WATERSHED ASSESSMENT

Burnett Creek – Sunshine Coast Community Forest

Project Number: 23-197

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SUMMARY

The Sunshine Coast Community Forest (SCCF) retained Statlu Environmental Consulting Ltd. (Statlu) to complete a watershed assessment for the Burnett Creek watershed. The assessment evaluates the effects of past, present, and proposed future forest development, road building, and natural disturbances on hydrologic values in the watershed.

The watershed ECA is currently 15.6% of watershed area (134.4 ha) and will decrease to 14.4% by 2026, and 12.5% by 2029, if no development occurs and if hydrologic recovery proceeds at the current rate.

The proposed harvesting will increase watershed ECA to 18.6% (160.4 ha) by 2026 and to 19.6% (169.0 ha) by 2029, which is below a level where increased hydrogeomorphic risk would be expected to increase.

Road density is currently 2.0 km/km² and will increase to 2.3 km/km² by 2026, if all proposed roads are developed and no roads are deactivated. Road density can be managed by reducing the length of road in the watershed by hydrologically deactivating unneeded roads. If at least 2.2 km of existing roads and 2.5 km of the proposed roads are deactivated, the road density will remain below the moderate benchmark (1.5 km/km² to 2.1 km/km²).

A road status survey of all roads in the watershed should be completed. The survey should record the status (e.g., existing, deactivated, wilderness, proposed) of all road segments. The data should be used to derive a more accurate road density estimate in the watershed in order to plan future road construction, maintenance, and deactivation.

Burnett Creek watershed has very low to moderate hydrological partial risk. The peak flows could damage water intakes and low flow conditions could decrease water supply and increase water temperatures. These factors are classed as moderate hydrological partial risk.

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1.0 INTRODUCTION

The Sunshine Coast Community Forest (SCCF) retained Statlu Environmental Consulting Ltd. (Statlu) to assess the Burnett Creek Watershed, near Sechelt, BC. SCCF has forest development plans in the watershed and requested a watershed assessment to assess the effects of the proposed development on watershed hydrology and to provide guidance for current and future forest management.

2.0 OVERVIEW AND BACKGROUND

Burnett Creek watershed is on the east side of Sechelt Inlet, about 3 km northeast of the District of Sechelt in the Pacific Ranges of the Coast Mountains. The mouth of Burnett Creek is about 700 m south of Porpoise Bay Provincial Park. Elevations in the watershed span from sea level to 1200 m above sea level near Mount Crucil. It is 864 ha in extent.

2.1 Physiography and Geology

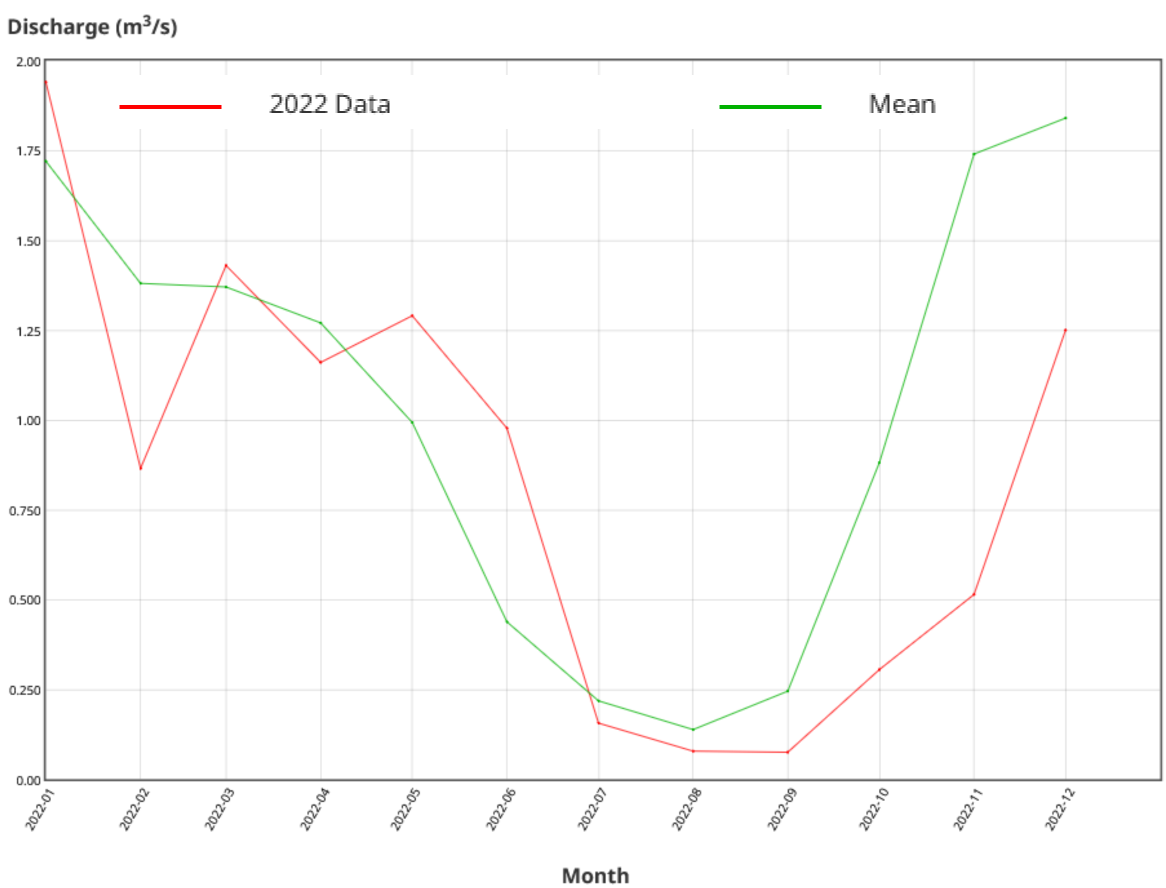
Burnett Creek drains a subalpine plateau, a relict peneplain surface formed by the uplift of the Coast Mountains forming a portion of the face of the ridge between the deeply incised Gray Creek and Chapman Creek drainages. It flows into Sechelt Inlet south of the large alluvial fan of Angus Creek, but unlike Angus Creek, Burnett Creek does not have an appreciable fan.

Sediments in the watershed can be grouped according to elevations. Above 300 m in elevation have thin soils derived from till and weathered bedrock, and the slope gradients average 45%. Below 300 m, the sediments are more complex because of the interaction of glaciers, ice-contact sediment deposition, sedimentation during deglaciation, and changing sea levels. The sediments are derived from till, glaciomarine, marine, glaciofluvial, and fluvial sediments (McCammon, 1977). The depth of the sediments found below 300 m in elevation is variable, with deep glaciofluvial sands and gravels next to bedrock outcrops. Capilano fluvial sediments (sands and gravels) in the lower elevation part of the watershed are a source of aggregates. Swanson's Ready-Mix, a gravel pit located on the Capilano sediments, has been in operation for more than 50 years. The main channel of Burnett Creek crosses this gravel pit.

Bedrock underlying the watershed is mapped as granodioritic intrusive bedrock (iMapBC, 2023). Granodiorite is coarse-grained and can weather to grus. In general, intrusive bedrock is associated with good surface water quality and low turbidity in BC (Brown et al., 2011).

2.2 Hydrology

Burnett Creek is not gauged. The nearest gauged stream with similar watershed characteristics is Roberts Creek, about 10 km to the southeast (Wateroffice, 2023). Roberts Creek watershed is larger than Burnett Creek watershed (32.6 km² compared to 8.63 km²), but both watersheds have south aspect and the same elevation range. In addition, they have similar bedrock and surficial geologies. The general shape of Burnett Creek's hydrograph should be similar to that of Roberts Creek, although the magnitude of flow is greater in Roberts Creek.



Statistics corresponding to 63 years of data recorded from 1959 and 2022.*

Graph 1: Hydrograph for Roberts Creek (08GA047) (Wateroffice, 2023).

The hydrograph for Roberts Creek (Graph 1) indicates that peak flows occur in winter (November to January), when rain and rain-on-snow conditions are common (Wateroffice, 2023). The summer low flows occur from June to September, with the lowest flows in August. The discharge declines rapidly in the spring and rises quickly again in the fall, following the precipitation patterns in the area.

2.3 Climate

The current climate in Burnett Creek watershed, described using recent normals data from the ClimateNA model (Wang et al., 2016, Table 1), has warm summers and temperate winters, with some snow, particularly at higher elevations. Most of the precipitation occurs in winter. Precipitation increases significantly with elevation.

Table 1: Climate Conditions in Burnett Creek watershed

Location	Elevation (m)	MAT* (°C)	MWMT (°C)	MCMT (°C)	MAP (mm)	PAS (cm)	Winter PPT (%)	ERef (mm)	Runoff (mm)	CMD (mm)
High elevation forest	1045	5.8	13.8	-0.4	2845	577	79.7	570	2337	52
Bridge	710	7.4	15.2	1.2	2299	466	79.7	232	1739	78
Burnett Falls	46	10.5	17.9	4.4	1121	231	79.4	29	510	207

**MAT - mean annual temperature, MWMT - mean warmest month temperature, MCMT - mean coldest month temperature, MAP - mean annual precipitation, PAS - precipitation as snow, Winter PPT - proportion of precipitation in autumn and winter, ERef - Hargreaves reference evapotranspiration, Runoff - notional runoff, CMD - climatic moisture deficit*

2.4 Climate Change

The climate is changing and this affects watershed hydrology. Understanding the changes is necessary in order to separate and distinguish climate change from the effects of forest management on hydrologic conditions in the watershed. Modeling climate change is useful for evaluating the direction and possible magnitude of trends in climate factors that affect streamflow in order to estimate changes in streamflow.

The Plan2Adapt tool provides a summary for of the projected climate changes for the regional districts in BC, including SCRD (Table 2) (PCIC, 2023). The tool uses a standard set of climate projection data to generate the output.

Table 2: Summary of Climate Change for the Sunshine Coast in the 2050s from Plan2Adapt

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	**Range (10th to 90th percentile)**
Temperature (°C)	Annual	+3.0 °C	+2.0 °C to +4.1 °C
Precipitation (%)	Annual	-1.0%	-5.0% to +3.4%
	Summer	-13%	-40% to +1.4%
	Winter	+0.97%	-4.0% to +5.4%
Precipitation as Snow* (%) *CAUTION: This variable may have a low baseline**.*	Annual	-54%	-61% to -45%
	Winter	-56%	-59% to -45%

** These values are derived from temperature and precipitation.*

*** Percent changes from a low baseline value can result in deceptively large percent change values. A small baseline can occur when the season and/or region together naturally make for zero or near-zero values. For example, snowfall in summer in low-lying southern areas.*

The ClimateNA model (Wang et al, 2016) downscales and aggregates the results from 13 global circulation models (GCM) to evaluate potential future climate scenarios. The model uses Shared Socioeconomic Pathways (SSP) to approximate how different greenhouse gas emission scenarios, coupled with different mitigation strategies, will affect future climates. The SSP 5[1] scenario was used because it represents unrestrained growth with continued fossil fuel dependence (worst-case scenario). If less carbon and other greenhouse gases are emitted than modelled under this worst-case scenario, it is probable that the effects will be less severe than what is described here. The same locations in the watershed that were used to describe the current climate were used to model predicted climate changes (Table 3).

The temperature and precipitation will increase by 2040. Most of the expected increased precipitation will arrive in winter, with a corresponding decrease in summer precipitation. More of the winter precipitation will fall as rain and less will fall as snow. That means that the summer drought will likely be longer and could result in lower and longer low flow conditions in Burnett Creek. The combination of lower flows in the summer and warmer air temperatures will result in

[1] https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change

warmer water temperatures and increased evapotranspiration. A hint of what this predicted change might look like occurred in 2023, when the Sunshine Coast Regional District imposed Stage 5 water restrictions in Sechelt and other nearby communities, then declared a local state of emergency[2] as a response to the ongoing drought.

Table 3: Expected change relative to current climate conditions in Burnett Creek watershed – to 2040

Location	Elevation (m)	MAT* (°C)	MWMT (°C)	MCMT (°C)	MAP (%)	PAS (%)	Winter PPT (%)	ERef (%)	Runoff (%)	CMD (%)
Forest	1045	0.6	1.1	-0.1	2.7	0.9	0.7	5.3	2.2	7.7
Bridge	710	0.6	1.1	-0.2	2.8	1.0	0.8	5.2	2.0	17.9
Burnett Falls	46	0.7	1.1	-0.3	3.3	1.2	0.9	5.1	1.2	9.2

**MAT - mean annual temperature, MWMT - mean winter temperature, MCMT - mean summer temperature, MAP - mean annual precipitation, PAS - precipitation as snow, Winter PPT - proportion of precipitation in autumn and winter, ERef - Hargreaves reference evapotranspiration, Runoff - notional runoff, CMD - climatic moisture deficit*

2.5 Watershed Resources

Resources in Burnett Creek watershed include fish habitat, water resources, recreational trails, and forest resources. Trails in the mid-elevation part of the watershed are used for mountain biking, hiking, and dog walking. Four active water license points of diversion are located within the watershed (WRBC, 2023 and Table 3). Two are used for irrigation and two are used for processing and manufacturing. One domestic water license point of diversion on Burnett Creek is abandoned and inactive. Only the processing and manufacturing licences are on Burnett Creek. Burnett Falls is a barrier to fish passage, and all fish observations are recorded on the reach between the falls and Sechelt Inlet. Coastal cutthroat trout, cutthroat trout, rainbow, sculpin, coast range sculpin, coho, and chum salmon were observed in Burnett Creek (Habitat Wizard, 2023).

[2] https://www.cbc.ca/news/canada/british-columbia/sunshine-coast-drought-stage-4-restrictions-1.6960243

Table 4: Water Licences in Burnett Creek Watershed

POD Number	Status	Licence Number	Licence Status	PURPOSE	SOURCE	QUANTITY
PD79303	Active	C121111	Current	Irrigation: Private	Porpoise Bay Spring	3700.44 m3/year
PD79303	Active	C121111	Current	Irrigation: Private	Porpoise Bay Spring	3700.44 m3/year
PD45068	Inactive	C044395	Abandoned	Domestic	Burnet Creek	2.27305 m3/day
PD45158	Active	C029551	Current	Processing & Mfg	Burnet Creek	9.09218 m3/day
PD45158	Active	C038807	Current	Processing & Mfg	Burnet Creek	27.27654 m3/day

2.6 Land Use History

Burnett Creek watershed is the traditional territory of the shíshálh people. A main settlement was at tewankw near Porpoise Bay. The people speak she shashishalhem, a Coast Salish language. The effects of colonialism harmed the people, but they are still here and are reasserting themselves as stewards of the land. In 1986, the shíshálh First Nation regained self-government and are continuing to work with the Province of British Columbia to protect the environment[3].

Historic Indigenous land management practices are difficult to interpret from the air photo record because the earliest photo is from 1947. The shíshálh people had (and continue to have) a strong connection to the land[4]. They carefully managed forest resources to care for cedar trees, for example. In addition, the fish in the lower reaches of Burnett Creek were (and still are) an important food source.

The air photo record begins in 1947, but changes to the landscape, such as logging, began before that time. Logging in Burnett Creek and adjacent watersheds likely began with the development of truck logging in the 1920s and 1930s. It is possible that some of the lower elevation land near Sechelt Inlet was logged from floating A-frames before the start of the 1920s truck logging era, or by using flumes to transport wood from higher elevations to tidewater, as was done in the Roberts Creek area.

[3] https://en.wikipedia.org/wiki/Sh%C3%ADsh%C3%A1lh_Nation
[4] https://shishalh.com/

Table 5: Historic air photographs – Burnett Creek watershed

Air Photo Numbers	Date	Observations
BC349: 15-13, 92-95, 114-1124	1947	Roads and cutblocks are visible near the uppermost bridge on Burnett Creek. Much of the riparian forest harvested in blocks, but some remains where the stream flows in deeply-incised channels.
BC2099:66-64 BC2393:30-24 BC2392:90-96, 27-22	1957	The power transmission line corridor is now visible. Burnett Creek has lots of sediment visible in the channel, perhaps a result of deposition following a flood or debris flood. Log booms are visible in Sechelt Inlet. The small lake in the middle of the watershed is visible on the images. A large block on the west side of Burnett Creek, upstream of the bridge, is harvested. The riparian forest is harvested in the block, except along the reach where the stream flows in the canyon. Downstream of the falls, logging and land clearing removed the riparian forest. The riparian forest on the south side of the upper reaches of Burnett creek have been logged, except where the stream banks are very steep. Overall, more cutblocks and roads are visible in Burnett Creek and adjacent watersheds.
BC5102: 40-37, 72-74	1964	More logging is visible in the mid-elevation part of the watershed. Older blocks are starting to revegetate. Development near Sechelt Inlet is increasing, including gravel pits and other land clearing.
BC4426: 240-245, 190-182, 148-155	1967	Not much more logging than observed on earlier images, but the roads are all still clearly visible. Blocks first observed on 1957 images are starting to revegetate.
BC5758: 251-254 BC5760: 148-154, 248-251	1976	The gravel pits have larger footprints. More development is visible in the lowest part of the watershed. Not much new harvesting is visible in the middle part of the watershed, but a few new blocks are visible above the blocks harvested before 1957. Many slides are visible from blocks and roads in the adjacent Chapman Creek watershed.
30BC80060: 179-176, 199-205, 242-236	1980	The watershed appears similar to the earlier images.
30BC85015: 199-203, 214-207 30BC85030: 63-66	1985	Swanson's gravel pit is much larger than on earlier images. A new block is visible near where the Sechelt-Dakota FSR crosses Burnett Creek. A new resource road is under construction.
BCB90014: 140-148, 180-176, 113-106 BCB90046: 16-14	1990	A new block is visible near the lake and other new block on the north side of the stream are visible. The new blocks are smaller than the older ones. A quarry is visible near the E200 Road. The older blocks are continuing to revegetate.
30BCC94145: 055, 114-107, 118-126 30BCC94151: 28-20, 37-45, 85-80, 110-112	1994	Most of the watershed appears similar to the 1990 images. The blocks harvested in the 1950s and 1960s, and their associated roads, are revegetating. The roads are still visible but are becoming overgrown.
30BCB98008: 215-211, 182-189, 177-170, 144-151	1998	More clearing is visible upslope of the gravel pit. Otherwise, similar to 1994 images.
BCC03039: 14-18, 78-72, 105-112, 159-152	2003	A new block on the E200 Road and two small blocks near the lake are visible. Otherwise, the watershed appears similar to 1998.
Google Earth	2003-2023	A new block is visible near the top of the canyon in the 2009 image and another one is upslope of that by 2017. The 2017 block has some new roads. A block at the same elevation as the small lake is visible on the 2021 image. The 2021 slide is visible on the 2022 image.

2.7 Previous Assessments

Statlu is not aware of any previous assessment reports for Burnett Creek watershed.

3.0 ASSESSMENT METHODS

3.1 Rationale

The potential for forest harvesting and road building to affect watershed hydrology were assessed using the rationale of the Coastal Watershed Assessment Guidebook (1999) and Hudson and Horel (2007). This assessment method examines the cumulative effects of past and proposed future forest development. The discussion of hydrologic risk follows the 2020 EGBC/FPBC guidelines for watershed and hydrologic assessment. The assessment considers changes in forest cover, forest stand age, and forest species composition using equivalent clearcut area (ECA). It also considers hydrologic risk from roads, sedimentation hazards posed by road networks and landslides, changes to riparian forest, and changes in channel patterns. A detailed description of the rationale for assessment and the assessment methods used, particularly in the delineation of the transitions between rainfall and rain-on-snow zones, is presented below and Appendix 2.

3.1.1 Peak Flow Generating Hydrologic Processes

The CWAP guidebook (1995, 1999) recommends using three elevation bands (sea level to 300 m, 300 m to 800 m, and 800 m and up) for evaluating hydrologic recovery, corresponding to the rainfall, rain-on-snow, and snowmelt-dominated portions of the watershed. Hudson and Horel (2007) discriminate between warm rain-on-snow and cold rain-on-snow because warm rain liberates more water from a snowpack than cold rain does. Although Hudson (2000) suggested that the main source of runoff from elevations above 800 m was from spring snowmelt, and this is certainly true for runoff as a whole, runoff during fall and winter atmospheric river events which cause the largest Coastal peak flow events is caused by rain-on-snow processes. Consequently, this assessment has considered the elevation band from 800 m to 1200 m as having peak flows generated by cold (<5°C) rain-on-snow events.

3.1.2 Age of Full Recovery

The provincial Vegetation Resources Inventory (VRI) dataset defines tree height and age for each forest cover polygon based on field surveys added to the database over time, with a projection date of 2020. It does not include recent events, such as logging or fire. To determine present ECA, the projections were extended to January 1, 2023, and all recent cut blocks and fires were incorporated into the ECA calculations.

The age of full recovery is determined by looking at canopy dominant tree age, height, and historic forest disturbance from fire (Chart 1). Any disturbance within the historic period, whether from fire, logging, etc., is considered for hydrologic effects, but effects from before the historic period are considered to be natural.

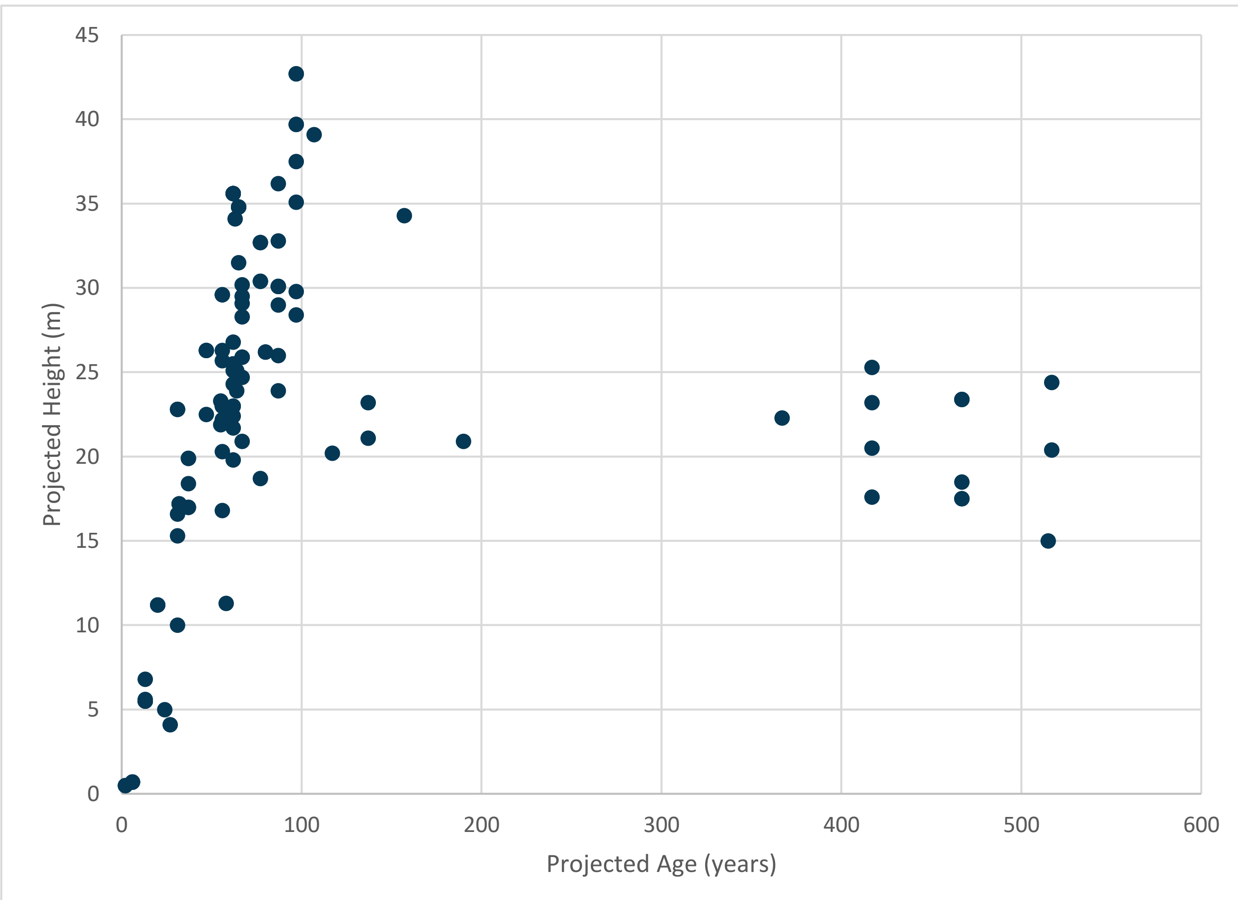


Chart 1: Projected stand age vs. projected stand height in Burnett Creek watershed.

Stands older than 100 years were assumed to be fully hydrologically recovered. It is probable that much of the watershed was harvested before the air photo record began in 1947, but, judging from the appearance of the stands on the 1947 imagery and the presence of a road network suggesting truck logging, the harvesting most likely occurred between about 1915 and 1947, therefore stands older than that were likely not harvested. Stands with heights greater than 20 m were also assumed to be fully recovered.

3.1.3 Snow Depth and Recovery Thresholds

Burnett Creek is entirely within Snowpack Zone 4 as defined by Hudson (2000) and has three elevation bands (Table 6). I used the Snowpack Zone 4 equation from Hudson and Horel (2007) to estimate the expected peak snowpack depth within the warm rain-on-snow elevation band (300 m to 800 m), using the median elevation of the zone (550 m) to estimate snowpack depth for the whole zone. The result is a peak snowpack depth of 1.3 m. The height threshold for the start of recovery for young stands in rain-on-snow elevation bands is 0.5 m greater than the expected maximum snowpack depth at the same elevation (Hudson and Horel, 2007). Therefore, a threshold of 1.8 m was used to calculate the start of hydrologic recovery and resultant ECA in that elevation band. Similarly, for the cold rain-on-snow (800 m to 1200 m) band, the calculated threshold is 1.7 m and the value was increased by 0.5 m, therefore, the threshold is 2.2 m.

Table 6: Elevation Bands, Flood Processes, and Peak Snowpack Depths

Elevation Band (m)	Flood Generating Process	Peak Snowpack Depth (m)
0-300	Rain	0
300 -800	Warm rain-on-snow	1.8
800-1200	Cold rain-on-snow	2.2

3.1.4 Land Use Assumptions

Parts of the Burnett Creek watershed include developed lands adjacent to the mouth of the creek. These lands appear to be used as rural residential, residential, and gravel pits. Residential and gravel pit uses represent a permanent loss of forest cover. The VRI polygons classified as rural were assumed to be mostly permanently unforested, and the proportion of rural use for each polygon was used to calculate the ECA for that polygon. For example, a rural residential polygon with approximately 70% forest cover was assumed to have at least a 30% ECA. No recovery projection was applied to these polygons over the period of assessment.

3.2 GIS Analysis

GIS analysis was used to prepare the data for ECA calculation. The watershed was divided into elevation bands using contours. The watershed boundary and elevation bands were then intersected with the VRI data. The resultant attribute table was exported for ECA calculation using Excel. Block and road data, both existing and proposed, was intersected with the watershed boundary and the resulting attributes were also exported for further analyses. SCCF provided GIS data that showed their proposed harvest and road building in the watershed. Blocks (proposed and harvested) and roads were clipped to the watershed boundary so only those parts of each feature that lie within the watershed was considered in the ECA analysis.

3.3 Hydrologic Recovery of Unvegetated Polygons

Watersheds contain areas that will never become forested and thus do not count towards estimates of equivalent clearcut area, for example, unvegetated, unforested, or non-productive forestland with small trees such as wetlands or alpine forest. All forest cover polygons were reviewed so that all polygons describing non-vegetated and non-productive lakes, rivers, or bedrock outcrops were considered 100% hydrologically recovered. Areas temporarily deforested, even if by natural processes, such as patches with shrub vegetation, are considered to be hydrologically recovering in the same way as logged patches, and their effects are summed with logging to evaluate cumulative hydrologic effects.

4.0 HYDROLOGIC RISK ASSESSMENT

Hydrologic risk is defined as the product of likelihood of occurrence of an event and the consequence, with respect to watershed values (EGBC, 2020). Hydrologic risk assessment is a partial risk analysis because it only considers the potential for damage of watershed values but does not consider vulnerability. For example, when fish habitat is the watershed value and partial risk assessment determines there is moderate hydrologic risk, it means that in fish habitat could be damaged by the proposed changes in the watershed, but it will not quantify the magnitude of the harm.

The watershed assessment method includes evaluation of the cumulative effects and the partial risk of past harvesting and road construction on watershed properties and hydrologic regimes. The assessment considers changes in forest cover, forest stand age, and forest species composition. It also considers hydrologic risk from roads, sedimentation hazards posed by road networks and landslides, changes to riparian forest, and changes in channel patterns.

Hydrologic partial risk assessment identifies and characterizes the risks posed by forest disturbance and potential sources of disturbances (either natural or human-caused) that can potentially affect hydrologic parameters of value. These risks result from the presence of the parameters of value and the likelihood that natural and human-caused disturbances can affect those parameters of value. Risk assessment requires identification of risks, determination of the level of risk, evaluation of means to alter or reduce the risk, and evaluation of the acceptability of the unmodified and modified levels of risk. Ultimately, determination of the acceptability of a particular level of risk is the responsibility of land managers and statutory decision-makers.

4.1 Risk Identification

With respect to Burnett Creek watershed, identified hydrologic risks include:

- Changes in the timing, duration, magnitude, or frequency of stream flows, including peak flows (floods), low flows, and mean flows, that could result in changes to the amount of usable water for water licensees, reductions in flow or water level for fish, or damage to infrastructure;

- Decreases in channel stability either due to increased sedimentation or channel avulsion, that could result in sedimentation at water intakes or loss of riparian habitat;
- Changes in water quality as a result of increased sedimentation or changes in stream temperature that could adversely affect drinking water quality, fish, or fish habitat; and
- Changes in channel pattern and riparian function that could affect fish habitat.

The primary parameters of value (elements at risk) with respect to these risks include water supply and water quality for water users. Secondary parameters of value are fish and fish habitat. Tertiary parameters of value include transportation infrastructure in the watersheds, including highways, logging roads, mountain bike trails, bridges, and culverts, that could be affected by increased peak flows. This ranking of risks is based on their identified sensitivity to potential changes and to their perceived significance. Water supply and quality for licensed water users is the primary parameter of value. Changes to low flows will not affect transportation infrastructure, but could affect fish and fish habitat; therefore, fish habitat has a higher sensitivity to disturbance and is consequently the secondary parameter of value.

5.0 RESULTS

5.1 Field Observations, Riparian Assessment, and Channel Conditions

Eryne Croquet, M. Sc., P. Ag., P. Geo., and Warren Hansen, RPF, completed the field assessment on November 2, 2023. It was raining and warm during the assessment, but weather conditions did not limit visibility.

We walked along a deactivated road to the uppermost crossing of Burnett Creek. The road crosses a tributary to Burnett Creek. That stream moves 5 cm cobbles over larger boulders and did not appear to have bedrock in the channel.

The mainstem of Burnett Creek near the uppermost bridge crossing flows in a gully that is incised 5 m to 7 m. The sideslopes have 70% to 80% slope gradients. The stream had high flow during the field visit and was moving small woody debris and fine sediment. The stream has a cascade-pool morphology on this reach.

Just upstream of the canyon (lower down the stream from the bridge crossing), sandy sediment and woody debris recently deposited against coarse woody debris spanning the channel. This reach has a step-pool to cascade-pool morphology. Historic logging had resulted in some removal of the riparian forest. The existing, partly second growth riparian forest has a significant component of alder in it.

I could not observe the stream in the canyon because the flow was too high to approach safely.

The lower crossing (near the small lake) is just downstream of the canyon. Fine cobbles and sands deposit on this reach. Wood is in and across the channel but not damming the flow. This reach has riffle-pool morphology. The riparian forest is intact along the bedrock canyon and the riffle-pool reach downstream.

Burnett Creek flows across the northern and western parts of the gravel pit at Swanson's Ready-Mix, downstream of Burnett Creek Falls. Swanson's has a licensed point of diversion, located close to where the stream flows onto the property. A narrow road follows the stream channel. The point of diversion is near an old, derelict log crib bridge that was damaged by a flood on the stream, possibly floods caused by the November 2021 atmospheric river storms. The intake could not be located, but pipes and taps were observed near the stream, suggesting that the intake was damaged during the flood that destroyed the bridge. The bridge was moved about 5 m downstream during the flood.

Upslope of the damaged bridge, the stream has a riffle-pool morphology. Sandy textured sediment was recently deposited along the banks of this reach. A large woody jam is just upslope of the bridge and could have dammed the flow during the flood, leading to deposition.

Sechelt Inlet Road crosses Burnett Creek, about 300 m from the mouth. This crossing is an open-bottom concrete culvert (about 2 m wide) that was most likely installed when the road was built. The reach upslope of the crossing is on private property. The riparian forest was removed along a 50 m reach. The stream is depleted of fines on this reach, with a bed consisting almost entirely of cobbles about 10 cm in diameter.

Recently harvested blocks in the watershed have not begun hydrologic recovery because the seedlings are still too small to have reached the threshold for the start of recovery. The older blocks adjacent to the roads on the south side of Burnett Creek near the small lake are almost fully recovered, with even aged coniferous stands that are nearly ready to be harvested again.

The riparian forest along Burnett Creek is mostly intact in the forested or upland parts of the watershed. Where the stream flows across private land and the gravel pits, several reaches have parts of the riparian forest removed, but the reaches with depleted riparian vegetation have maximum lengths of 70 m. The riparian forest mostly consists of a mix of coniferous and hardwood trees, with salmonberry, blackberry, and alder in the understory. The riparian forest in a block near the uppermost crossing that was harvested in the 1960s or 1970s was removed. In this location, riparian forest is regrowing, but has more alder than coniferous forest at this time.

A fair amount of woody debris is present in the stream, much of it consists of older wood that is starting to decompose, with some more recent smaller diameter wood (branches) pushed against the larger, older wood. In the reach downstream of the canyon, recently fallen trees span the channel.

The stream has a low likelihood for avulsion because it is either confined in a bedrock canyon or incised into the till or other sediments. The reach near the uppermost road crossing has some potential for avulsion because the stream is not as deeply incised into the surrounding sediments, but it is somewhat confined by the local topography.

5.2 Sediment Source Survey

The primary potential source of sediment in Burnett Creek watershed is roads. Roads can supply sediment to the stream at stream crossings and from poor drainage and maintenance. The existing roads in the Burnett Creek watershed are not currently supplying sediment, with the exception of the 2021 slide, because ditches and water management structures are functioning properly.

Burnett Creek has relatively stable banks with intact riparian forest along most reaches and flows in a bedrock canyon for some length. Bank erosion supplies some sediment to the stream. The stream moves sediment, but it appears that much of the mobile sediment comes from roads or is reworked from within the stream itself.

There are few examples of mass movement in Burnett Creek watershed. In November 2021, a landslide initiated near the recently harvested Block AN12. The slide was investigated and the causes were not definitively defined, but drainage from a road built in the 1980s may have been a contributing factor. The slide reached a tributary to Burnett Creek and delivered fine sediment and woody debris to the main channel.

5.3 Effective Clearcut Area

In Burnett Creek watershed, the ECA is currently 15.6% of watershed area (Table 7). The projected watershed ECA that would occur if no additional logging were to take place, computed in two 3-year increments for 2023 and 2029, is 14.4% in 2026 and 13.5% by 2029. The rate of hydrologic recovery is about 3 ha/year. This provides a baseline for considering the effects of proposed logging, as described in Section 5.

Table 7: Watershed Current and Projected Equivalent Clearcut Area

Area (ha)	ECA (ha)			ECA (% watershed area)		
	2023	2026	2029	2023	2026	2029
864	134.4	124.0	116.4	15.6	14.4	13.5

5.4 Road Density

Road density is the ratio of road length (km) to watershed area (km²). It includes all resource roads, highways, and other roads. The road data is a compilation of resource roads provided by SCCF and roads from the Digital Road Atlas for non-resource roads. Watershed road density is currently 2.0 km/km² (Table 8). Approximately 4.6 km of roads are the permanent roads from the Digital Road Atlas and 12.6 km are resource roads.

Table 8: Watershed Road Length and Road Density Values

Watershed Area (km²)	Active Road Length (km)	Road Density (km/km²)
8.6	17.2	2.0

The current road density in the watershed may be slightly overestimated because the status of resource roads was not described in the GIS data provided to Statlu. For example, deactivated roads may have been included in the active road length, which would lead to a higher calculated road density.

6.0 PLANNED FOREST DEVELOPMENT

Both SCCF and BC Timber Sales (BCTS) have proposed blocks within the Burnett Creek watershed. BCTS will harvest one block, with a gross area of 26.2 ha in the 2023 to 2026 interval. SCCF proposes to harvest 10.4 ha in the same interval, 16.2 ha between 2026 and 2029, with an additional 51.3 ha planned for after 2029.

The proposed harvesting will increase watershed ECA to 18.6% of watershed area by 2026 and 19.6% by 2029, if all the harvesting proceeds as planned. The harvest planned for after 2029 will further increase ECA, but since the timeline is further in the future than the ECA forecast, it is uncertain how it will affect ECA.

Table 9: Planned Harvest and Post-Harvest Watershed ECA

Planning Interval	Planned Harvest (ha)	ECA (ha)	ECA (% area)
2023-2026	36.4	160.4	18.6
2026-2029	16.23	169.4	19.6

To access the blocks, 2.5 km of new roads will be built in the watershed. The new roads will increase road density to 2.3 km/km².

7.0 DISCUSSION

Watershed ECA is a valuable indicator because it measures how changes to forest cover effect stream hydrology. Since Burnett Creek watershed is not a community watershed or a fisheries-sensitive watershed, it has not previously been assessed and has not had any ECA management thresholds specified. SCCF is shifting towards an ecosystem-based (EBM) approach to forest management in Burnett Creek watershed. Specific objectives that might apply to manage watershed risk could be recommending 40 m to 50 m wide buffers on S5 streams. The width of the riparian forest will depend on ecological function of the stream, for example.

General recommendations for ECA thresholds are set depending on watershed sensitivity, with lower ECA thresholds for the most sensitive watersheds. The Cumulative Effects Framework[5] uses ECA and a number of other watershed characteristics to evaluate the effects that land use will have on streamflow, in particular peak flows. The variation in the benchmark depends on watershed characteristics, including the Melton ration (length of streams in km to watershed area in km^2) that have inherent measurement errors. The CEF method, applied to Burnett Creek watershed with ECAs from 13% to 15% over the period of covered by the analysis, predicts low to moderate likelihood of increased peak flows.

The current ECA is 15.6% of watershed area and will increase to 19.6% after the proposed blocks are harvested. These ECA levels are below the benchmark above which changes to peak flow would start to be expected. The proposed harvesting, including both SCCF and BCTS blocks, will not raise the ECA above the benchmark, which means the hydrogeomorphic risk is not expected to increase.

The CEF has defined road density benchmarks to assist in evaluating the potential effects that road density could have on water quality and water quantity (Table 10). The road density in the watershed is greater than the thresholds where declining water quality and changes to water quantity are expected. The road density is currently 2.0 km/km^2 and will increase to 2.3 km/km^2 when the proposed roads are constructed.

Table 10: Road density benchmarks used to determine the likelihood that roads will affect sedimentation and peak flows (PAET, 2020)

Road Density Benchmark	Water Quality	Water Quantity
Low	<0.6	<1.5
Moderate	0.6 to 1.2	1.5 to 2.1
High	>1.2	>2.1

[5] https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/cumulative-effects/protocols/cef-aquatic-ecosystems-protocol-dec2020.pdf

7.1 Hydrologic Partial Risk Assessment

This assessment provides a partial risk assessment because some details related to exposure of elements at risk, vulnerability of those elements, and consequences are beyond the scope of this assessment. The resultant partial risk is a function not only of factors such as watershed ECA or road density but also of the time over which those indicators change. Watershed ECA levels depend on tree growth and integrate the effects of past disturbance as well as present and proposed future conditions. The partial hydrologic risk from harvesting and other disturbances will remain the same or decrease over time if there are no additional fires, insect infestations, or other unforeseen disturbances. The following tables summarize the hydrologic partial risk to the identified resources (see Section 4.1) in Burnett Creek watershed.

Table 11: Hydrological Partial Risk Summary

Parameters of Value	Relevant Hydrologic Risks	Likelihood	Consequence	Partial Risk	Comments
Water supply and water quality	Damage due to increased peak flows	Moderate	Moderate	Moderate	The Swanson's water intake was damaged by a flood and/or debris flow.
	Damage due to longer and lower low flows	Moderate	Moderate	Moderate	Water supply for irrigation may be inadequate during droughts.
	Damage due to decreased water quality and increased fine sediment transport	Moderate	Low	Low	The water licenses are for irrigation or processing and manufacture, so water quality and sediment have less influence on use.
	Damage due to increased water temperature	Moderate	Very Low	Very Low	Water temperature is not important for industrial water license holders.
	Damage due to degraded riparian habitat	Low	Very Low	Low	Riparian forests are in good condition along most reaches of Burnett Creek.
	Damage due to increased coarse sedimentation from landslides	Low	Low	Low	Few landslides were observed in the watershed. The 2021 slide added fine sediment to the channel.
Fish and fish habitat	Damage due to increased peak flows	Very Low	Moderate	Very Low	Peak flows would need to occur in successive years to damage fish and fish habitat.
	Damage due to longer and lower low flows	Low	High	Moderate	The lower reach could dry out under climate change scenarios where droughts are more intense and last for longer than in 2023.

Parameters of Value	Relevant Hydrologic Risks	Likelihood	Consequence	Partial Risk	Comments
	Damage due to decreased water quality and increased fine sediment transport	Very Low	High	Low	There are few sources of fine sediment.
	Damage due to increased water temperature	Low	High	Moderate	The riparian forest is effective at shading most reaches of Burnett Creek. Longer periods with low water conditions are known to increase water temperatures.
	Damage due to degraded riparian habitat	Low	Moderate	Low	Much of the original riparian forest along Burnett Creek was left intact. The second growth riparian forest is maturing, with conifer replacing deciduous vegetation. The stream has adequate woody debris supply.
	Damage due to increased coarse sedimentation from landslides	Low	Moderate	Low	Very few landslides were observed in the watershed.
Infrastructure including roads, bridges, and culverts	Damage due to increased peak flows or coarse sedimentation	Low	Low	Low	Roads in the watershed are in decent condition. Some older culverts might be undersized.

The risk scenario described in Table 11 evaluates partial risk under current climate conditions. If the climate changes according to the predictions described in Section 2.4, conditions in Burnett Creek Watershed will likely have longer and more intense summer droughts. Those conditions will increase the overall hydrologic risk in Burnett Creek to moderate, especially when considering the secondary parameters of value: fish and fish habitat in the lower reaches of Burnett Creek.

8.0 RECOMMENDATIONS

The effects of increased ECA could lead to detectable changes to peak flows in Burnett Creek. It is difficult to reduce ECA by using forest management practices that would increase the rate of hydrologic recovery, since recovery is a function of stand age and height, and it appears from the existing age and height data that the second-growth forest in the area is already recovering about as rapidly as can be expected, and at a much higher incremental rate than is possible for much of the rest of the province. It is best to manage ECA by keeping it lower than the benchmark of 30% of watershed area. This can be achieved by reducing the net harvest area, deferring harvest until sufficient recovery has occurred, or a combination of these. The ECA is currently below the benchmark and is not expected to surpass it when the proposed harvest is complete.

Road density in Burnett Creek watershed exceeds the CEF benchmarks. Approximately 5 km of the roads in the watershed are paved roads near the mouth of Burnett Creek and cannot be easily deactivated. Resource roads, on the other hand, are easier to deactivate to restore natural hydrologic conditions. Hydrologically-effective deactivation requires removing culverts, restoring streams, and adding a hydrologically effective number of cross ditches or waterbars (at least 10/km on low-gradient terrain and 20/km on steep roads or roads that cross steep terrain) to prevent the diversion and concentration of runoff.

Due to the likelihood that the calculated road density is an overestimate because of the lack of road status information in the GIS data, it is difficult to recommend an exact minimum length of road to deactivate. As long as road density remains at or below 2.1 km/km^2, road density should not result in reduce water quality or alter water quantity. This could be achieved by deactivating 2.2 km of the existing active road (assuming it is all active), and deactivating all 2.5 km of proposed road as soon as possible after it is constructed and used. Because the GIS data provided did not discriminate between active and deactivated roads, a road status survey of all roads in the watershed should be completed. The survey should record the status (e.g., existing, deactivated, wilderness, proposed) of all road segments. The data should be used to derive a more accurate road density in the watershed that should be used to plan future road development.

Continue maintaining drainage structures on the resource roads in Burnett Creek watershed to prevent them from becoming significant sediment sources.

9.0 CONCLUSIONS

SCCF retained Statlu to complete a watershed assessment for the Burnett Creek watershed. The assessment evaluates the effects of past, present, and proposed future forest development, road building, and natural disturbances on hydrologic values in the watershed.

The watershed ECA is currently 15.6% of watershed area (134.4 ha) and will decrease to 14.4% by 2026, and 12.5% by 2029, if no development occurs and if hydrologic recovery proceeds at the current rate.

The proposed harvesting will increase watershed ECA to 18.6% (160.4 ha) by 2026 and to 19.6% (169.0 ha) by 2029, which is below a level where increased hydrogeomorphic risk would be expected to increase.

Road density is currently 2.0 km/km² and will increase to 2.3 km/km² by 2026, if all proposed roads are developed and no roads are deactivated. Road density can be managed by reducing the length of road in the watershed by hydrologically deactivating unneeded roads. If at least 2.2 km of existing roads and 2.5 km of the proposed roads are deactivated, the road density will remain below the moderate benchmark (1.5 km/km² to 2.1 km/km²).

A road status survey of all roads in the watershed should be completed. The survey should record the status (e.g., existing, deactivated, wilderness, proposed) of all road segments. The data should be used to derive a more accurate road density estimate in the watershed in order to plan future road construction, maintenance, and deactivation.

Burnett Creek watershed has very low to moderate hydrological partial risk. The peak flows could damage water intakes and low flow conditions could decrease water supply and increase water temperatures. These factors are classed as moderate hydrological partial risk.

10.0 LIMITATIONS

The recommendations provided in this report are based on observations made by Statlu and are supported by information Statlu gathered. Observations are inherently imprecise. Conditions other than those indicated above may exist on the site. If such conditions are observed or if additional information becomes available, Statlu should be contacted so that this report may be reviewed and amended accordingly.

This report was prepared considering circumstances applying specifically to the client. It is intended only for internal use by the client for the purposes for which it was commissioned and for use by government agencies regulating the specific activities to which it pertains. It is not reasonable for other parties to rely on the observations or conclusions contained herein.

Statlu prepared the report in a manner consistent with current provincial standards and on par or better than the level of care normally exercised by Professional Geoscientists currently practicing in the area under similar conditions and budgetary constraints. Statlu offers no other warranties, either expressed or implied.

11.0 CLOSURE

Prepared by:	*Reviewed by:*
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Agrologist and Geoscientist	*Hydrologist*
EC/DB/js	

Permit to Practice Number: 1000170

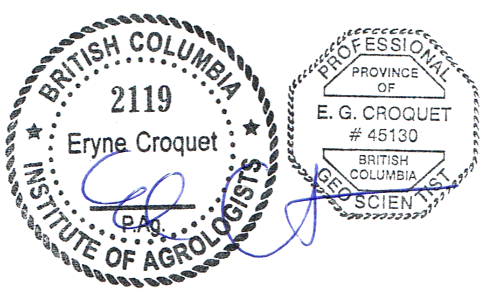
12.0 ASSURANCE STATEMENT – REGISTERED PROFESSIONAL

Note: This Statement is to be read and completed in conjunction with the Professional Practice Guidelines – Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector and is to be provided for Watershed Assessments or Hydrologic Assessments.

October 24, 2024
To: Warren Hansen, RPF
SUNSHINE COAST COMMUNITY FOREST
213-5710 Teredo Street
Sechelt, BC V0N-3A0

With Reference to the Burnett Creek Watershed, the undersigned hereby gives assurance that they are a Professional Geoscientist, registered with Engineers and Geoscientists BC, and a Professional Agrologist, registered with the BC Institute of Agrologists.

I, Eryne Croquet, have signed, sealed, and dated this Watershed Assessment report in general accordance with the Joint Professional Practice Guidelines - Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector[6].



2024-10-24

[6] https://www.egbc.ca/getmedia/8742bd3b-14d0-47e2-b64d-9ee81c53a81f/EGBC-ABCFP-Watershed-Assessment-V1-0.pdf.aspx

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statlu
ENVIRONMENTAL CONSULTING
Figure 1: Burnett Creek Watershed
1:10,000
Client: SCCF
Project Number: 23-197
Gray Community Watershed
Chapman Community Watershed
Burnett Creek
AN21
AN12C
AN12
AN12A
AN13
AN27A
AN27
G052B4R8
PORPOISE BAY PARK
Legend
Water Rights - Licences
Bridges
Field Route - Nov. 2, 2023
Proposed Roads
Roads
Digital Road Atlas
Transmission Lines
Streams
Harvested Blocks
Proposed Harvest 2024
Proposed Harvest 2025
Proposed Harvest 2030-2035
Proposed Harvest 2035-2040
Reserves
Parcel Fabric (Private Land)
Sunshine Coast Community Forest
Watershed Boundaries
Provincial Parks
Base Data Legend
Contour - Index
Contour - Intermediate
River or Stream - Definite
River or Stream - Dry
River or Stream - Indefinite
River or Stream - Left Bank
River or Stream - Right Bank
Marsh
Swamp
Mine - Tailing Pond
Reservoir - Definite
Lake - Definite
Canal
River or Stream - Definite
Flooded Land - Inundated
Marsh
Swamp
0 100 200 300 400 500
Meters
N
Author: E. Croquet
Date Saved: Mar 25, 2024
NAD 1983 BC Environment Albers

APPENDIX 2: HYDROLOGIC RISK AND RISK ASSESSMENT METHODOLOGY

Peak flow is the maximum flow rate that occurs within a specified period, usually on an annual or event basis. Generally, melting of the snowpack in spring and/or heavy rainstorms or rain-on-snow events generate peak flows. Tree removal and road building by forestry can affect peak flow timing and volumes. By removing trees, not only is more precipitation able to reach the ground and infiltrate the soil, but the timing of the delivery may be altered. Timber harvesting reduces interception and evapotranspiration, and increases the winter snowpack. This can result in an earlier and more rapid snowmelt, and higher flow resulting from the deeper snowpack. It can also result directly in higher runoff during rainfall events and/or higher groundwater levels. By changing the longwave and shortwave radiative balance, logging can also change the timing of snowmelt, although this depends on aspect and other shading as well as forest canopy removal.

Construction of logging roads can affect the pathway and the timing in which precipitation or snowmelt reaches the stream channel. Subsurface flow may be intercepted and directed down ditches as surface flow, reaching stream channels at an accelerated rate. Compacted surfaces of roads reduce infiltration, transferring surface flow to ditches, which also means that surface water reaches stream channels at an accelerated rate.

Cumulative hydrologic effects are commonly expressed as the likelihood that logging will result in increases to peak flow magnitude or frequency. Cumulative hydrologic effects are evaluated by considering the net area logged over time and determining the equivalent clearcut area (ECA) for each logged area, which consists of the initially clearcut area modified by a recovery term that accounts for the restoration of forest canopy, root structures, transpiration, and interception as new trees grow. For instance, an area of 10 ha, originally clearcut, fully restocked, and with vigorous new growth 20 years old, might be calculated to have recovered 30% of the original hydrological effectiveness of the previous forest in terms of rainfall and snowfall interception and ground shading. The ECA is calculated as clearcut area times the recovery factor (percent clearcut minus percent recovered). In this example, the ECA is 10 ha * (100%-30%) = 7 ha. Therefore the 10 ha, 20-year-old block would be determined to be hydrologically equivalent to a 7 ha fresh clearcut. ECA is summed for each past block harvested in a watershed to determine cumulative hydrologic effects. Intermediate categories (such as very low to low) are included in the table to indicate the range of watershed sensitivities, which depend on woody debris abundance, channel substrate, geology, hydrograph type (snowmelt or rainfall dominated) and other factors.

In addition to peak flow changes, cumulative hydrologic effects can result in changes to mean annual or low flow, and to changes in the timing and duration of flow. Flow might become less variable if melt from different aspects and elevations is synchronized. The timing of low flow might be altered, and its duration lengthened, if snowmelt occurs earlier in the year. Conversely, by reducing transpiration, forest harvesting might increase low flow levels or decrease the duration of summer low flows.

ECA Range (percent of total watershed area)	Hydrologic Risk	Qualitative Interpretation
0% to 15%	Very low	Detectable changes to peak, mean and 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.

Risk is a function the likelihood of an event occurring and the exposure of downslope or downstream resources to the event, and vulnerability of the downslope resources, which together determine the consequences should the event occur. Land Management Handbook 56 (Wise et al. 2004) and the BC Ministry of Forests Forest Road Engineering Guidebook (2002) define risk as the product of the probability of hazard (likelihood of occurrence) and consequence. Consequence further depends on the nature of the element(s) at risk, exposure, and vulnerability.

Statlu recognizes that the evaluation of the exposure and vulnerability of elements at risk is difficult and may require specialized skills or additional information not available to professional geoscientists. Since the information is available or potentially available to land managers and statutory decision makers, we have concentrated on identifying and describing the geomorphic components of the consequences, specifically their likelihood of reaching downstream identified elements and resources at risk. This is a partial risk analysis since it identifies the geomorphic components of a risk analysis without addressing the vulnerability of the elements at risk.

As an example, consider a theoretical watershed of 1000 ha. The existing ECA is 150 ha, and another 100 ha are planned for logging, with associated road construction, which will raise the watershed ECA to 25%. The main stream in the watershed flows into a lake and has built a fan at its mouth; there are cabins on the lake, with a community water license intake near the head of the fan, and fish present in stream reaches on and near the fan, while higher stream reaches are too steep for fish habitat. Statlu estimates that the post-harvest likelihood of peak flow changes is low, and that if changes to peak flow regimes do occur they are likely to be transient and persist for less than five years. Small changes to the timing of flow are likely: spring snowmelt may occur up to a week earlier, and the summer low flow period may be extended by a similar length of time, but summer low flows may be slightly higher for up to ten years due to reduced evapotranspiration. Changes to channel pattern in the stream and on the fan are unlikely and changes to water quality are unlikely if all roads are built as planned and incorporate site-specific erosion and sediment control measures, and if old roads are deactivated.

To extend this hydrogeomorphic analysis to a full evaluation of the consequence of the potential harvesting and road building and the resultant risk, requires information on the frequency of use, and designated flood construction level and flood control measures incorporated into the design of the cabins on the fan, the nature and frequency of use of the forest service roads by industrial and recreational traffic, the quality of riparian habitat, species present and seasonality of use of the fish stream by those species, the water diversion and treatment methods used at the water intake, and other information beyond the purview of geoscience but available or potentially available to land managers and statutory decision makers.

Broadly speaking, the qualitative estimations of probability determined by Statlu correspond to the following classes of consequence from the Forest Road Engineering Guidebook (Table A2). These correspondences are approximate and are provided only to help with decision-making.

Qualitative Probability of Consequence	Range of Quantitative Probabilities of Occurrence	Approximate Qualitative Consequence Class
Certain; Will Occur	>50%	Very High
Likely to Occur	25-50%	High
Probable; Could Occur	10-25%	Moderate
Unlikely to Occur	1-10%	Low
Remote or Will not Occur	<1%	Very Low

APPENDIX 3: RATIONALE FOR HYDROLOGIC ASSESSMENT

Rationale for Assessment

Forest harvesting can affect hydrology in many ways. The assessment of hydrologic impacts in a CWAP focuses on the potential for:

- Changes to peak stream flows,
- Accelerated surface soil erosion,
- Accelerated landslide activity,
- Changes to riparian zones; and,
- Changes to channel morphology.

The following section describes the potential effects of changes to these five indicators resulting from forestry and forestry-related activities.

Changes to Peak Stream Flow

Peak flow is the maximum flow rate that occurs within a specified period, usually on an annual or event basis. Generally, melting of the snowpack in spring and/or heavy rainstorms or rain-on-snow events generate peak flows. Tree removal and road building by forestry can affect peak flow timing and volumes. By removing trees, not only is more precipitation able to reach the ground and infiltrate the soil, but the timing of the delivery may be altered. Timber harvesting reduces interception and evapotranspiration, and increases the winter snowpack. This can result in an earlier and more rapid snowmelt, and higher flow resulting from the deeper snowpack. It can also result directly in higher runoff during rainfall events and/or higher groundwater levels.

Construction of logging roads can affect the pathway and the timing in which precipitation reaches the stream channel. Subsurface flow may be intercepted and directed down ditchlines as surface flow, reaching stream channels at an accelerated rate. Compacted surfaces of roads reduce infiltration, transferring surface flow to ditches, which also means that surface water reaches stream channels at an accelerated rate.

Accelerated Surface Soil Erosion

Surface soil erosion is defined as the detachment, entrainment, and transport of individual sediment particles due to falling or running water, or wind. It is a function of surface cover, mineral soil type, slope gradient, slope length and shape, and rainfall intensity.

The principal effect of forest practices on surface soil erosion results from road building. Sediment generated from ditches, cut and fill slopes, and road surfaces is introduced to stream channels through ditches and at stream crossings. Higher road densities indicate higher potential for sediment delivery to streams. High quantities of sediment can clog ditches and stream channels, accelerate stream bank erosion, deposit fine sediments in reservoirs, cover fish spawning grounds, and reduce downstream water quality. Timber harvesting can also cause accelerated surface soil erosion due to exposing soil as a byproduct of removal of vegetation. However, roads, particularly old pre-*Forest Practices Code* roads that have not been deactivated, pipeline and powerline access roads, and other similar roads, are a far greater potential source of sediment than conventional harvesting done to current *Forest and Range Practices Act* (FRPA) standards.

Landslide Activity

Landslides are a natural process on steep terrain, and occur over time at a natural rate. Forest practices can accelerate this natural rate through road construction and logging on unstable or potentially unstable terrain.

The alteration of natural drainage patterns through road building can lead to unusual concentrations of water on hillslopes, road fillslopes, and road beds, leading to a higher likelihood of landsliding. Timber harvesting can alter slope hydrology. Removal of forest cover results in a reduction of transpiration and interception losses, leading to increased soil saturation, subsurface flow, and surface runoff. In addition, when trees are harvested, the roots of the stumps decay and begin to lose their soil binding strength, reducing their reinforcing capacity. This makes slopes more susceptible to landsliding until new growth re-establishes deep root systems.

The harvesting method can also lead to slope instability. Log yarding can disrupt natural pathways for water drainage, and create new pathways. Yarding logs across slopes and using heavy machinery can damage the soil surface and the roots that help hold the soil.

FRPA requires that logging not cause landslides, adverse gully processes, or fan destabilization. The frequency of landsliding from logged terrain has been reduced by identifying and avoiding harvesting on unstable slopes, and by applying mitigation measures that promote stability on harvested slopes.

Changes to Riparian Zone

The riparian area, or land adjacent to the high water line in watercourses and standing bodies of water, is important to stream ecosystems and stream morphology. Riparian areas help maintain water quality by controlling sedimentation, supplying nutrients and large woody debris, and maintaining stream channel morphology. Excessive harvesting within riparian areas can destabilize stream banks, increase bank erosion and stream sedimentation, diminish the supply of woody debris to the channel, and increase the size of sediment wedges of some stream reaches.

Changes to Stream Channel Pattern

Analysis of stream channel patterns can indicate that changes to sediment supply, riparian vegetation, or peak flow indices may have influenced a watershed because these variables influence changes to stream channel pattern. For instance, increased flooding can lead to increased bank erosion or overbank deposition as well as changes in bed material texture. Increased sediment supply can result in increased sediment deposition in-channel and a consequent widening of the channel or changes in the texture and composition of channel bedforms. Changes to riparian vegetation can change coarse woody debris inputs to the channel, altering the frequency and size of logjams as well as the bed texture.