in Cumberland, Royston Road area and Royston) x 100, to determine the final ECA % for the watershed. ECA details by DU are presented in Appendix 10.3.

Note: *The total area has been decreased for this ECA calculation for the Trent River watershed, because the 2020 Protocol currently has no effective way of considering the hydrological recovery of urban areas within a functioning watershed. This aspect of the Protocol maybe be addressed in the next version of the Protocol in 2026, under the Supplemental Indicators. Also, this is an accepted current procedure in detailed professional hydrological watershed assessments (specifically within the Mt. Elphinstone South Watershed Assessment for BCTS in 2023⁽¹⁰⁾) where urban areas were deleted from the assessment area for the ECA calculations, to better reflect the impact from forest harvesting directly on the industrial landscape of the watershed.*

Final - Peak Flow Index Rating:

The **1) Hydrologic Response Potential Rating** is combined with the **2) Proportion of ECA** in the following matrix, to result in a **Peak Flow Index Number** (consistent with Lewis et al, 2016)⁽³⁾.

		Peak Flow Index Number																			
Hydrologic Response Potential Class	VH	0.05	0.1	0.21	0.23	0.31	0.33	0.43	0.45	0.56	0.58	0.6	0.63	0.66	0.7	0.75	0.8	0.85	0.9	0.95	1
	H	0.04	0.09	0.14	0.22	0.25	0.32	0.35	0.44	0.47	0.57	0.59	0.62	0.65	0.69	0.74	0.79	0.84	0.89	0.94	0.99
	M	0.03	0.08	0.13	0.17	0.24	0.27	0.34	0.37	0.46	0.48	0.5	0.61	0.64	0.68	0.73	0.78	0.83	0.88	0.93	0.98
	L	0.02	0.07	0.12	0.16	0.19	0.26	0.29	0.36	0.39	0.41	0.49	0.52	0.54	0.67	0.72	0.77	0.82	0.87	0.92	0.97
	VL	0.01	0.06	0.11	0.15	0.18	0.2	0.28	0.3	0.38	0.4	0.42	0.51	0.53	0.55	0.71	0.76	0.81	0.86	0.91	0.96
		0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100
		ECA																			

Table 5: Scoring matrix to derive Peak Flow Index Number⁽³⁾.

These numerical scores for **Peak Flow** are classified as follows:

LOW <0.3

MODERATE 0.3-0.42

HIGH >0.42

5.3 Trent River Data Metric Values and Core Indicator Calculations

Data and /or Metric	Value	Description and / or Calculation
Date of satellite imagery used	July-2023	
Total Watershed Area	8,203 ha 82.03 km ²	
Area of Alpine and Non-Forested	281 ha 3.4%	
Areas of Wetlands and Lakes	219.9 ha	
Areas of Wetlands and Lakes at 3 elevation levels lower 30% - 2,461 ha middle 30% - 2,461 ha upper 40% - 3,281 ha	148.47 ha 26.0 ha 45.38 ha	$6.03\% \times 100\% = 6.03$ $1.06\% \times 75\% = 0.79$ $1.38\% \times 25\% = 0.34$ Area Weighted Proportion 7.16%
Length of the watershed in km	17.69 km	Elevation difference - 1210 m. to 0 m.
Area of >60% slope	148.5 ha	1.8% of the total watershed area
Length in km of all streams and rivers	104.81 km	
BEC Subzones (4 subzones)	Sensitivity Score (SS) 2	MHmm1 SS 2 CWHmm2 SS 2 CWHmm1 SS 2 CWHxm1 SS 2
Total Equivalent Clearcut Area (ECA)	57%	

Table 6: Data Metric Values

Core Indicator	Metric Value	Indicator Rating Value																																																																																																																																																																																														
1. Road density (km/km ²)	309.0 km Roads	3.77 km/km ²																																																																																																																																																																																														
2. Road density located <100 m from a stream (km/km ²)	54.4 km Roads	Aquatic Habitat 0.65 km/km ²	Water Quality 0.22 km/km ²																																																																																																																																																																																													
3. Road density on potentially unstable terrain (km/km ²)	0.8 km Roads	0.01 km/km ²																																																																																																																																																																																														
4. Number of stream crossings	# 115	1.41 /km ²																																																																																																																																																																																														
5. Riparian disturbance (km/km)	11.8 km	0.11 km/km																																																																																																																																																																																														
6. Peak Flow (most complex indicator)		0.61 (Calculation Details below)																																																																																																																																																																																														
Graphic of Peak Flow process																																																																																																																																																																																																
a) Natural Runoff Generation Potential HIGH Cumulative Score 3+3=6	<u>BEC Unit 2 value (≥ 1.5 – Score 3) & Proportion Alpine and Non-Forest Area 3.4% (< 30% - Score 3)</u> <table><tr><th rowspan="4">Proportion of Alpine Non-Forested Area (%)</th><th rowspan="4"></th><th colspan="3">BEC Unit Score</th></tr><tr><th>1</th><th>2</th><th>3</th></tr><tr><td>Moderate</td><td>High</td><td>Very High</td></tr><tr><td>Low</td><td>Moderate</td><td>High</td></tr><tr><td><30</td><td></td><td></td><td></td><td></td></tr><tr><td>31-70</td><td></td><td></td><td></td><td></td></tr><tr><td>>70</td><td></td><td></td><td></td><td></td></tr></table>			Proportion of Alpine Non-Forested Area (%)		BEC Unit Score			1	2	3	Moderate	High	Very High	Low	Moderate	High	<30					31-70					>70																																																																																																																																																																				
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b) Surface Flow Attenuation VERY HIGH Cumulative Score 1+1=2	<u>Drainage Density Ruggedness - Stream length / total area(km/km²) and elevation difference (km) 2.49 value (<2000 Score 1) & Absence of lakes and wetlands 7.16% (>6.1% Score 1)</u> <table><tr><th rowspan="4">Location Weighted Percent Area of Lakes/Wetlands</th><th rowspan="4"></th><th colspan="3">Drainage Density Ruggedness</th></tr><tr><th><2000</th><th>2001-4000</th><th>>4000</th></tr><tr><td>Moderate</td><td>Low</td><td>Very Low</td></tr><tr><td>High</td><td>Moderate</td><td>Low</td></tr><tr><td><2000</td><td></td><td></td><td></td><td></td></tr><tr><td>2.1-6.0</td><td></td><td></td><td></td><td></td></tr><tr><td>>6.1</td><td></td><td></td><td></td><td></td></tr></table>			Location Weighted Percent Area of Lakes/Wetlands		Drainage Density Ruggedness			<2000	2001-4000	>4000	Moderate	Low	Very Low	High	Moderate	Low	<2000					2.1-6.0					>6.1																																																																																																																																																																				
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1) Hydrological Response Potential MODERATE 2) Proportion of ECA 57%	a) <u>Natural Runoff Generation Potential</u> and b) <u>Surface Flow Attenuation</u> resultant scores are summed – 6+2=8 1) Hydrologic Response Potential Rating: VERY LOW: < 6 LOW: ≥ 6 and ≤ 8 MODERATE: ≥ 8 and < 9 HIGH: ≥ 9 and < 11 VERY HIGH: ≥ 11																																																																																																																																																																																															
Final Peak Flow Rating 0.61 VERY HIGH	<table><tr><th colspan="2"></th><th colspan="22">Peak Flow Index Number</th></tr><tr><td rowspan="4">Hydrologic Response Potential Class</td><td>VI</td><td>0.05</td><td>0.1</td><td>0.21</td><td>0.23</td><td>0.31</td><td>0.33</td><td>0.43</td><td>0.45</td><td>0.56</td><td>0.58</td><td>0.6</td><td>0.63</td><td>0.66</td><td>0.7</td><td>0.75</td><td>0.8</td><td>0.85</td><td>0.9</td><td>0.95</td><td>1</td><td></td><td></td></tr><tr><td>V</td><td>0.04</td><td>0.09</td><td>0.14</td><td>0.22</td><td>0.25</td><td>0.32</td><td>0.35</td><td>0.44</td><td>0.47</td><td>0.57</td><td>0.59</td><td>0.62</td><td>0.65</td><td>0.69</td><td>0.74</td><td>0.79</td><td>0.84</td><td>0.89</td><td>0.94</td><td>0.99</td><td></td><td></td></tr><tr><td>M</td><td>0.03</td><td>0.08</td><td>0.13</td><td>0.17</td><td>0.24</td><td>0.27</td><td>0.34</td><td>0.37</td><td>0.46</td><td>0.48</td><td>0.5</td><td>0.61</td><td>0.64</td><td>0.68</td><td>0.73</td><td>0.78</td><td>0.83</td><td>0.88</td><td>0.93</td><td>0.98</td><td></td><td></td></tr><tr><td>L</td><td>0.02</td><td>0.07</td><td>0.12</td><td>0.16</td><td>0.19</td><td>0.26</td><td>0.29</td><td>0.36</td><td>0.39</td><td>0.41</td><td>0.49</td><td>0.52</td><td>0.54</td><td>0.67</td><td>0.72</td><td>0.77</td><td>0.82</td><td>0.87</td><td>0.92</td><td>0.97</td><td></td><td></td></tr><tr><td></td><td>VL</td><td>0.01</td><td>0.06</td><td>0.11</td><td>0.15</td><td>0.18</td><td>0.2</td><td>0.28</td><td>0.3</td><td>0.38</td><td>0.4</td><td>0.42</td><td>0.51</td><td>0.53</td><td>0.55</td><td>0.71</td><td>0.76</td><td>0.81</td><td>0.86</td><td>0.91</td><td>0.96</td><td></td><td></td></tr><tr><td></td><td></td><td>0-5</td><td>6-10</td><td>11-15</td><td>16-20</td><td>21-25</td><td>26-30</td><td>31-35</td><td>36-40</td><td>41-45</td><td>46-50</td><td>51-55</td><td>56-60</td><td>61-65</td><td>66-70</td><td>71-75</td><td>76-80</td><td>81-85</td><td>86-90</td><td>91-95</td><td>96-100</td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Peak Flow Index Number																						Hydrologic Response Potential Class	VI	0.05	0.1	0.21	0.23	0.31	0.33	0.43	0.45	0.56	0.58	0.6	0.63	0.66	0.7	0.75	0.8	0.85	0.9	0.95	1			V	0.04	0.09	0.14	0.22	0.25	0.32	0.35	0.44	0.47	0.57	0.59	0.62	0.65	0.69	0.74	0.79	0.84	0.89	0.94	0.99			M	0.03	0.08	0.13	0.17	0.24	0.27	0.34	0.37	0.46	0.48	0.5	0.61	0.64	0.68	0.73	0.78	0.83	0.88	0.93	0.98			L	0.02	0.07	0.12	0.16	0.19	0.26	0.29	0.36	0.39	0.41	0.49	0.52	0.54	0.67	0.72	0.77	0.82	0.87	0.92	0.97				VL	0.01	0.06	0.11	0.15	0.18	0.2	0.28	0.3	0.38	0.4	0.42	0.51	0.53	0.55	0.71	0.76	0.81	0.86	0.91	0.96					0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100																										
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Table 7: Core Indicator Calculations

6.0 Results per Core Indicator

The following is a Summary Table listing the six Core Indicators' final values. High values are shown in **red**.

Core Indicator	Road Density	Road Density < 100 m Stream		Road Density Unstable Slopes*	Stream Crossing Density	Riparian Disturbance	Peak Flow (sub metric is ECA)
		Aquatic Habitat	Water Quality				
Core Indicator Values	3.8 km/km ² HIGH	0.7 km/km ² HIGH	0.2 km/km ² MOD	0.01 km/km ² LOW	1.41 #/km ² HIGH	0.11 km/km LOW	0.61 HIGH
Core Indicator Thresholds ₍₃₎							
LOW	< 1.5	< 0.12		< 0.12	< 0.60	< 0.12	< 0.3
MODERATE	1.5 – 2.1	0.12 – 0.30		0.12 – 0.25	0.6 – 1.40	0.12 – 0.21	0.3 – 0.42
HIGH	> 2.1	> 0.30		> 0.25	> 1.40	> 0.21	> 0.42
ECA % Total							57%
Priv. Forest							58%
Public Forest							43%

Table 8: Summary Table of all Core Indicator Values with thresholds.

*One area containing a slope failure was identified on Google Earth images within the area of > 60% slope. No ground verification was performed and therefore, it was not possible to determine if the road construction caused the slide or not.

7.0 Overall Risk Rating

Figure 6 summarizes how the Overall Watershed Health rating was determined by the Core Indicator's values and ratings, as defined in the hierarchy of the Protocol₍₃₎.

Within the Indicators that impact the watershed Components – *Water Quality, Water Quantity and Aquatic Habitat Function* – the highest rating of the Indicators determines the rating for that Component. Likewise, the highest rating of all the Components determines the Overall rating for the watershed.

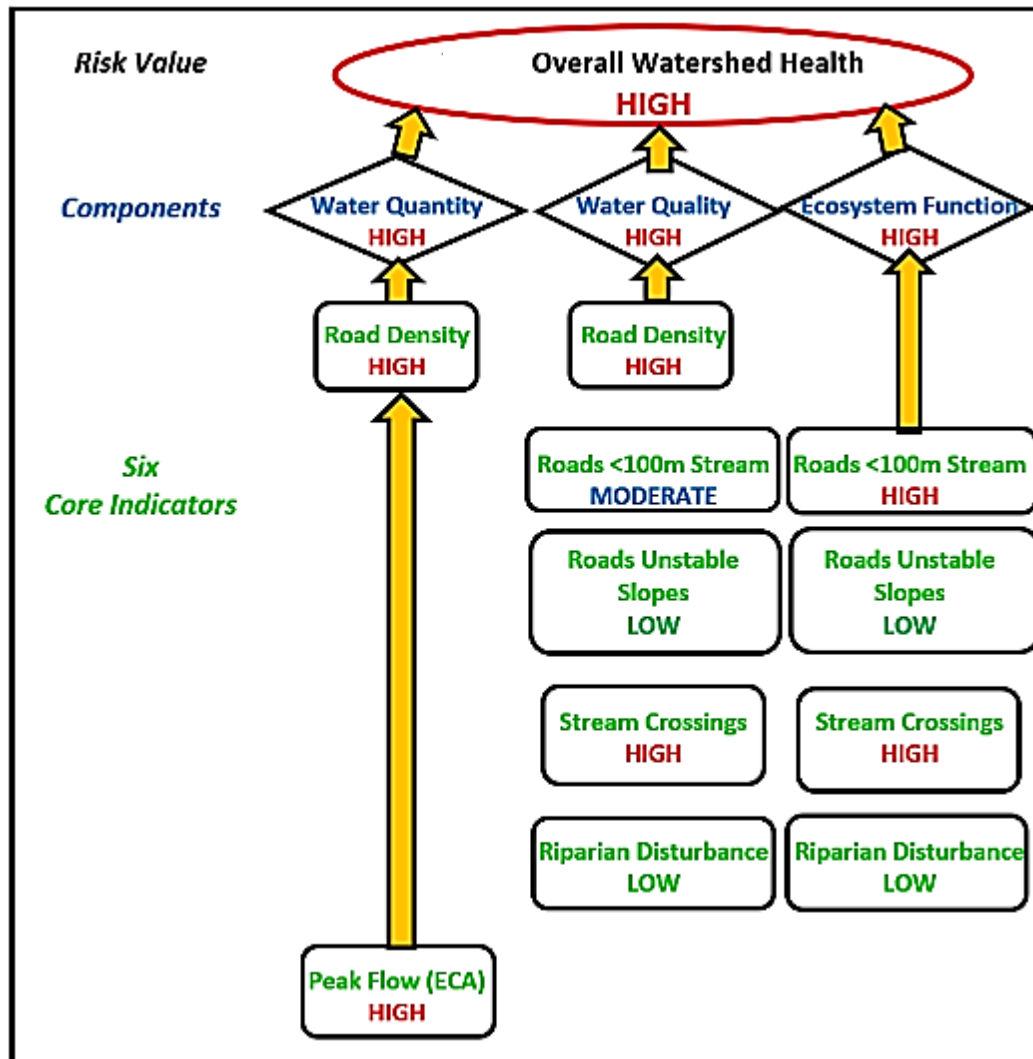


Figure 6: How the Overall Trent River Watershed Ratings are determined as per the Protocol model.

Therefore, using the procedures and hierarchy of the Protocol, the Trent River Watershed is rated as a **high-risk** overall, of potential negative impacts to hydrological and aquatic ecosystem function due to the cumulative effects of industrial development⁽³⁾. When a high rating is produced, the Protocol recommends an adjustment of developmental activities be undertaken⁽³⁾.

The Protocol also recommends that watersheds with a resultant high-risk rating (using these Protocol coarse filter procedures), should be highlighted as requiring further rigorous assessments by qualified professionals, to verify this preliminary risk rating. This is consistent with procedural recommendations made by the forest hydrologist Dr Alila^(1,2) and is also consistent with the guidance within the *Joint Professional Watershed Practice Guidelines* document, published by the *Forest Professionals of BC (FPBC)* and the *Engineers and Geoscientists BC* in 2020⁽⁸⁾.

8.0 Recommendation

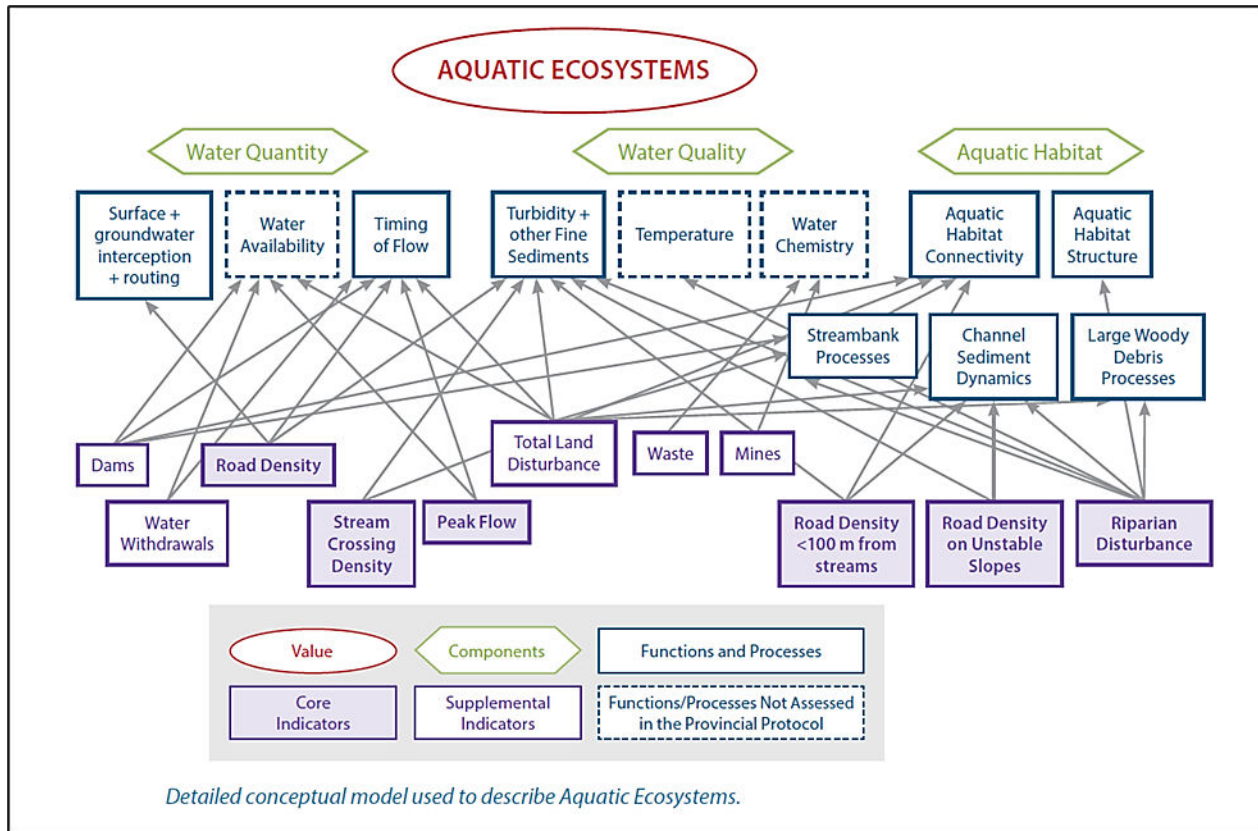
Due to the resultant high-risk rating of the cumulative effects potential impacts assessed within this Trent River Watershed Report, further professional assessment of the Trent system is recommended to be undertaken. This action follows the next steps of a high-risk rating outcome, as presented within the Protocol and supported by BC professionals and scientists.

9.0 References

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https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/lmh66/lmh66_volume1of2.pdf
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10.0 Appendices

10.1 Original Conceptual Model of the Protocol



10.2 Equivalent Clearcut Area (ECA) Explanation₍₉₎

What is **ECA** and Hydrological recovery?

- **Equivalent Clearcut Area (ECA)** is basically a “snap shot in time” of the percentage of the watershed area still in a *hydrological “clearcut state”*



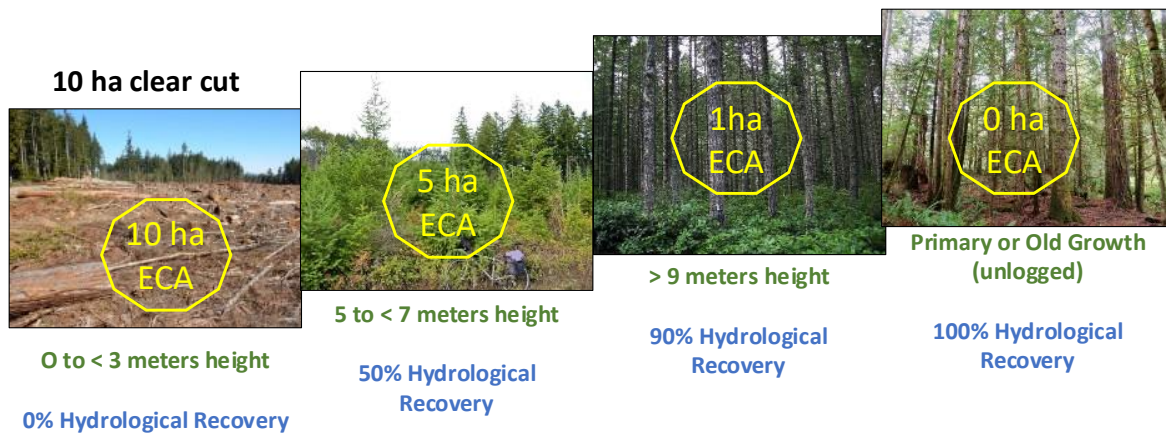
- **Clearcut State** is all disturbed / denuded / clearcut harvested forest areas, that have had the vegetation cover removed and the resultant regenerating vegetation has not yet achieved hydrological recovery



- **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

Height of Trees = % Hydrological Recovery

+/- best match



10.3 Disturbance Units (DU) Classes and Equivalent Clearcut Area (ECA) Determinations

Tree Height Range (Meters)	Hydrological Recovery Factor (HRF)
0 - <3 m	1
3 - <5 m	0.86
5 - <7 m	0.75
7 - <9 m	0.63
9 - <20 m	0.25
≥20 m 2nd Growth	0.1
Old Growth	0

HRF - Averaged Hydrological Recovery Factors are from the CE Protocols 2020 Excel descriptions (reference Hudson 2007 from the Protocol₍₃₎).

Trent TOTAL						
DU Class		Ha	Tree Ht	HRF	ECA Ha	
Red		1329.8	0 - <3 m	1	1329.8	
Purple		1182.8	3 - <5 m	0.86	1017.208	
Orange		1426.5	5 - <7 m	0.75	1069.875	
Yellow		819.5	7 - <9 m	0.63	516.285	
Yellow Green		541.8	9 - <20 m	0.25	135.45	
Light Green		2024.29	≥20 m 2nd Growth	0.1	202.429	
Dark Green		145.4	≥20 m Primary Growth	0	0	
		7470.09			TOTAL	4271.047
	Check	7470.09			ECA Ha	57.17%

10.4 Riparian Disturbance Measurements and Images

All documented by Stream.

Lower Trent Area – No Riparian Disturbance observed

North Cumberland Area

Riparian Vegetation and Stream Channel Altered
– Maple Creek adjacent to Sewage Treatment
Plant – 1.8 km



South Cumberland Area

“Soggy Mountain Bike (MB) Trail” No riparian
protection – 0.22 km



“Amore MB Trail” No riparian protection –
0.66 km

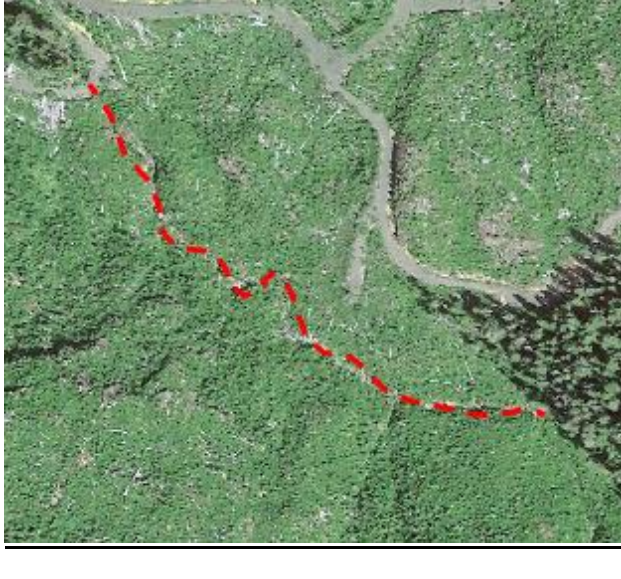
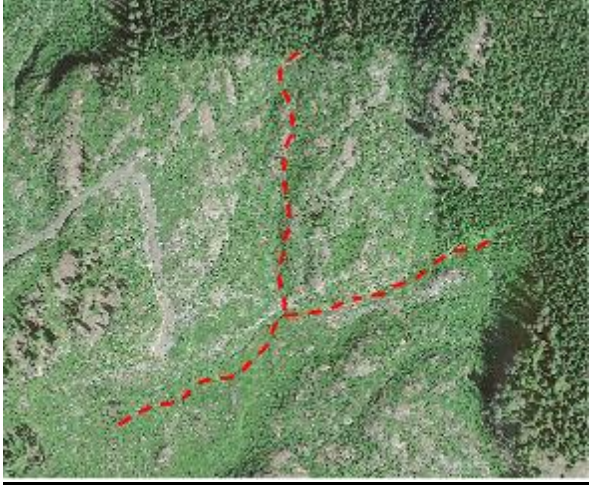


“Parmesan MB Trail” No Protection – 0.42 km



Mid Trent Trent River Main / Allen Lake Main - No Riparian Protection – 0.60 km	Trent River Main and East Trent Main - No Riparian Protection – 0.33 km
	
East Trent Main - No Riparian Protection – 0.44 km	No Riparian Protection – 0.25 km
	
No Riparian Protection – 0.43 km	No Riparian Protection – 0.91 km
	

No Riparian Protection – 1.81 km	No Riparian Protection – 0.72 km
	
<u>Bloedel</u> No Riparian Protection – 0.47 km	Incomplete Riparian Protection – 0.7 km
	
No Riparian Protection – 0.26 km	No Riparian Protection – 0.3 km
	

No Riparian Protection – 0.14 km	Upper Trent No Riparian Protection – 0.42 km
	
No Riparian Protection – 0.73 km	No Riparian Protection – 0.25 km
	

10.5 GIS Maps per Metrics, Core Indicator and Land Ownership

