VILLAGE OF SILVERTON

Regular Open Council Meeting Agenda

Wednesday, January 8, 2025 at 7:00 p.m.
Memorial Hall, 203 Lake Avenue, Silverton, BC

Electronic Participation via Zoom. The Zoom meeting link for this meeting is:
https://us06web.zoom.us/j/85448531679

A. CALL TO ORDER

B. INDIGENOUS ACKNOWLEDGEMENT

The Village of Silverton acknowledges the indigenous peoples on whose traditional territories we stand.

C. ADDITION OF LATE ITEMS IF ANY

D. ADOPTION OF THE AGENDA

1. **Agenda for January 8, 2025 Regular Council meeting.**

Recommendation:
THAT the agenda for the January 8, 2025 Regular Council meeting be adopted as presented or amended.

E. ADOPTION OF THE MINUTES AND COMMITTEE RECOMMENDATIONS

1. **Adoption of Minutes for Regular Council meeting held on December 10, 2024.**

Recommendation:
THAT the minutes of the Regular Council meeting held on December 10, 2024 be adopted as presented or amended.

2. **Adoption of Public Hearing Record for December 10, 2024 as presented or amended.**

Recommendation:
THAT the Record of the Public Hearing held December 20, 2024 be adopted as presented or amended.

F. DELEGATIONS

G. UNFINISHED BUSINESS AND BUSINESS ARISING FROM THE MINUTES

H. NEW BUSINESS

1. **RDCK Housing Needs Report - Village Profile - Silverton** 5 - 45

Recommendation:
THAT Council receives the RDCK Housing Needs Report, Village Profile - Silverton - for information.
RDCK HNR - Village Profile - Silverton - December 2024

2. **Early Budget Approval Request - Village Server** 46 - 47

Recommendation:
THAT Council gives early budget approval for Sensible Solutions to replace the Village's server ($14,385.00), in the net amount of our deductible insurance through Municipal Insurance Association of BC, of $5,000 plus GST

Staff Report Early Budget Approval for Server
Quote_Village of Silverton_324

I. CORRESPONDENCE FOR INFORMATION

1. ***External Correspondence* - Post Wildfire Reports** 48 - 154

Recommendation:
THAT the Post Wildfire Reports - Natural Hazards Risk Assessments for the Nemo and Komonko wildfires be received for information.

PostWildfire Nemo Level 2 Natural Hazards Risk Assessment
PostWildfire Komonko Level 2 Natural Hazards Risk Analysis
PostWildfire Komonko Level 3 Natural Hazards Risk Analysis

2. *Internal Correspondence*

J. COUNCIL REPORTS

1. Mayor Tanya Gordon

2. Councillor Donald Broughton

3. Councillor Clarence denBok

4. Councillor Leah Main

5. Councillor Brian Mills

K. ADMINISTRATION/DEPARTMENT REPORTS

L. BYLAWS

1. **Zoning Amendment Bylaw #548, 2024 - for adoption**

Recommendation:
THAT Zoning Amendment Bylaw No. 548, 2024 be adopted.

M. PUBLIC INPUT PERIOD

Members of the gallery are welcome to ask questions of council, and the questions must be directed to the Mayor. The questions must be relevant to issues dealt with on the agenda and that address policy or determinations made by council. Questions of an operational or administrative nature may be referred to staff directly at the meeting or in the judgement of the Mayor, deferred for discussion between the questioner and staff at a separate time and place. The Mayor shall reserve the right to limit the number and type of questions and discussion.

N. IN CAMERA MEETING

1. **Move To In Camera meeting**

Recommendation:

THAT pursuant to Section 90(1) of the Community Charter, the meeting held on January 8, 2025 be CLOSED to the public to discuss matters related to:
Section 90(1)(a) personal information about an identifiable individual who holds or is being considered for a position as an officer, employee or agent of the municipality or another position appointed by the municipality; and
Section 90(1)(g) litigation or potential litigation affecting the community;
and
Section 90 (1)(i) the receipt of advice that is subject to solicitor-client privilege, including communications necessary for that purpsoe.

O. ITEMS BROUGHT FORWARD FROM IN CAMERA IF ANY

P. ADJOURNMENT

Village of Silverton Housing Needs Report Update

REGIONAL DISTRICT OF CENTRAL KOOTENAY COMMUNITY PROFILES

DECEMBER 2024

Acknowledgments

The authors of this report acknowledge that this study takes place on the traditional land and territory of the Ktunaxa, Sinixt, Syilx and Secwépemc people. We hope to continue their legacy of learning from, caring for, protecting, and enjoying the blessings of tradition and territory.

The development of this Housing Needs Report Update Community Profile was led by the Regional District of Central Kootenay (RDCK) and supported by staff from the Land Use and Planning department as well as staff from the Village of Silverton.

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Appendix A: Definitions

Executive Summary

In 2020, the Regional District of Central Kootenay (RDCK), in partnership with participating member municipalities, including the Village of Silverton, released its first iteration of Housing Needs Reports (HNRs) in response to new legislation and the changing housing landscape. Like many other Canadian communities, the Village of Silverton is facing escalating housing pressures and rising housing costs.

Recognizing the dynamic nature of the housing market, the availability of new data, and the necessity for updated housing reports, the RDCK commissioned HNR updates for its rural Electoral Areas (A, B, C, D, E, F, G, H, I, J, and K) and partnering municipalities (the Villages of Kaslo, Nakusp, Salmo, Silverton, and Slocan). This Community Profile aims to provide an overview of Silverton's current and anticipated local housing conditions and needs and meet new provincial legislative requirements.

KEY FINDINGS

The Population of Silverton is Evolving

- The province estimates that Silverton's population declined by 5% between 2016 and 2021, from 200 to 190 people. The total population is estimated to return to 2016 levels over the next two decades; however, the age distribution is likely to change. In 2021, about 76% of the population was 45+ years old. Projections anticipate growth among younger residents (under 45 years old) and decreases among older working age adults and early seniors over the next 20 years.
- By 2041, senior-led households could comprise 80% of total households in the Village.
- Projections expect there to be a total of 200 residents in the Village of Silverton by 2041.

Sale Prices are Rising, and Home Ownership is Increasingly Out of Reach for Many

- From 2012 to 2016, home ownership was reasonably affordable to most households in Silverton. As of 2017, the median price of a home has become increasingly out of reach for all median household types without external support or existing equity. In 2021, the median home price surpassed what the median couple income could afford for the first time.
- Homeownership attainability data highlights the notable disparity between growth in house sale prices and growth in estimated incomes, leading to reduced purchasing power for shelter for most households in the community.

Demand is Expected to Increase over the Next 20 Years

- Over the next two decades, provincial projections suggest Silverton may need to add 208 new homes across the housing spectrum to mitigate increased market imbalances, account for anticipated new demand, and address existing housing deficits. Readers may note that the number of required units surpasses the anticipated population in 2041. The unit demand methodology considers future population change as only one of six components included in the calculations. Results demonstrate that there is a considerable number of households that may have been suppressed from forming since 2006 and the province expects Silverton to need a greater buffer than other RDCK communities to bring local and regional markets back to a "healthy" threshold. More detailed is provided in section 4.
- Rental demand projections suggest an estimated 52% of new rental units would need to be affordable or offered at a below-market price to best meet the needs of Silverton residents.

Interim Report Requirements

The first legislative requirements for housing needs reports were established in 2019, and required local governments to collect data, analyze trends and present reports that describe current and anticipated housing needs. The RDCK and its partner communities, including the Village of Silverton, completed a Housing Needs Assessment in September 2020.

In 2023, amendments to the *Local Government Act* introduced new requirements for housing needs reports. Local and regional governments must now use an established methodology to identify the 5- and 20-year housing need in their communities and local governments must update their official community plans and zoning bylaws to accommodate expected demand.

Communities must complete an interim housing needs report that is required to include three new additional items:

1. The number of housing units needed currently and over the next 5 and 20 years;
2. A statement about the need for housing in close proximity to transportation infrastructure that supports walking, bicycling, public transit or other alternative forms of transportation; and,
3. A description of the actions taken by local government, since receiving the most recent housing needs report, to reduce housing needs.

The RDCK and partnering communities have elected to complete the interim report requirements and a comprehensive data update using 2021 census data. For reference, required report content fulfilling the interim report requirements is included in this section. The body of this Community Profile contains all information required by legislation for the Interim Housing Needs Reports and should remain relevant until the next release of Census data, projected for 2027 or 2028.

NUMBER OF HOUSING UNITS REQUIRED TO MEET CURRENT AND ANTICIPATED

Table 0-1: HNR Method base year versus current year estimates

Description	5-year	20-year
Total demand from 2021 base year	59	208
Estimated total demand from current year (2024)	77	223

Further discussion and analysis of anticipated need is included in Section 5 of this report.

KEY AREAS OF LOCAL NEED

Based on analysis of data and feedback from elected officials and community organizations, the following summary statements describe the current and anticipated housing needs across the following seven key areas: affordable housing, rental housing, special needs housing, housing for seniors, housing for families, shelters for individuals experiencing or at risk of homelessness and housing in close proximity to transportation infrastructure that supports walking, bicycling, public transit, and alternative forms of transportation.

Table 0-2: Key areas of local need

Need	Description
Affordable housing	Affordability remains the largest contributor to Core Housing Need in the RDCK, with about 16% of regional households (no local data for Silverton available) spending more than 30% of their total income on shelter in 2021. Since then, the gap between income purchasing power and actual house prices has widened, indicating that homeownership is further out of reach for most residents in Silverton than it was three years ago. Individuals or families with one income are struggling the most to find affordable housing options in the community, whether to rent or own. Approximately 19% of RDCK households earned a "very low" or "low" income. While many in these categories may already be shelter-secure (e.g., retired households with fully paid-off mortgages), this percentage represents a significant portion of the population that may be especially vulnerable to affordability challenges. Projections anticipate at least 61 subsidized affordable units and 147 additional market units will be needed by 2041 in Silverton to meet demand and begin to balance local prices.
Rental housing	Homeownership is becoming increasingly unaffordable for the typical household in Silverton, forcing many who would prefer to own a home to rent instead. Although the cost of renting is also increasing, it often remains the more cost-effective option between the two tenures. Broader vacancy trends in the RDCK's municipalities and across BC suggest that this trend will continue. As rental vacancy rates continue to decrease, there is a clear rise in demand for rental housing relative to available supply. Although vacancy rates typically reflect purpose-built rentals in urban areas, a declining vacancy rate in these markets forces households to seek alternatives in lower-density markets where there is better availability and prices. This leads to increased demand overall. Although there is limited data available on the rental market in smaller communities within the RDCK, engagement with elected officials and community organizations/groups confirmed that vacancy rates remain well below the 3-5% healthy vacancy rate. Residents have reported having an extremely difficult time finding affordable, suitable rental options to meet their needs. Projection calculations support the data trends, anticipating an increase in rental housing demand, with approximately 39% of all dwellings in Silverton expected to be rental units in 2041.

Need	Description
Special needs housing	Although data on waitlists and core housing need is not specific to community members with special needs, national disability statistics show that overall rates of disability increased from 22.3% to 27.0%[1] between 2017 and 2022 surveys. Much of this increase is attributed to the growth of the senior population. As the population in Silverton ages, projections expect the need for more accessible and specialized housing to increase. Increases were also observed among youth and working-age adults, with significant rises in mental health, learning, and developmental challenges. This indicates a broad need for improved access to supportive housing options that cater to various specific support needs and age demographics.
Housing for seniors	According to BC projections, Silverton can expect that senior-led households will continue to grow over the next two decades. By 2041, senior-led households may increase by 14% and could comprise 80% of total households. In 2022, the Canadian disability rate among the senior population was 40%, an increase of three percentage points since the last survey in 2017. A significant portion of this rate is related to mobility issues, and the likelihood of disability that increases with age. Given the anticipated growth in senior households and the elevated disability rate within this group, increased senior housing interventions are necessary. These could include ensuring senior housing and facilities are widely permitted locally, further modifying building standards to support aging in place, and/or developing and improving existing senior services and programs. While many solutions fall outside the direct influence of local government, there may be opportunities to partner with other levels of government and local or regional organizations to encourage appropriate seniors housing.
Housing for families	Projections anticipate that growth among young family households may be limited over the next two decades. Consequently, the demand for family-specific dwellings (e.g., those with more bedrooms or larger floor areas) may be marginal. However, projections are inherently imperfect and should not be viewed as absolute. The growth of family-aged individuals is vital for sustaining local employment and productivity. Silverton should ensure that family-suitable dwelling sizes, across various housing types, remain available for existing households that may grow and new households projected to join the community.

1 Statistics Canada. (2023, December 1). Canadian Survey on Disability, 2017 to 2022. https://www150.statcan.gc.ca/n1/daily-quotidien/231201/dq231201b-eng.htm

Need	Description
Shelters to address homelessness	While shelters are often located in larger urban communities, homelessness is not confined to these areas. National and provincial trends show that overall homelessness is on the rise, with hidden homelessness likely increasing, particularly in small urban and rural areas. About 2% of regional households were identified as earning "very low" incomes. These individuals are the most vulnerable to changes in their housing circumstances and are the most likely to require emergency housing interventions. Addressing homelessness locally is ideal, as it allows residents to remain within their community. However, doing so can be challenging without provincial or federal support. Silverton should stay engaged in regional homelessness strategies to help coordinate and determine the allocation of emergency housing services and programs.
Proximity to transportation	The Village of Silverton acknowledges the importance of situating future housing developments near transportation infrastructure to encourage more sustainable living choices for residents. Offering housing options close to facilities that support walking, cycling, and other transit alternatives not only improves quality of life by providing convenient and affordable mobility for individuals of all ages and abilities, but it also plays a crucial role in reducing the Village's carbon footprint. By cultivating neighbourhoods where residents can easily commute and run errands without relying on personal vehicles, the Village can foster a more inclusive, vibrant, healthy, and interconnected community.

LOOKING BACK

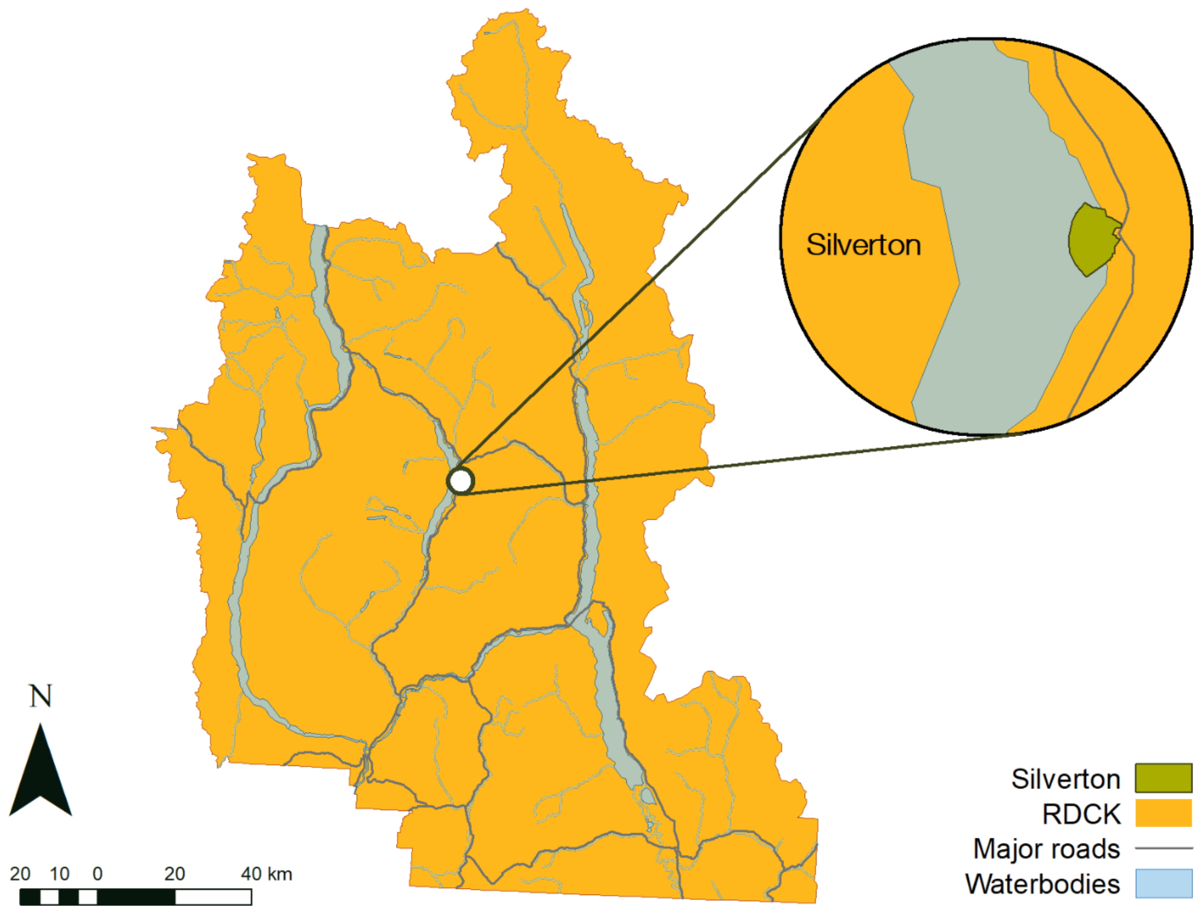
Table 0-3: Actions taken by the Village of Silverton to reduce housing needs since the last HNR was received

General Housing Actions	
Date	**Description of Action or Policy**
2024	Amended the Zoning Bylaw to allow for Temporary Use Permits (TUPs) for temporary accommodation to house workers for future developments in the community.

1. Introduction

Using a wide range of quantitative data and qualitative input from elected officials and community organizations, this document analyzes existing and anticipated housing needs and gaps in the Village of Silverton. All data presented in the report refers to Silverton unless otherwise identified in the text. Figure 1-1 illustrates Silverton's location in relation to adjacent communities and the RDCK.

Figure 1-1: Map



Source: BC Geo Warehouse, Statistics Canada

The purpose of this report is to catalogue current and anticipated challenges so that decision makers, regulators, funders, and community members can better understand and react to housing issues. A thorough assessment of housing need is a vital foundation to support future initiatives. The data gathered and insights generated by a needs report can inform land use and social planning initiatives at local levels, as well as provide hard evidence to further advocacy to senior levels of government. They are also a useful resource for those engaged in or entering the housing sector.

1.1 DATA AVAILABILITY

Some data sections present in the other RDCK HNR Village Community Profiles are absent from this report. Given its small population, some of Silverton's data is supressed by Statistics Canada, resulting in data that is unavailable or unsuitable for analysis.

1.2 DATA SOURCES

This report refers to several pieces of data that work together to contextualize housing conditions experienced by residents of the Village of Silverton. The following is a list of secondary quantitative data sources (i.e., information collected by other organizations and used for this report):

- BC Assessment
- British Columbia Statistics
- Canada Mortgage and Housing Corporation (CMHC)
- Local government data
- Statistics Canada
- UBC Housing Assessment Resource Tools (HART)

Limitations for each source are detailed in the next subsection. At a high level, no analysis can be exact without individualized person or household datasets. Many datasets in this report rely on population samples which, though statistically sound, may not feel representative or reflect lived experience in Silverton. Any analysis in this report should be considered informed estimates rather than precise descriptions.

This is especially applicable to projection work from any source. Estimating variable changes without knowledge of future conditions is inherently flawed. The projections included in this report are subject to economic, social, and environmental conditions that may not persist in the future. Projections should serve as guideposts, regularly recalculated and adjusted to incorporate new information as needed.

1.2.1 Data Limitations

BC Assessment

Grouped Information

BC Assessment provides assessment roll spreadsheets for communities across British Columbia for the years 2005/2006 through 2022/2023. Assessment roll information is not on an individual property level; rather, similar types of properties are grouped together in "folios" based on several factors, such as property type and dwelling type. These folio groups also mean that assessment and sale price values reflect averages, making it more difficult to express community level average and median values.

British Columbia Statistics

Urban Focus

BC Statistics helpfully consolidates most data related to complete Housing Needs Reports, like the new homes registry, non-market housing, post-secondary student housing, and homeless count sources. The database primarily offers data for urban areas, potentially excluding unincorporated or rural data, or suppressing data for confidentiality. This is often due to urban communities having greater data quality and quantity.

Canada Mortgage & Housing Corporation (CMHC)

Reporting Landscape

CMHC conducts its Rental Market Survey (RMS) every year in October to estimate the relative strengths in the rental market. The survey collects samples of market rent levels, turnover, and vacancy unit data for all sampled structures. The survey only applies to **primary rental markets**, which are those urban areas with populations of 10,000 and more. The survey targets only privately initiated rental structures with at least three rental units, which have been on the market for at least three months. In the RDCK, CMHC only collects rental data for the City of Nelson.

Statistics Canada

Area and Data Suppression

Some geographic areas are too small to report, resulting in the deletion of information. Suppression can occur due to data quality or for technical reasons, limiting the use of granular Census geographies. This was not a particular concern for this study but limited the ability to use granular Census geographies (specifically, Dissemination Areas – see **Definitions**).

Random Rounding

Numbers are randomly rounded to multiples of "5" or "10," leading to potential discrepancies when summed or grouped. Percentages derived from rounded data may not accurately reflect true percentages, introducing a level of approximation. Additionally, the sums of percentages may not equal 100%.

UBC Housing Assessment Resource Tools (HART)

Sourced from Statistics Canada

While HART offers detailed methodologies for their analysis, they do rely on Statistics Canada datasets. Consequently, the same limitations as stated above apply for HART analysis results.

1.3 ENGAGEMENT

The RDCK Housing Needs Report Updates Engagement Summary Report summarizes engagement activities conducted by the M'akola Development Services (MDS) and Turner Drake & Partners (TD) in collaboration with RDCK staff for the HNR updates. Engagement opportunities included targeted surveys, presentations, and facilitated discussions.

The Engagement Summary Report captures key themes and feedback shared by engagement groups, including RDCK elected officials, municipal staff, and community organizations/groups. The feedback gathered through these engagement activities informed and contextualized sections of the HNR updates. These findings are incorporated throughout the RDCK Regional Summary Report, Electoral Area Summary Report, and Village Profiles.

2. Demographic Profile

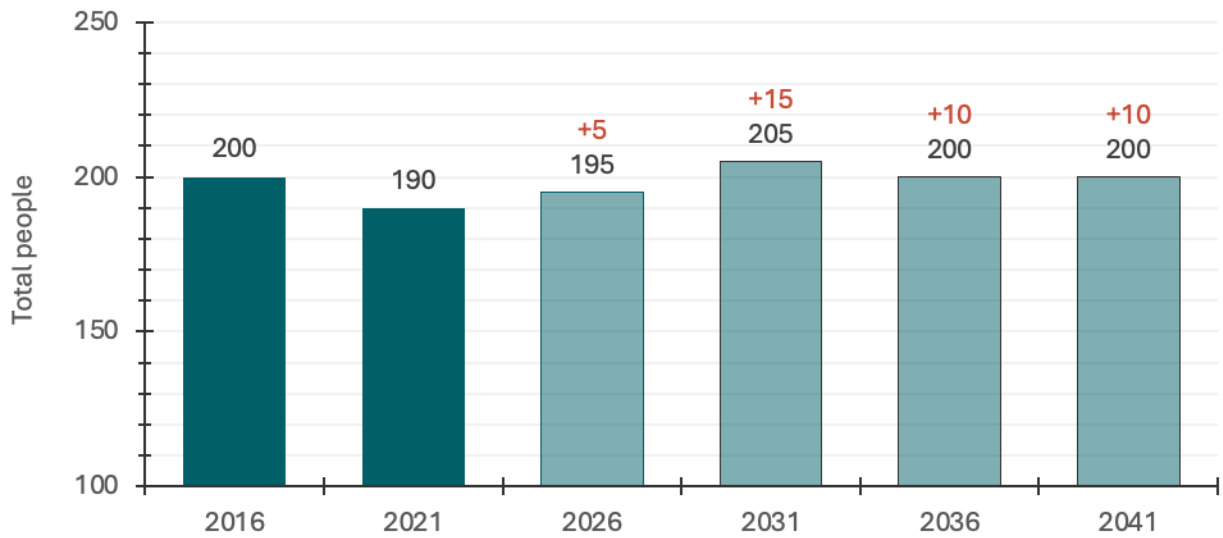
2.1 POPULATION

2.1.1 Historical & anticipated population

Government of British Columbia estimates show that the Village of Silverton's total population declined by 5% between 2016 and 2021.[2]

Figure 2-1 illustrates the changing total population in Silverton from 2016 and 2021 (BC estimates for Census years) and from 2026 to 2041 (BC Government projections).

Figure 2-1: Historical and anticipated population, net anticipated change of population since 2021



Source: BC P.E.O.P.L.E estimates, BC P.E.O.P.L.E projections

Table 2-1 provides a summary of the historical population changes across different age cohorts and includes anticipated population figures over the next two decades.

2 Note that Statistics Canada's 2021 Census reports a 24% decrease to the Village of Silverton's population. The totals from which the results are calculated differ between sources. BC estimates are adjusted to account for possible undercounting during the Census' enumeration. Also note that Statistics Canada reported an error for Silverton's Census results, amending the 2021 Census population from 149 to 181 persons.

Table 2-1: Historical (BC Gov't estimates) and anticipated population by age cohort (BC Gov't projections)

	Total	0 to 14	15 to 24	25 to 44	45 to 64	65 to 84	85+
Historical population							
2016 population	200	15	5	30	85	65	5
2021 population	190	15	15	20	60	80	5
% change ('16-'21)	-5%	+0%	+200%	-33%	-29%	+23%	+0%
Anticipated population							
2026 population	195	0	10	25	50	95	10
% change ('21-'26)	+3%	-100%	-33%	+25%	-17%	+19%	+100%
2041 population	200	15	10	45	30	65	40
% change ('26-'41)	+3%	-	+0%	+80%	-40%	-32%	+300%
% change ('21-'41)	+5%	+0%	-33%	+125%	-50%	-19%	+700%

Source: BC P.E.O.P.L.E estimates, BC P.E.O.P.L.E projections

- The province estimates that the Village of Silverton's population was 190 people in 2021, down from 200 in 2016.
- In 2021, about 76% of the population was 45 years or older.
- Historically, the highest rates of growth have been largely among senior (65+) populations. Across the same time period, adults (25 to 44) and older working age adults (45 to 64) decreased.
- The total population is estimated to return to 2016 levels over the next two decades; however, the age distribution is likely to change. Projections anticipate growth among residents younger than 45 years old and seniors 85 and older and decreases among older working age adults (45 to 64) and early seniors (65 to 84).

2.2 HOUSEHOLDS

Statistics Canada defines a household as a person or group of persons sharing the same dwelling without another usual residence. A household is the highest-level descriptor of many unique living situations. Households are often categorized in this report by the primary household maintainer's age, which is the age of the person responsible for major expenses like rent, mortgage, taxes, and utilities. When multiple people share this responsibility, the first listed individual becomes the primary household maintainer.

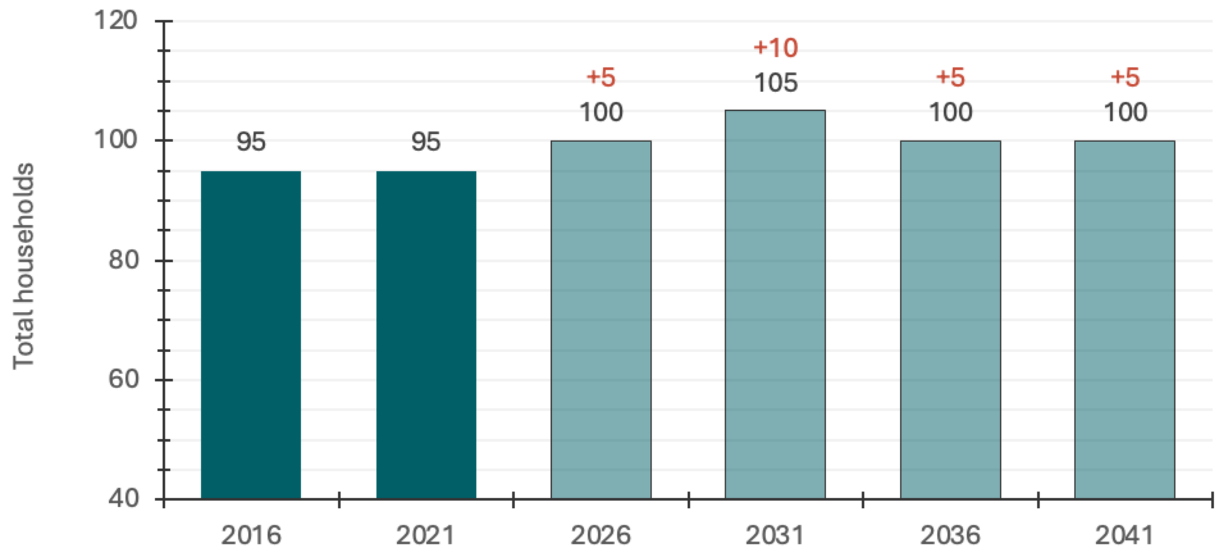
2.2.1 Historical & anticipated households

Total households and the age distribution of maintainers are influenced by population changes, and driven by factors like relocations, preferences, and financial situations. Changes in household patterns typically align with broader population trends. Household growth is a key driver of housing demand. Since households need dwellings, projections are closely tied to the needed increase in housing stock to accommodate expected population changes. Economic and financial drivers, while influential, are excluded since they are difficult to predict, both in the near- and long-term.

Important note: There were errors reported with Silverton's Census totals when the household data was first released in 2021. The data originally indicated that there were 78 households in Silverton. This total was later revised to 97. Readers should be aware of this discrepancy when reviewing the following data.

Figure 2-2 illustrates Silverton's 2021 estimated total households and the anticipated 20-year net growth in households.

Figure 2-2: Historical and anticipated households, net anticipated change of households since 2021



Source: Statistics Canada, BC P.E.O.P.L.E estimates, BC P.E.O.P.L.E projections

Table 2-2 summarizes historical shifts in total Silverton households, providing insights into expected figures over the next two decades. Note that individual age category totals may not sum to the totals due to rounding.

Table 2-2: Historical and anticipated households by primary maintainer age (BC Gov't projections)

	Total	15 to 24	25 to 44	45 to 64	65 to 84	85+
Historical households by primary maintainer age						
2016 households	95	0	10	30	60	0
2021 households	95	0	0	25	70	0
% change ('16-'21)	+0%	-	-100%	-17%	+17%	-
Anticipated households by primary maintainer age						
2026 households	100	0	10	15	75	0
% change ('21-'26)	+5%	-	-	-40%	+7%	-
2041 households	100	0	5	10	80	0
% change ('26-'41)	+0%	-	-50%	-33%	+7%	-
% change ('21-'41)	+5%	-	-	-60%	+14%	-

Source: Statistics Canada, BC P.E.O.P.L.E estimates, BC P.E.O.P.L.E projections, Turner Drake & Partners

- The province estimates that Silverton had 95 households in 2021, the same as in 2016. Similar to population growth, increases occurred mostly among 65- to 84-year old led households.
- Total households may grow by 5% between 2021 and 2041, reaching approximately 100. Senior led households are likely to be the main contributor to household growth, indicating that fewer and fewer working age individuals may live in Silverton over the next two decades.

2.2.2 Additional household characteristics

Table 2-3 summarizes the totals and distributions of households by their size per the 2016 and 2021 Censuses, as well as their respective tenure splits.

Household totals for 2016 and 2021 may differ between this and previous sections, as each section draws from different data sources with distinct purposes. This section relies on a custom Census dataset, purchased by the province from Statistics Canada, which provides more detailed information about households based on a 25% sample of the population. In contrast, the previous section's household data is from a separate provincial dataset, included here as it is an input for the province's prescribed unit demand calculations described later in the report.

Table 2-3: Historical households by household size and tenure share

2016 Census	Total	1 person	2 persons	3 persons	4 persons	5+ persons	Average HH size
Total households	100	45	50	0	0	0	1.6
Share of total	100%	47%	53%	0%	0%	0%	
Owner households	80%	80%	82%	-	-	-	1.6
Renter households	20%	20%	18%	-	-	-	2.0
2021 Census	**Total**	**1 person**	**2 persons**	**3 persons**	**4 persons**	**5+ persons**	**Average HH size**
Total households	90	40	50	0	0	0	1.7
Share of total	100%	44%	56%	0%	0%	0%	
Owner households	89%	75%	100%	-	-	-	1.8
Renter households	11%	25%	0%	-	-	-	-
% change ('16-'21)	-10%	-11%	+0%	-	-	-	

Source: BC Government purchased Custom Statistics Canada Census Tabulations

- Due to the size of Silverton, much of the specific household characteristic data is suppressed. Although 1- and 2-person households are reported as the only household sizes in the community, it is likely that 3+ person households exist but are not reported by Statistics Canada to ensure confidentiality for small datasets.
- In 2021, the share of owner households increased. This shift is predominantly due to an approximate loss of 10 renter households from 2016 to 2021, compared to no change for owner households.

Table 2-4 summarizes the totals and distributions of households by their household family type per the 2016 and 2021 Censuses, as well as their respective tenure splits. Note that a "census-family with a child" includes both couples and lone parents. A "non-census family" refers to a household made up of a single person or unrelated individuals (i.e., roommates).

Table 2-4: Historical households by census-family type and tenure share

2016 Census	Total	Census-family w/o children	Census-family w/ children	Non-census family*
Total households	100	45	15	45
Share of total	100%	45%	15%	45%
Owner households	80%	100%	0%	78%
Renter households	20%	0%	100%	22%
2021 Census	**Total**	**Census-family w/o children**	**Census-family w/ children**	**Non-census family***
Total households	90	50	0	40
Share of total	100%	56%	0%	44%
Owner households	89%	100%	-	75%
Renter households	11%	0%	-	25%
% change ('16-'21)	-10%	+11%	-100%	-11%

Source: BC Government purchased Custom Statistics Canada Census Tabulations

- The number of census-families with children (i.e., couples with children or lone parents) decreased between 2016 and 2021. This corresponds with the decrease in the number of households led by a 45-to 44-year old during the same time period.
- While the data suggests that no families with children live in Silverton, this may not be the case. It is likely these households exist but are not reported by Statistics Canada to ensure confidentiality for small datasets.
- Couples without children are the most prevalent household type in Silverton, followed by non-census families (i.e., single persons or unrelated roommates). This corresponds with the trends for 1- and 2-person households over the same period (2016-2021).

3. Housing Profile

The 2021 Census recorded 149 total dwellings in Silverton, of which 97 were occupied by usual residents. These numbers reflect Statistics Canada's amended values for the community. A usual resident is an owner or renter that lives in their dwelling more than half of the year, which qualifies the dwelling as their primary place of residence. Conversely, a non-usual resident occupied dwelling could include a recreational property, short-term rental, or unoccupied dwelling.

Given these numbers, it is estimated that about 35% of local dwellings may have been used for purposes other than permanent occupation. In 2016, the percentage was about 32%, indicating a marginal change and suggesting that the notable growth reported over the five years was less an outlier caused by the pandemic, but rather the pandemic accelerating existing in-migration trends for Silverton (i.e., moving to the community for retirement).

Table 3-1 summarises the totals and distribution by structure type for Silverton.

Table 3-1: Dwellings occupied by usual residents by structural type and tenure, 2021

	Total	Single	Row	Semi	Duplex	Apt (<5 floors)	Apt (5+ floors)	Mobile
Total	90	80	0	0	10	0	0	0
Share	100%	89%	0%	0%	11%	0%	0%	0%
Owner	89%	100%	-	-	0%	-	-	-
Renter	11%	0%	-	-	100%	-	-	-

Source: BC Government purchased Custom Statistics Canada Census Tabulations

- Single-detached homes account for about 89% of the housing supply (80 units), followed by duplex units at 11%. Other housing typologies may exist in Silverton but are not provided by Statistics Canada due to the small data set and confidentiality concerns. Note that Statistics Canada includes single-detached homes with secondary units within the definition of a duplex.

3.1 PROPERTY OWNERSHIP

The Census identified that approximately 35% of dwellings were reported as not being occupied by a usual resident in 2021. While a useful number to quantify the relationship between permanently and non-permanently occupied dwellings, Statistics Canada does not offer much in terms of who owns these non-permanent dwellings. Despite the lack of detailed data, some initiatives from Statistics Canada – particularly the Canadian Housing Statistics Program – provide some insights into local property ownership.

Key Definitions

Investment property: A property owned by someone that is not identified as a primary place of residence by the owner.

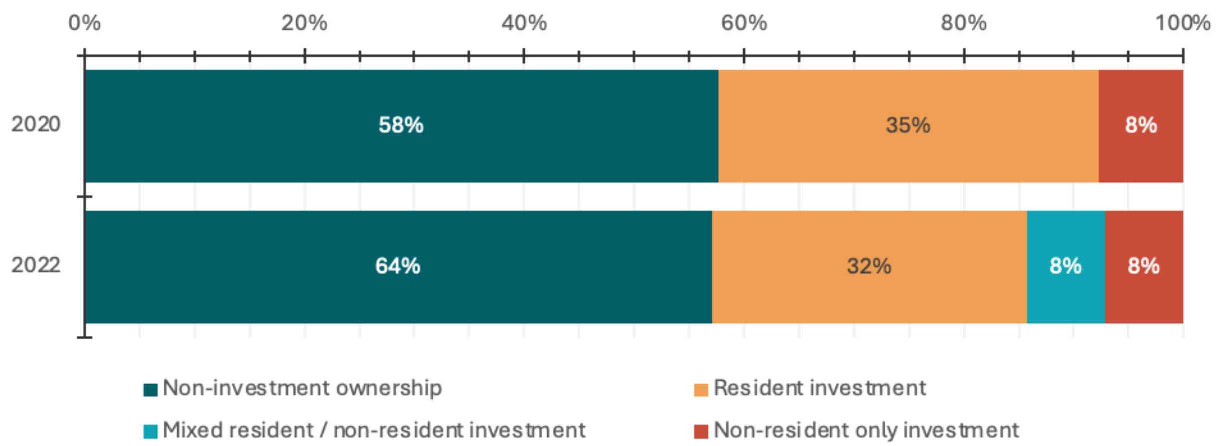
Non-investment property: A property owned and occupied by the owner.

Resident: A person who lives in Canada as their primary country of residence.

Non-resident: A person who does not live in Canada as their primary country of residence

Figure 3-1 illustrates how the distribution of improved residential property ownership (i.e., a property with a dwelling on it) has changed from 2020 to 2022; specifically, what share of properties are owned locally, by residents of Canada, and by non-residents of Canada. Note that values may not equal 100% due to rounding.

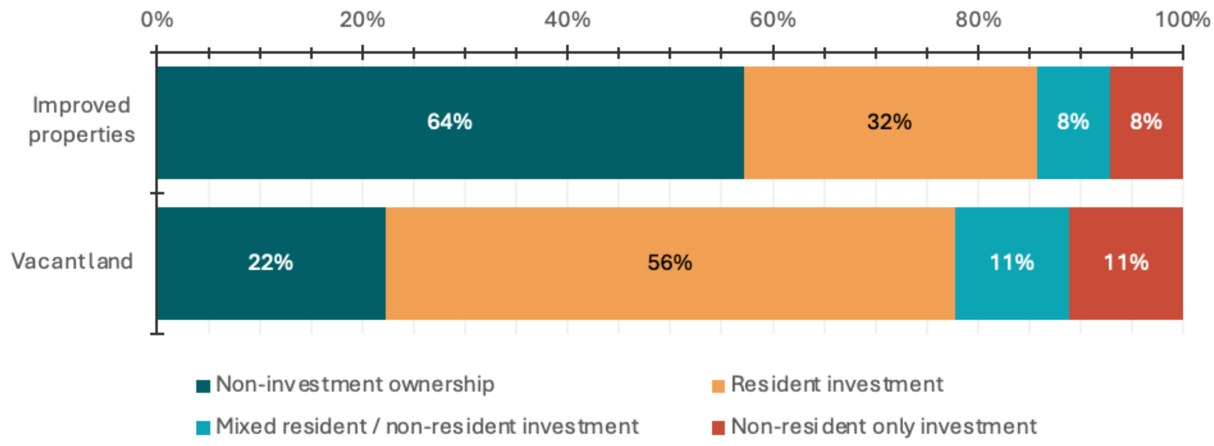
Figure 3-1: Share of local residential improved properties by ownership type



Source: Canadian Housing Statistics Program

Figure 3-2 illustrates how the distribution of ownership differs between an improved residential property and vacant land intended to be residential in 2022 (the most recent year collected). Note that values may not equal 100% due to rounding.

Figure 3-2: Share of local residential improved properties versus vacant residential properties by ownership type, 2022



Source: Canadian Housing Statistics Program

- About 43% of properties with a dwelling were classified as "investments" by Statistics Canada in 2020. Included in this percentage are permanently occupied rental properties owned by someone who may or may not have lived locally.
- In the same year, about 8% of dwellings were owned entirely by someone who does not live in Canada full-time.
- By 2022, the share of non-resident participants jumped from 8% to 16% which demonstrates that either previous owners living in Canada moved abroad or more people outside Canada are choosing to own local property.
- Vacant properties intended for residential uses were majority owned by resident investors, which could include locals or people elsewhere in Canada. Statistics Canada reported that no persons from outside of Canada owned local land (though some may exist but were not counted due to rounding).

3.2 RENTAL UNIVERSE

The rental universe includes a variety of different types of rental housing, most commonly categorized as either primary market, secondary market, or non-market rental housing.

CMHC's Rental Market Survey provides detailed data on the primary rental market (i.e., purpose-built rentals with 3+ unit) data. Unfortunately, CMHC only surveys communities with a population of larger than 10,000 people. Because

Key Definitions

Primary Market Rental: Purpose-built rental buildings with at least three rental units. These units are privately initiated, usually with the intention of being offered for rent at market rates.

Secondary Market Rental: All privately rented homes not categorized as primary market rentals. Can include: Rented detached homes, duplexes, semi-detached homes or row homes, r**ented freehold row/town homes**, rented accessory apartments or suites, and rented condominiums.

the Village of Silverton does not meet the minimum community size requirements, there is limited available data specific to the Village's primary rental market.

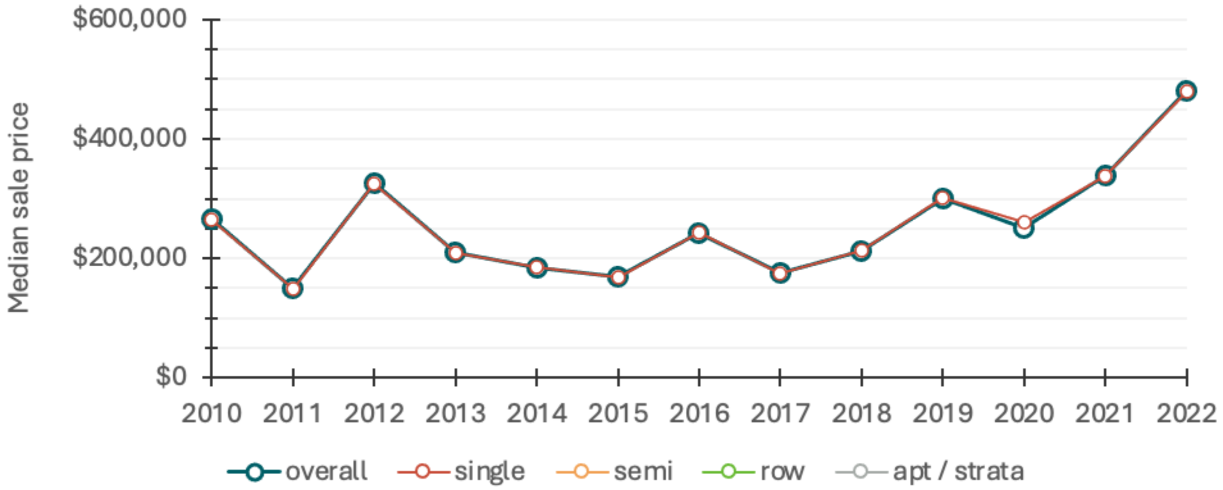
The 2021 Census offers some, but limited, detail about the rental market in Silverton, indicating that about 10 dwellings were rented by a household that considers the Village their primary place of residence. All 10 were categorized as a duplex – or as previously noted, potentially a single-family home with a secondary suite.

3.3 MARKET HOUSING

3.3.1 Home price trends

Figure 3-3 illustrates historical median home prices by dwelling type. The data is sourced from BC Assessment's historical revised rolls, which include sales information up to and including 2022. The dwelling types provided by BC Assessment have been reclassified to align with the categories used by Statistics Canada in their Census questionnaire.

Figure 3-3: Annual median sale price by dwelling type



Source: derived from BC Assessment

Table 3-2 offers the same data, but this time it presents the percentage change in median home prices by dwelling type over specific time intervals.

Table 3-2: Sale price and percentage change by dwelling type and select years

	Sale price				Percent change		
	2010	2016	2019	2022	'10-'16	'16-'19	'19-'22
Overall	$265,000	$242,700	$300,600	$479,500	-8%	+24%	+60%
Single-detached	$265,000	$242,700	$300,600	$479,500	-8%	+24%	+60%

Source: derived from BC Assessment

- From 2010 to 2016, house prices fluctuated, with noticeable increases in the early half of that time period. Fluctuations are largely due to Silverton's small sample size of sales – since 2010, the municipality averaged 4 home sales annually based on BC Assessment data.
- Price escalations became more significant after 2016, rising 24% between 2016 to 2019. Escalations ramped up even further post-2019, rising another 60% from 2019 to 2022.
- By 2022, the median home sale price had reached $479,500. Based on the available data, the median home price is synonymous with the median single-detached home price.

3.3.2 Homeownership attainability

Figure 3-4 compares the median home price in Silverton to the estimated price different household types earning the median income could afford. An "affordable price" is set using a variety of mortgage assumptions and the median annual income of each household family type. The purpose is to highlight the impact of changing local incomes and prices on affordability.

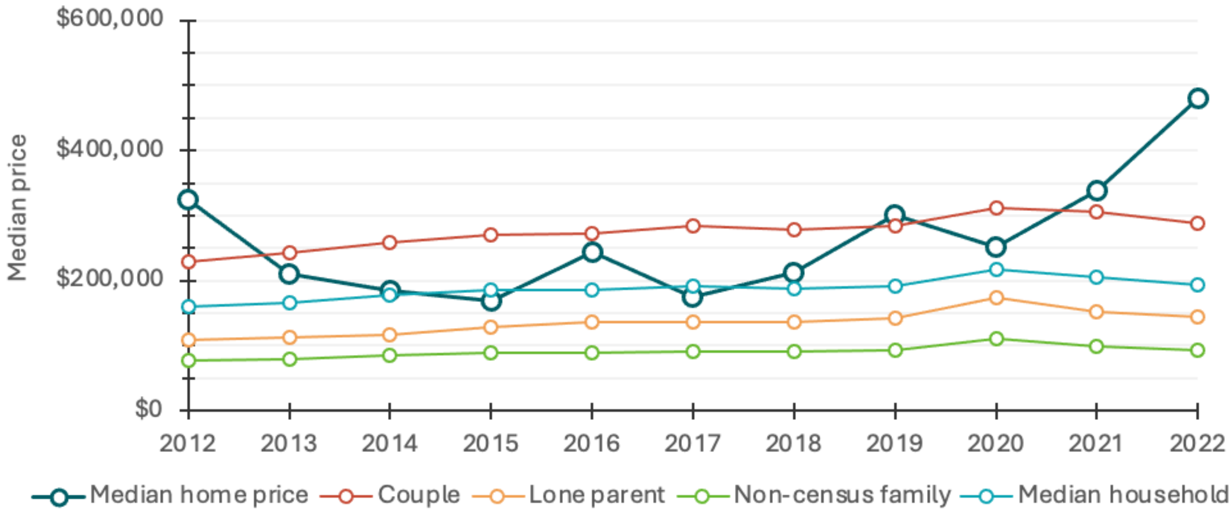
Assumptions

- Amortization period = 25 years
- Payment frequency = monthly
- Interest rate = prevailing (at given year) average weekly rate for 5-year fixed mortgage
- Down payment = 10%
- CMHC insurance = 3.10%
- Income used for shelter expenses = 30%
- Ancillary shelter costs = 25%
- Direct shelter costs (for a mortgage payment or rent) = 1 – ancillary = 75%

Calculations

- Collect 2021 median before-tax household incomes by household type, income bracket ranges, and income category ranges, as well as total households by characteristic.
- Estimate an affordable monthly payment using affordability assumptions above (i.e., income x 30% x [1 – 25%] = monthly payment).
- Convert the affordable monthly payment to an affordable purchase price, based on mortgage and down payment assumptions.
- Collect the 2022 median purchase prices by dwelling type.
- Compare median purchase prices to household budgets. If budget is below, a household's income cannot afford the purchase price.

Figure 3-4: Historical estimated affordable dwelling price by household type vs actual median home price



Source: derived from BC Assessment, custom Statistics Canada dataset3 and mortgage assumptions

- From 2012 to 2016, approximately 50% of households could afford the median house price in Silverton (with affordability fluctuating minimally over the four years).
- Since 2017, the median price of a home has become increasingly out of reach for all median household types. In 2021, the median home price surpassed what the median couple income could afford for the first time.
- Notably, the gap between the median house price and the affordable threshold for the median household was approximately $56,300 in 2016. The gap widened to $286,100 by 2022.
- Homeownership attainability data highlights the notable disparity between growth in prices and growth in estimated incomes, leading to reduced purchasing power for shelter for most households in the community.

Important note: The gap between the affordable purchase price and actual price reflects the median. There are individuals or households who face significantly greater and significantly less financial challenges related to their shelter. As of 2021, 12% of owner households in the RDCK reported not reasonably affording where they live.

3 Statistics Canada. Table 11-10-0012-01 Distribution of total income by census family type and age of older partner, parent or individual. DOI: https://doi.org/10.25318/1110001201-eng

3.4 NON-MARKET HOUSING

Non-market housing encompasses all forms of housing not subject to market forces. This includes public or social housing, affordable housing offered by non-profit organizations, and transitional and emergency shelters, among others.

Table 3-3 provides an overview of the current housing and program offerings within Silverton, as reported by BC Housing in March 2024. The "XX" in the table below indicates that a unit of housing or programming may exist but is kept hidden to protect confidentiality.

Table 3-3: Summary of local non-market housing and programs, March 2024

Emergency Shelter and Housing for the Homeless	
Homeless housed	0
Homeless rent supplements	0
Homeless shelters	0
Total	0

Transitional Supported and Assisted Living	
Supportive seniors housing	0
Special needs	0
Women & children fleeing violence	0
Total	0

Independent Social Housing	
Low income families	0
Low income seniors	0
Total	0

Rent Assistance in Private Market	
Rent assistance for families	XX
Rent assistance for seniors	XX
Canada Housing Benefit recipient	XX
Total	6

Source: BC Housing

- The Village of Silverton is not the non-market housing centre of the RDCK, but its residents do benefit from programs and services. Specifically, six individuals or households obtained rental assistance in 2024.

3.5 ENERGY POVERTY

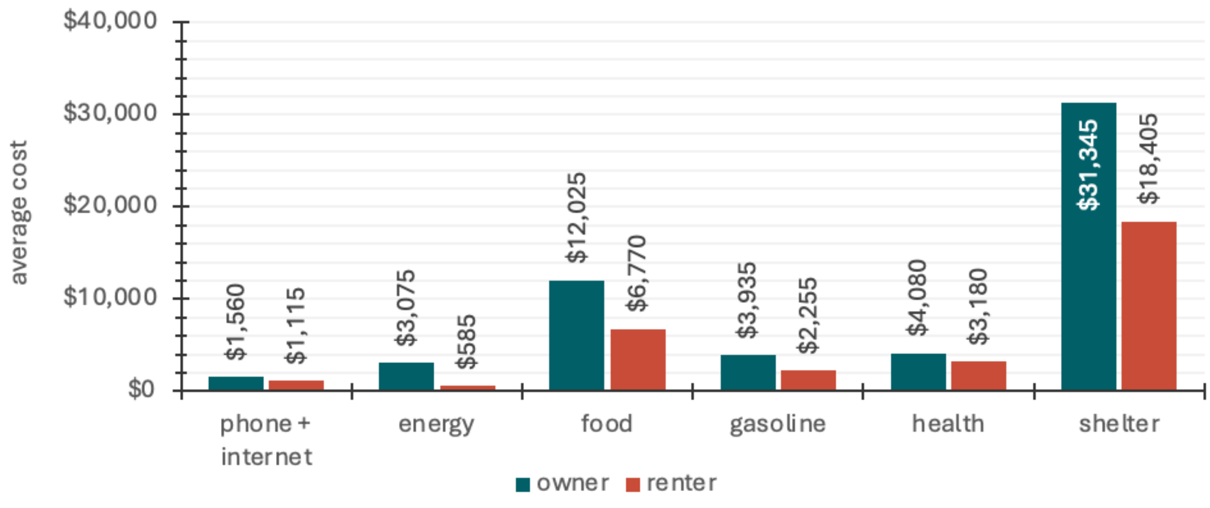
There are several expenses that contribute to the overall cost of housing. While these costs have always been a critical factor in determining a home's affordability, recent years of high inflation have brought household expenses to the forefront — namely, the rising cost of energy. Alongside increasing mortgage and rent payments, concurrently rising energy costs are pushing more households into "energy poverty."

According to the Canadian Urban Sustainability Practitioners (CUSP), energy poverty refers to the experience of households or communities that struggle to heat and cool their homes and power their lights and appliances. Canadian academics have developed three key thresholds to define a disproportionate energy cost burden relative to a household's average after-tax income. A home is considered in energy poverty if it meets any of the following criteria:

1. Spending more than 6% of after-tax income on utilities,
2. spending more than 4% of after-tax income on fuel used for transportation, and
3. spending more than10% of after-tax income for the combined of (1) and (2).

Figure 3-5 illustrates selected average annual living cost estimates for owning and renting households in Silverton, inclusive of energy and gasoline costs. These estimates are produced using Statistics Canada's 2019 Household Spending Survey data, adjusted by inflation and estimated locally based on distributions of dwelling structure types.

Figure 3-5: Average annual living expenses, 2023



Source: Statistics Canada Household Spending Survey, 2019 – adjusted to 2023 dollars using annual CPI

- Shelter cost estimates are the most expensive item for a household. The typical household pays approximately $18,400 annually on rent or $31,350 on a mortgage. Both figures include ancillary costs like insurance, condo fees, and taxes (if applicable).
- Food costs are the second-highest expense. With owner households generally having a higher average number of people, their reported average annual food cost is noticeably higher.

- To avoid being considered in "energy poverty," a renter household requires an after-tax income of at least $9,800 to afford the average annual energy bill, while an owner household requires an income of at least $51,300. Note that the small sample size of renter households may skew the data, and the required renter income is likely higher.
- To consider vehicle gasoline costs affordable, a renter household would need an after-tax income of $56,400, and an owner household would need $98,400.
- Based on after-tax household incomes reported by Statistics Canada in 2021 for the RDCK overall ($53,700 and $79,500, respectively), the most burdensome energy costs for households are vehicle expenses (particularly for owner-occupied dwellings). This is related to the vast geographies that many residents must regularly travel.

It is important to note that results for energy poverty may be underrepresented, as they cannot quantify whether households are living comfortably or just scraping by. The closer a household is to the energy poverty line, the greater the likelihood that they must make concessions in comfort to reduce energy costs.

4. Anticipated Housing Demand

4.1 DEMAND BY COMPONENT

In June 2024, the Province of BC released a standardized HNR demand calculation methodology. The HNR method estimates the total number of housing units required to address a community's current and anticipated housing needs over 5- and 20-year timeframes, based on publicly available data sources that can be applied to communities of various scales. It is composed of six components (labeled A through F in Table 5-1). The standardized method for calculating demand ensures that all local governments produce consistent and comparable assessments of their housing need.

It is important to note that the HNR demand calculation methodology does not consider the unique challenges to development in Silverton, such as servicing limitations/constraints, high construction costs, the availability of trades, and planning staff capacity, among other factors. Coordinated growth management planning with the RDCK, funding from senior levels of government, and creative solutions to densification will all be required to support the Village of Silverton to meet anticipated demand.

Table 4-1 provides a summary of the result for each component of the HNR Method for the Village of Silverton over the next 5 and 20 years as required by legislation.

Table 4-1: Anticipated housing demand by anticipated period and component (with explanations)

Component	Housing units for:	Intention	5 year (by 2026)	20 year (by 2041)
A	Households in Extreme Core Housing Need	To estimate the number of new units required for those in vulnerable housing situations. Extreme need refers to those paying more than 50% of household income on shelter costs.	0	0
B	Individuals experiencing homelessness	To quantify the supply of permanent housing units required for those currently experiencing homelessness.	1	1
C	Suppressed households	To address those households that were unable to form between 2006 and the present due to a constrained housing environment.	18	72
D	Anticipated household growth	To quantify the additional households required to accommodate an increasing population over twenty years. Note that anticipated growth for municipalities is based on the average of local and regional projections (thus, population / household growth trends discussed above may not follow the same trajectory as dwelling projections) and electoral areas use solely regional projections.	12	20

Component	Housing units for:	Intention	5 year (by 2026)	20 year (by 2041)
E	Increasing the rental vacancy rate to 3%	To add surplus rental units to restore local vacancy rates to levels representing a healthy and well-functioning rental housing market. Typically, rates between 3% and 5% are considered healthy rates.	0	0
F	A local demand buffer	To reflect additional demand for housing within a given community, beyond the minimum units required to adequately house current and anticipated residents. This is called the "demand buffer" and is designed to better account for the number of units required to meet "healthy" market demand in different communities. For the purposes of HNRs, a demand factor is based on a ratio of housing price to housing density, and is calculated for each applicable community.	29	114
TOTAL:			**59**	**208**

Source: HNR demand calculation methodology (link)

HNR Method Considerations

The HNR method prescribed by the BC Government is a standardized demand calculation methodology to ensure that all local governments produce consistent and comparable assessments of their housing need. This methodology works better for some areas than others. For municipalities with a small population base, the methodology is likely to result in an overestimate of demand. No projections are perfect, which is why the provincial legislation requires that municipalities repeat them every five years (as new information and data becomes available) as part of the HNR updates. The purpose of these projections is to serve as a target for municipalities to consider when assessing their zoning capacity to prepare for potential housing demand.

While it is required by legislation to report both the 5- and 20-year demand, the BC government is more interested in the 20-year projection. The short-term projection was a focus of the previous iteration of the HNR legislation which has since been revised to encourage communities to align housing projections with long term planning policies and tools (e.g., official community plans, zoning bylaws).

- The results indicate that Silverton may need to build 59 units by 2026 and 208 units by 2041. While some of the demand will come from future growth, the next greatest portion relates to the number of suppressed households since 2006 and the demand buffer adjustment. The HNR method suggests that Silverton may have been notably larger in 2021 had there been more favourable housing market conditions. Instead, 72 households were suppressed, or unable to form. The province, based on their internally calculated demand multipliers, estimates that Silverton will need 114 more dwellings to improve local and regional affordability.

- The anticipated projection of 208 new units by 2041 is more than double the projected number of households for that year. As noted, this calculation considers several factors beyond just future growth to determine how much housing a community should build. While BC projections estimate that the household base could be 100 in 2041 based on current trends, the municipality may need 208 new households over the next two decades to restore housing affordability and availability.
- Components A, B, C, and E attempt to catalog unmet "current" demand, and thus serve as an estimate of the existing housing shortage (without considering any changes since 2021, which is the reference year).

4.2 DISTRIBUTION OF DEMAND

4.2.1 Housing price model and dwelling size

An adaptation of the HNR method provides a rough idea of current market and non-market housing demand and what Silverton can expect over the 20-year projection period. HNR method guidelines do not prescribe how to perform this analysis, which could allow for more community level discretion.

Table 4-2 summarizes the results of applying the dwelling size distributions discussed in the **2024 Regional District of Central Kootenay Housing Needs Report** to project demand in the Village of Silverton. The outcome of this analysis is a table outlining anticipated demand, disaggregated by the number of bedrooms and intended market / price model. Note that non-market housing has been further separated into "affordable / below-market" housing (i.e., housing explicitly offered at prices below market, like the 80% of Median Market Rent criteria described by CMHC funding opportunities or rent-geared to income housing) and "deeply affordable" housing (i.e., rents offered at the shelter rate of income assistance, often combined with support services).

To distinguish what portion of the community might benefit from non-market housing, UBC Housing Assessment Resource Tools (HART) income categories and how they overlap across the housing continuum are considered. The historical proportions of households earning "very low" and "low" incomes are applied to the demand totals. The demand for deeply affordable and below-market units represents these respective income categories. For Silverton, regional income data trends are used to supplement the analysis due to suppression at the local level.

HART Income Categories

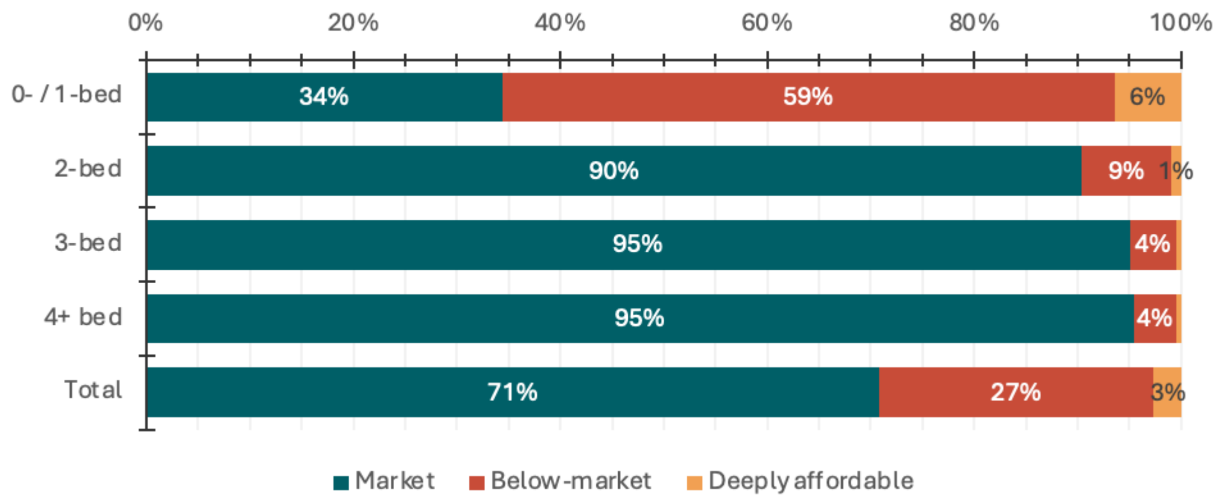
- **Very low income**: 20% or less of area median household income (AMHI), generally equivalent to shelter allowance for income support recipients.
- **Low income**: 21-50% AMHI, generally equivalent to one full-time minimum wage job.
- **Moderate income**: 51-80% AMHI, generally equivalent to a starting salary, depending on the job and sector.
- **Median income**: 81-120% AMHI, representing the 'middle class.'
- **High income**: More than 120% AMHI, the group with the greatest housing wealth

Table 4-2: Anticipated demand disaggregated by anticipated price model and required number of bedrooms

	Market		Affordable / below-market		Deeply affordable		Total	
	5-year	20-year	5-year	20-year	5-year	20-year	5-year	20-year
0- / 1-bed	8	27	14	47	2	5	23	79
2-bed	15	52	2	5	0	1	17	58
3-bed	12	42	1	2	0	0	13	44
4+ bed	7	25	0	1	0	0	7	27
Total	42	147	16	55	2	6	59	208

Figure 4-1 illustrates the distributions of the above price models by the number of bedrooms to show what dwelling sizes are best targeted by market or non-market interventions.

Figure 4-1: Distribution of price model demand by number of bedrooms, 2041



- The 5- and 20-year demand projections suggest a need for 59 and 208 units, respectively.
- Market housing should remain the primary contributor to the local inventory, though there is a clear need for non-market interventions. By 2041, Silverton may need 55 affordable / below-market offerings and 6 additional deeply affordable units.
- Engagement respondents expressed the importance of ensuring all demographics have access to non-market, affordable housing options in the communities they live in.
- As suggested by the calculated shares of units by number of bedrooms, market housing demand will likely focus more on 2- and 3-bedroom units; whereas, non-market solutions may distribute more to 0- and 1-bedroom dwellings.

4.2.2 Housing price model and tenure

For the most part, the market will ultimately decide whether new dwellings are built for rental or ownership based on prices and preferences. However, adapting data to estimate how demand might be distributed between owner and renters is useful for understanding which price models might be most needed over time.

Table 4-3 showcases the results of this analysis (with greater detail in the regional housing report, highlighting how different forms of housing may be distributed by size).

Table 4-3: Anticipated demand disaggregated by anticipated price model and tenure

	5-year (by 2026)		20-year (by 2041)	
Price model:	Owner	Renter	Owner	Renter
Market housing	31	11	108	39
Affordable / below-market	5	11	18	37
Deeply affordable	0	2	0	5
Total	36	24	126	81

- While it is likely that market housing demand will mainly be for owner-occupied housing, there is a notable forecasted interest in expanding the local market rental inventory.
- Non-market solutions typically take the form of rentals, but data suggests there could be demand for below-market ownership options, which could mean considering alternative forms of ownership such as co-operatives or community land trusts if funding and support programs materialize.

5. Bill 44 Analysis and Recommendations

Bill 44 – Housing Statutes (Residential Development) Amendment Act includes a suite of legislative changes to the local government land use planning framework aimed at providing additional housing in British Columbia communities. As previously noted, all local governments are now required to use a standardized projection method to understand housing needs over the next 5 and 20 years. The new legislation mandates that municipalities update Official Community Plans (OCPs) and zoning bylaws to permit the total anticipated housing demand over at least the next 20 years, as identified by the HNR Method. OCPs must also include policies that address a wide range of housing types (e.g. affordable housing, rental housing, seniors housing, family housing, etc.). Local governments must complete their first review and OCP update based on the interim HNR projections by December 31, 2025.

Bill 44 also includes legislative amendments that require local government bylaws to allow for small-scale, multi-unit housing (SSMUH). SSMUH describes a range of housing units that can provide attainable housing for middle-income families, including secondary suites in single family dwellings, detached accessory dwelling units, triplexes, townhomes, and house-plexes. Local and regional governments were required to update their bylaws by June 30, 2024, to accommodate SSMUH.

To support the Village of Silverton to complete the required OCP and corresponding zoning bylaw updates, the consulting team has identified several best practices and considerations for meeting the requirements of Bill 44. The team reviewed the Silverton OCP and identified areas for policy intervention, outlined in Table 5-1. It is important to note that this review is a starting point for staff and should not be considered a complete review. A full OCP update with specific policy recommendations is outside the scope of a typical HNR.

Table 5-1: Bill 44 best practices and considerations for legislated OCP updates

Best Practice:	OCP Alignment/non-alignment:	Recommendations:
Low density language in the OCP (often referred to as "traditional residential or "stable residential) should explicitly support various forms of missing middle and small scale multi-residential. No zones/areas within the Village should exclusively allow single detached dwellings or single-family homes.	The language in the Village of Silverton's Official Community Plan largely aligns with best practices for supporting a variety of missing middle and small-scale multi-unit residential developments. For example, **Objective 5.7.1c** "support[s] mixed use and medium density development in lands adjacent to where services and amenities are available." **Section 3.8 Growth Management** states "there is opportunity for the Village to satisfy the new housing demand through a small amount of infill and more compact developments, such as suites over garages, and carriage houses off lane ways." **Objective 5.1.2** is to " Ensure new development occurs through infill within existing developed areas that are already serviced. New development should be compatible with the form and character of existing development." **Objective 5.1.3.** is to "allow more density in residential development in the form of small apartments in the village centre above commercial buildings."	While language is largely supportive of various forms of missing middle and SSMUH residential development, more explicit language and policies should be included to better promote this type of building. Policies should strive to achieve the aspirations of the listed objectives as they relate to SSMUH. **Objective 5.1.1iv,** "ensure a sufficient supply of suitably zoned land to permit a variety of housing types in anticipation of future housing needs" should be amended to explicitly allow for accessory dwelling units, triplexes, townhomes, and rowhomes, and should remove reference to Health Authority approval.
Consider allowing purpose built rental apartments in several areas in the Village rather than solely in growth/core/arterials. This could encourage more purpose-built rentals in areas throughout the Village. This type of housing is important for a community as it is often the only form of housing that is accessible to lower-income families, seniors, and young people.	The Village of Silverton OCP does not include any language referencing or considering purpose built rental apartments. Although mixed-use development in the form of rental suites, condos, or residences above commercial property is mentioned in the strategy for **4.2.1 Commercial Development in High Corridor and Lakeshore Development**, there are no policies specifically related allowing or supporting purpose built rental apartments.	Add new policy in **5.1.1** "Objective: Ensure a sufficient supply of suitably zoned land to permit a variety of housing types in anticipation of future housing needs" to explicitly promote the consideration of purpose-built rental units. Add new Special Condition in **4.2.1. Commercial Development in Highway Corridor and Lakeshore Development** to explicitly promote the development of denser, purpose-built rental units.

Best Practice:	OCP Alignment/non-alignment:	Recommendations:
Ensure Development Permit Area (DPA) policies and guidelines do not unreasonably prohibit or restrict SSMUH development. According to the provincial policy manual, local governments are discouraged from using DPAs to regulate form and character of SSMUH development in all but exceptional circumstances. It is recommended to amend existing DPAs to remove SSMUH developments from intensive or multi-family residential definitions.	Some of the Development Permit Area policies and guidelines identified in the Village of Silverton OCP include language that is restrictive and prohibitive of SSMUH development. For example: **4.2.1 Commercial Development in Highway Corridor and Lakeshore Development** "Development Permits" Section 1 states that "for new buildings or renovations of existing buildings, the owner will be encouraged to reflect the historical and heritage character of the community (as illustrated by the Municipal Office, Memorial Hall, or Silverton Gallery), the mountain/lakeside setting of the community (as illustrated by the Silverton Resort), or the small village character of the community (as illustrated by the dentist office and the Municipal Office building). Lakeshore buildings must not be over two stories."	Amend policy language to exclude SSMUH developments from local regulations that impose unreasonable restrictions on form and character. This amendment reduces regulatory barriers, allowing for quicker and more flexible development. Revising these policies aligns with the provincial recommendation to support more flexible and diverse housing options, only applying additional regulations in exceptional cases.

Best Practice:	OCP Alignment/non-alignment:	Recommendations:
The life-cycle costs of infrastructure and servicing are significantly more cost-efficient when growth occurs in existing neighbourhoods, and within urban containment boundaries, compared to sprawl. Local governments should focus growth in areas that are already serviced.	The Village of Silverton OCP states that "Council recognizes the limited potential for new residential development within existing Village boundaries" and language is supportive of focussing growth in areas that are already serviced. For example, **5.1.2** has a stated objective to "ensure new development occurs through infill within existing developed areas that are already serviced. New development should be compatible with the form and character of existing development." However, language is restrictive of supporting or facilitating new development of medium to higher density forms of housing by requiring health authority or Ministry of Health approvals for new housing development. For example: **5.1.1.a.iv** considers "allowing secondary suites or carriage houses on R1 zones provided the health authority approves." **5.1.2.a.i.** states that "it is the policy of Council that the density of all residential development will be established by either: I. minimum lot sizes required to satisfy the requirements of Ministry of Health Officials respecting on-site disposal of sewage effluent; II. where an alternative sewage disposal method (approved by Ministry of Health) is provided, increased density may be approved."	Language should be amended to explicitly support the development of secondary suites, accessory dwelling units, triplexes, townhomes, row homes, and apartments under 6 storeys within existing developed areas that are already serviced. Any reference to Health Authority or Ministry of Health approvals should be removed as this is not a standard practice and an added barrier to development that other OCP's in the region do not include.

6. Conclusion

The Village of Silverton's housing landscape is evolving. While the population has been relatively stable over the last few years, median home prices have been rising. From 2019 to 2022, the median home price appreciated 60% as result of regional market influences. This has exacerbated housing affordability challenges and put further strain on the rental market. Low vacancy rates across the RDCK and limited supply are expected to further challenge current and future residents looking for both rental and ownership housing.

Although there is limited affordability data on the Village of Silverton, it is likely that residents are facing similar affordability challenges to neighboring communities. Meeting the demand for affordable housing options in the Village of Silverton is crucial. Estimates suggest that about 61 subsidized units could be required over the next 20 years to meet the needs of those most vulnerable. Overall, the Village of Silverton may require an additional 208 housing units to be built by 2041 to mitigate existing and future market imbalances.

The data presented here is intended to support and supplement the important work already being undertaken by the Village and its partners. Though it will be challenging, the Village of Silverton, with support from the RDCK, non-profit and private partners, and senior levels of government, is more than capable of addressing the housing needs outlined in this report.

Consulting support from:

M'AKOLA DEVELOPMENT SERVICES

TURNER DRAKE & PARTNERS LTD.

Village of Silverton Housing Needs Report Update

REGIONAL DISTRICT OF CENTRAL KOOTENAY
COMMUNITY PROFILES

APPENDIX A:
DEFINITIONS

Definitions

"bedrooms" refer to rooms in a private dwelling that are designed mainly for sleeping purposes even if they are now used for other purposes, such as guest rooms and television rooms. Also included are rooms used as bedrooms now, even if they were not originally built as bedrooms, such as bedrooms in a finished basement. Bedrooms exclude rooms designed for another use during the day such as dining rooms and living rooms even if they may be used for sleeping purposes at night. By definition, one-room private dwellings such as bachelor or studio apartments have zero bedrooms;

"census" means a census of population undertaken under the Statistics Act (Canada);

"census family" is defined as a married couple and the children, if any, of either and/or both spouses; a couple living common law and the children, if any, of either and/or both partners; or a lone parent of any marital status with at least one child living in the same dwelling and that child or those children. All members of a particular census family live in the same dwelling. A couple may be of opposite or same sex;

"components of demographic growth" refers to any of the classes of events generating population movement variations. Births, deaths, migration, marriages, divorces, and new widowhoods are the components responsible for the variations since they alter either the total population or the age, sex, and marital status distribution of the population:

> **"emigrant"** refers to a Canadian citizen or immigrant who has left Canada to establish a permanent residence in another country.
>
> **"immigrant"** refers to a person who is, or who has ever been, a landed immigrant or permanent resident. Such a person has been granted the right to live in Canada permanently by immigration authorities;
>
> **"interprovincial migration"** refers to movement from one province or territory to another involving a permanent change in residence. A person who takes up residence in another province or territory is an out-migrant with reference to the province or territory of origin and an in-migrant with reference to the province or territory of destination;
>
> **"intraprovincial migration"** refers to movement from one region to another within the same province or territory involving a permanent change of residence. A person who takes up residence in another region is an out-migrant with reference to the region of origin and an in-migrant with reference to the region of destination;
>
> **"non-permanent residents"** refers to persons who are lawfully in Canada on a temporary basis under the authority of a temporary resident permit, along with members of their family living with them. Non-permanent residents include foreign workers, foreign students, the humanitarian population and other temporary residents;

"core housing need" is when housing falls below at least one of the adequacy, affordability or suitability standards and it would have to spend 30% or more of its total before-tax income to pay the median rent of alternative local housing that meets all three housing standards;

> **"adequate housing"** means that, according to the residents within the dwelling, no major repairs are required for proper use and enjoyment of said dwelling;
>
> **"affordable housing"** means that household shelter costs equate to less than 30% of total before-tax household income;
>
> **"suitable housing"** means that a dwelling has enough bedrooms for the size and composition of resident households according to National Occupancy Standard (NOS) requirements;

"dwelling" is defined as a set of living quarters. Two types of dwelling are identified in the Census, collective dwellings and private dwellings. The former pertains to dwellings which are institutional, communal or commercial in nature. The latter, Private dwelling refers to a separate set of living quarters with a private entrance either from outside the building or from a common hall, lobby, vestibule or stairway inside the building. The entrance to the dwelling must be one that can be used without passing through the living quarters of some other person or group of persons;

"private dwelling occupied by usual residents" refers to a private dwelling in which a person or a group of persons is permanently residing. Also included are private dwellings whose usual residents are temporarily absent on May 11, 2021.

"private dwelling not occupied by usual residents" refers to a private dwelling which is not considered the primary place of residence of a household over a calendar year.

"dwelling type" means the structural characteristics or dwelling configuration of a housing unit, such as, but not limited to, the housing unit being a single-detached house, a semi-detached house, a row house, an apartment in a duplex or in a building that has a certain number of storeys, or a mobile home;

"single-detached house" means a single dwelling not attached to any other dwelling or structure (except its own garage or shed). A single-detached house has open space on all sides, and has no dwellings either above it or below it. A mobile home fixed permanently to a foundation is also classified as a single-detached house;

"semi-detached house" means one of two dwellings attached side by side (or back to back) to each other, but not attached to any other dwelling or structure (except its own garage or shed). A semi-detached dwelling has no dwellings either above it or below it, and the two units together have open space on all sides;

"row house" means one of three or more dwellings joined side by side (or occasionally side to back), such as a townhouse or garden home, but not having any other dwellings either above or below. Townhouses attached to a high-rise building are also classified as row houses;

"duplex" (also known as apartment or flat in a duplex) means one of two dwellings, located one above the other, may or may not be attached to other dwellings or buildings;

"apartment in a building that has five or more storeys " means a dwelling unit in a high-rise apartment building which has five or more storeys;

"apartment in a building that has fewer than five storeys" means a dwelling unit attached to other dwelling units, commercial units, or other non-residential space in a building that has fewer than five storeys;

"mobile home" means a single dwelling, designed and constructed to be transported on its own chassis and capable of being moved to a new location on short notice. It may be placed temporarily on a foundation pad and may be covered by a skirt;

"extreme core housing need" has the same meaning as core housing need except that the household has shelter costs for housing that are more than 50% of total before-tax household income;

"household" refers to a person or group of persons who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada or abroad;

"owner household" refers to a private household where some member of the household owners the dwelling, even if it is still being paid for;

"renter household" refers to private households where no member of the household owns their dwelling. The dwelling is considered to be rented even if no cash rent is paid;

"household maintainer" refers to whether or not a person residing in the household is responsible for paying the rent, or the mortgage, or the taxes, or the electricity or other services or utilities. Where a number of people may contribute to the payments, more than one person in the household may be identified as a household maintainer. In the case of a household where two or more people are listed as household maintainers, the first person listed is chosen as the primary household maintainer;

"household size" refers to the number of persons in a private household;

"household type" refers to the differentiation of households on the basis of whether they are census family households or non-census-family households. Census family households are those that contain at least one census family;

"migrant" refers to a person who has moved from their place of residence, of which the origin is different than the destination community they reported in. Conversely, a non-migrant is a person who has moved within the same community;

"mobility status, one year" refers to the status of a person with regard to the place of residence on the reference day in relation to the place of residence on the same date one year earlier;

"primary rental market" means a market for rental housing units in apartment structures containing at least 3 rental housing units that were purpose-built as rental housing;

"Rental Market Survey" refers the collection of data samples from all urban areas with populations greater than 10,000 and targets only private apartments with at least three rental units. Among the information provided are median rental prices for units within the primary rental market;

"secondary rental market" means a market for rental housing units that were not purpose-built as rental housing;

"shelter cost" refers to the average or median monthly total of all shelter expenses paid by households that own or rent their dwelling. Shelter costs for owner households include, where applicable, mortgage payments, property taxes and condominium fees, along with the costs of electricity, heat, water and other municipal services. For renter households, shelter costs include, where applicable, the rent and the costs of electricity, heat, water and other municipal services;

"subsidized housing" refers to whether a renter household lives in a dwelling that is subsidized. Subsidized housing includes rent geared to income, social housing, public housing, government-assisted housing, non-profit housing, rent supplements and housing allowances;

"tenure" refers to whether the household owns or rents their private dwelling. The private dwelling may be situated on rented or leased land or be part of a condominium. A household is considered to own their dwelling if some member of the household owns the dwelling even if it is not fully paid for, for example if there is a mortgage or some other claim on it. A household is considered to rent their dwelling if no member of the household owns the dwelling;

"vacancy" means a unit that, at the time of the CMHC Rental Market Survey, it is physically unoccupied and available for immediate rental.

Staff Report

Date: January 8, 2025

Subject: Early Budget Approval – Server Replacement

PURPOSE

To obtain early budget approval from Council to replace the Village's computer server.

BACKGROUND

When the Village of Silverton was placed under evacuation order in the summer of 2024, the Village's computer server was packaged and sent to a safe location. When it was being returned to the Village Office after the evacuation order was rescinded, the courier company severely damaged the server enroute. Despite having insured the server against damages in transport, the courier refused to cover the damages, and we were left no option but to pursue coverage from our insurance provider, Municipal Insurance Association of BC (MIABC). MIABC has approved insurance coverage for the server, less our deductible with is $5,000 (plus GST).

DISCUSSION

Our contracted computer support provider, Sensible Solutions, has provided an estimate to MIABC which has been approved. Sensible Solutions is suggesting that we seek to purchase the server components required early in the year, as they expect product increases very soon. A copy of the estimate is attached for Council's information. The final numbers may change slightly due to labour hours, but MIABC has assured us they will cover our claim, and our responsibility will be just the deductible and GST.

This replacement server includes updating the operating system to Microsoft Server 2025, and Sensible Solutions confirms that it provides the most future proof investment for the Village.

RECOMMENDATION:

THAT Council gives early budget approval for Sensible Solutions to replace the Village's server ($14,385.00), in the net amount of our deductible insurance through Municipal Insurance Association of BC, of $5,000 plus GST

Elsie Lemke, LGA, Council Advisor

Estimate

Estimate Number: 324

Expiration Date: 01/02/2025

Estimate For

Village of Silverton
421 Lake Avenue
Silverton, BC V0G 1S0
Phone:(250) 358-2472
cao@silverton.ca

Prepared By

Rylan Kewen
Sensible Solutions Inc.
602 Front St
Nelson, BC V1L4B7
Phone:(250) 777-4357
rylan@sensiblesolutions.ca

Item#	Quantity	Item	Unit Price	Adjusted Unit Price	Extended Price
One-Time Items					
1)	1	AEM_Server HPE ML110 (G11) Xeon S-12core, Hardware RAID pro, 32GB RAM, SSD HDD with aprox 1.5TB RAW	$7,285.31	$7,285.31	$7,285.31
2)	1	MS Server 2025 - 16 core MS Server 2025 STD - 16 core - Perpetual LIC	$1,653.00	$1,653.00	$1,653.00
3)	1	IT Labour - Server Configuration and Server Migration from old OS - includes physical server setup, build VM, MS roles DC1 (AD, DHCP, DNS etc), specific software etc, to full function. MAIS SQL etc migration done via collaboration with 3rd party vendor (40 to 45 person hrs) - ** estimate total is using 42.5 hours	$4,165.00	$4,165.00	$4,165.00
4)	1	EHF tbd	$0.00	$0.00	$0.00
5)	1	Shipping tbd	$0.00	$0.00	$0.00
				One-Time Total	**$13,103.31**

::Assumptions / Notes
- Taxes, Shipping, EHF extra as needed
- Patch cables extra as needed
- Travel extra as needed
- Assuming 3rd party vendors are available as needed

Subtotal	**$13,103.31**
Total Taxes (approx.)	**$1,280.85**
Total	**$14,384.16**

Authorizing Signature ______________________________

Date ______________________________

We'll happily provide additional training or services. Please contact us for more information if interested.
Any Interest Charges on Past Due Accounts and Collection Costs on Overdue amounts will be subject to a monthly finance charge.

MINISTRY OF FORESTS: POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS

NEMO CREEK - LEVEL 2 RECONNAISSANCE REPORT

NOTE: The results given on this form are reconnaissance in nature and are intended to be a warning of potential hazards and risks. It is not a detailed risk analysis and further work may alter the conclusions. Please read the appendix of this report for important limitations. Contact the author for more information.

FIRE NUMBER: N51103 Nemo Creek and N51228	**FIRE YEAR: 2024**	**DATE OF REPORT:** December 19, 2024

AUTHOR: *Sarah Crookshanks, P.Geo., Ministry of Forests*

REPORT PREPARED FOR: Southeast Fire Centre, District Manager

FIRE SIZE, LOCATION, AND LAND OWNERSHIP: 5980 ha on provincially managed public lands on the west shore of Slocan Lake (N51103). This fire was mostly contained within Valhalla Provincial Park. An additional 234 ha was burned within Valhalla Provincial Park in the Nemo Creek drainage (N51228).

VALUES AT RISK:

1. Private residences
2. BC Parks campsites
3. Domestic surface water quality

WATERSHEDS AFFECTED	**TOTAL AREA**	**AREA BURNED**	**BURN SEVERITY** (% of watershed area)
Wee Sandy Creek	5543 ha	970 ha (17%)	3% High, 7% Moderate
Sharp Creek	1291 ha	117 ha (9%)	0.5% High, 4% Moderate
Nemo Creek	7009 ha	727 ha (10%)	2% High, 5% Moderate
Cove Creek	302 ha	147 ha (49%)	1% High, 27% Moderate

SUMMARY OF TERRAIN CONDITIONS AND THE EFFECTS OF THE FIRE

The Nemo Creek fire was discovered on July 18, 2024, and burned almost 6000 ha of land on the west shore of Slocan Lake extending from Cove Creek north up to Wee Sandy Creek (Figure 1). A second fire in the Nemo Creek drainage (N51228) was discovered the same day and burned 234 ha in that watershed. Helicopter reconnaissance flights were undertaken on August 7 and August 23, followed by field work along the Slocan lakeshore on October 31.

The vegetation burn severity map for N51103 was adjusted based on aerial photos, as the bedrock outcroppings show artificially high burn severity. The breakpoint between moderate and high burn severity classes was lowered, resulting in some high vegetation burn severity areas being adjusted down to moderate. Due to access challenges, no field work was undertaken to evaluate soil burn severity.

The Nemo Creek fire is located between lake level at 550 m up to the alpine (>2000 m). Nemo Creek and Wee Sandy Creek are large (5000-7000 ha) u-shaped valleys that drain alpine terrain within Valhalla Provincial Park. Two smaller (~1000 ha) streams, Hoben Creek and Sharp Creek, also drain alpine terrain. The burned area includes large areas of exposed bedrock overlain in places by a thin veneer of colluvium.

The BC Freshwater Atlas includes several channel and watershed delineation errors for the area west of Slocan Lake. The Atlas shows an unnamed creek adjacent to the Cory's Ranch campsite. No channel or surface expression of flow was identified in the field during the field assessment. A seep along the lakeshore was noted north of the campsite; however, no surficial channel was identified upslope of the spring. The Sharp Creek watershed is also incorrectly delineated. The outlet of the creek was observed in the field several hundred metres to the north of where it is mapped. The watershed area and creek were redrawn in ArcGIS and what is shown in Figure 1 reflects what was observed in the field.

Potential post-wildfire natural hazards include flooding, debris floods, debris flows, landslides, and rockfall. Over the first few years after a fire, hazardous events such as debris floods and flows are typically triggered by short-duration, high intensity (i.e. convective) rainfall threatening elements located on alluvial fans near or in the valley bottom. Debris flows and floods can also occur during spring runoff because of rapid snowmelt in burned areas, or less frequently during fall rain events. Due to changes in snow accumulation and melt processes, elevated flows during spring freshet or summer low flow periods may persist for many years until the forest canopy closure recovers.

SUMMARY OF POST-FIRE HAZARD AND RISK

1. Hazard = P(H), the probability of occurrence of a hazardous event
2. Probability of spatial impact, P(S:H), the probability of a hazard reaching or affecting an element at risk
3. Partial Risk, the probability of a hazard occurring and affecting an element at risk = P(H) x P(S:H)
4: Location with the highest risk rating given; at other locations the risk may be lower

Debris flood or clearwater flood on Wee Sandy Creek impacting campsites

Geohazard Event	Element at risk	Hazard P(H)[1]	Probability of spatial impact P(S:H)[2]	Partial Risk[3,4]
Debris flood	Campsites	Low	Moderate	Low
Clearwater flood	Campsites	Low	Moderate	Low

Wee Sandy Creek drains extensive areas of alpine terrain up to 2700 m in elevation around Mount Meers and Mount Niord and Mount Denver. The fire extended approximately 7 km up the watershed impacting the lower half of the catchment. The majority of the alpine terrain remained unaffected by the fire. Below 1400 m, the channel gradient of the main channel is 19% and moderates to 6%, before steepening to 13% as the channel drops to lake level over the last 1.5 km. The Melton ratio (watershed relief divided by the square root of the watershed area) has been shown to reasonably predict the dominant hydrogeomorphic hazard; for Wee Sandy Creek, the Melton ratio is 0.07, which suggests that the channel is prone to experiencing clearwater floods. The watershed was 17% burned (10% at high and moderate burn severity). The wildfire area is limited to the lower elevation (eastern) half of the watershed. Any increase in flow from the burned area will therefore occur early in the melt season, before peak runoff in Wee Sandy Creek. Given that the overall proportion of the watershed that has been burned is less than 20%, the incremental clearwater flood risk due to the fire is rated as low.

The watersheds of two potentially debris-flow prone tributaries that drain from the south into Wee Sandy Creek were >50% burned at moderate and high burn severity. It is anticipated that a post-wildfire debris flow from one of these channels will be diluted once it hits the mainstem, potentially transitioning to a debris flood that may affect the campsites on the fan. The distance between where the tributaries enter the mainstem and Slocan Lake is just over 2 km and channel gradients in the mainstem are insufficient for debris flows to be continue to Slocan Lake. Furthermore, no debris flow deposits were observed on the fan. The likelihood of a debris flow in a tributary to Wee Sandy has been rated as moderate, because historical satellite imagery or airphotos do not show a high degree of historical channel activity and the headwaters of these two channels remain unburned. The likelihood that a debris flow from these tributaries will be transported as a debris flood down to the Wee Sandy fan has been rated as low; deposition along the mainstem channel is possible given the channel gradient (<10% steepening to 13%) and the Wee Sandy Creek drainage area is large enough to allow for significant dilution particularly during periods of high flow.

Four tent pads are located on the fan of Wee Sandy Creek. These tent pads are near the channel, though not directly in an avulsion path or immediately adjacent to channel. Therefore, the probability of spatial impact has been rated as moderate.

Two tent pads at the south end of the campground are located below a rock bluff. The rock bluff area has been affected by the fire; therefore, the likelihood of rock detachment may be elevated for the next several years. I recommend not rebuilding these tent pads for several years to discourage camping in this area.

Debris flow on Sharp Creek impacting campground

Hazard P(H)[1] = Low   Probability of spatial impact P(S:H)[2] = Moderate   Partial Risk[3,4] = Low

Sharp Creek drains a 1300 ha watershed that includes the small (17 ha) New Denver Glacier. The watershed is only 1% glaciated, and glacial melt is assumed to be a minor contributing factor to the creek's annual hydrograph. Sharp Creek appears to be a debris flow prone channel. The fan gradient is 14%, and debris flow lobes and levees were observed on the fan. It is challenging to determine when these events occurred, though none of the deposits appear to be recent (i.e. within the last 100 years). Only 9% of the watershed was burned in the fire, and less than 5% at moderate and high burn severity; therefore, the hazard has been rated as low.

The campground is located south of the channel on the Sharp Creek fan, though none of the sites are located immediately adjacent to the stream channel or within a defined avulsion channel. For these reasons, the probability of spatial impact is rated as moderate.

Debris flood or flooding on Nemo Creek impacting private residences or campsites

Geohazard Event	Element at risk	Hazard P(H)[1]	Probability of spatial impact P(S:H)[2]	Partial Risk[3,4]
Clearwater flooding	Campsites	Low	Low	Very Low
Debris flood	Campsites	Low	Low	Very Low
Clearwater flooding	Cabin	Low	Moderate	Low
Debris flood	Cabin	Low	Moderate	Low

Nemo Creek is a large (>7000 ha) flood-prone creek that drains alpine terrain up to 2600 m. The channel gradient of the mainstem of the creek range from 4-7% until dropping the final 3.5 km to lake level at a gradient of 14%. Only 10% of the watershed area was burned, though the burn is composed mostly of moderate and high burn severity (Figure 2). Given the low proportion of the watershed that was burned, the incremental increase in the likelihood of post wildfire clearwater flooding has been rated as low.

A tributary that could be susceptible to debris-flows drains from the north into Nemo Creek and was burned mostly at high to moderate severity (Figure 3). The distance between where the tributary enters the mainstem and Slocan Lake is 3.5 km. The headwaters of this tributary are composed of unburned bedrock cliffs. If a debris flow were initiated in this drainage, the most likely scenario would be that the flow would be diluted once it converges with Nemo Creek, transitioning to a debris flood. If Nemo Creek discharge was at flood stage near its annual maximum, the debris flow may be further diluted into a clearwater flood. The likelihood of a debris flow event in this tributary has been rated as moderate, because while over 70% of the watershed has been burned at moderate/high severity, the headwaters remain unburned. The likelihood that a debris flow this tributary will be transported as a debris flood down to the Nemo Creek fan has been rated as low; deposition along the mainstem channel is possible and the Nemo Creek drainage area is large enough to allow for significant dilution particularly during periods of high flow.

The campsites at Nemo Creek are located to the north of the channel and a cabin on private property is located on the fan to the south of the channel (Figure 4). The channel through the upper portion of the fan is incised, where the bank height to the north is 6.5 m and to the south is 2 m. Therefore, the probability of an event (flood or debris flood) impacting the cabin or the campsites has been rated as moderate and low, respectively.

Water quality impacts to surface domestic water user on Nemo Creek

Hazard P(H)[1] = Low Probability of spatial impact P(S:H)[2] = High Partial Risk[3,4] = Moderate

There is one domestic water licence on Nemo Creek (Appendix 2). Given the low proportion of watershed burned, the likelihood of water quality impacts has been rated as low. Any water quality impacts are expected to be highly episodic.

Flooding on Cove Creek impacting campsites

Hazard P(H)[1] = Moderate Probability of spatial impact P(S:H)[2] = Low Partial Risk[3,4] = Low

Cove Creek is a small (300 ha) watershed that drains terrain up to 2200 m elevation. The watershed has a Melton ratio of 0.97, which indicates that the terrain may be susceptible to debris flows. However, no evidence of fan formation or debris flow deposits was observed at the creek's outlet. The channel bed is composed of cobbles and gravel where it flows into the lake. Based on field observations at the outlet into Slocan Lake and watershed morphometrics, the creek is likely flood-dominated. Approximately 50% of the watershed was affected by fire, with the majority of the burned area experiencing low to moderate burn severity. Due to the proportion of the watershed that was burned, the incremental increase in the post-wildfire flooding hazard is rated as moderate.

The campsites at Cove Creek are located north of the creek channel. Most are located on an elevated bench above the channel and lake and are not at risk of flooding from Cove Creek. One campsite is located on the beach, but this site is located well north of the channel with no risk of avulsion from Cove Creek. The probability of spatial impact is thus rated as low.

COMMENTS

There are approximately eight seasonal cabins on private land that are located north of Hoben Creek and the Sandy Point campground. These cabins are located below a rock bluff area that was burned at moderate severity. Numerous rocks were observed on the land surrounding the two northernmost cabins (one of which was burned in the fire), which indicates that rockfall has historically impacted the area and likely presents an ongoing hazard (Figure 5). Due to private land access restrictions, it was not possible to assess if any recent rockfall has occurred during or since the fire and no detailed assessment of the spatial distribution of the rockfall was undertaken. Additional lots further to the south may also be at risk. Affected residents may wish to hire a technical specialist to undertake a more detailed assessment to better understand the natural hazards which may impact their properties.

The increase in rockfall hazard after wildfire is typically due to the removal of vegetation or fallen logs that were supporting loose rocks. Thermal expansion and exposure can also make rocks more susceptible to detachment and increase the likelihood of rockfall during and after rainfall or freeze-thaw. The highest frequency of rockfall is typically seen during or immediately after the fire, and declines in subsequent years.

FURTHER ACTIONS

BC Parks may want to consider not-rebuilding or temporarily decommissioning two tent pads near the south end of the Wee Sandy Creek that are located below a rock bluff.

SIGNATURE, SEAL, FIRM PRACTICE #

SCrookshanks

December 19, 2024

PROFESSIONAL · PROVINCE OF · S. D. I. CROOKSHANKS # 37362 · BRITISH COLUMBIA · GEOSCIENTIST

Sarah Crookshanks, P.Geo.
Ministry of Forests
Permit to Practice #1003022
Reviewed by: Gareth Wells, P. Geo

ATTACHMENTS

See attached map, photos and Appendices

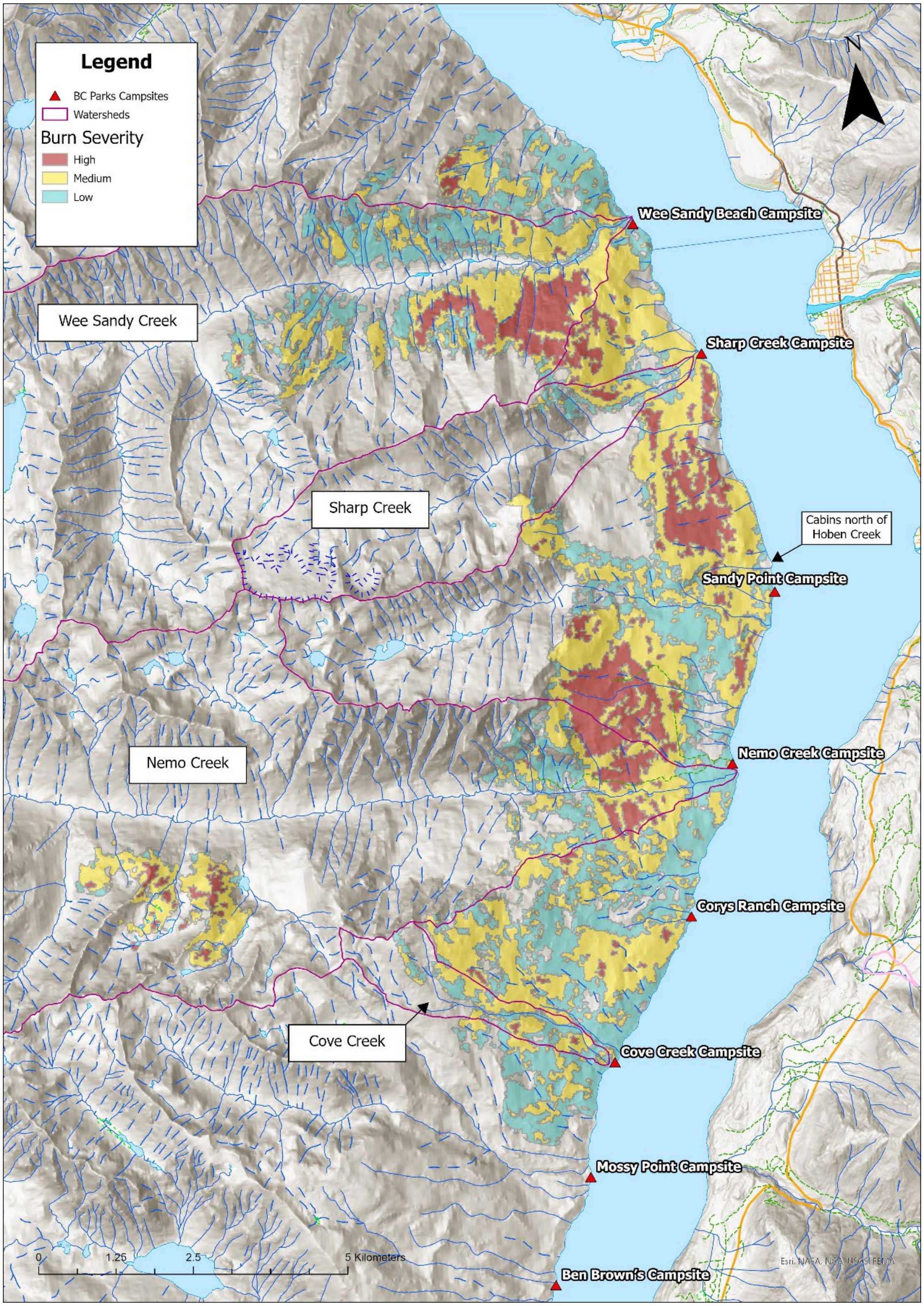


Figure 1 Burn severity map of the Nemo Creek fire showing estimated classes derived from Sentinel-2 imagery (prefire: July 7, 2024; post-fire: September 5, 2024). Burn severity classes were modified based on aerial photographs to correct for the high reflectance from bedrock outcropping areas.

Figure 2. Looking upstream at the Nemo Creek valley.

Figure 3. Potentially debris-flow prone tributary to Nemo Creek.

Figure 4. Nemo Creek fan (Photo: Ryan Williams, SNT Geotechnical)

Figure 5. Private cabins below a rock bluff north of Hoben Creek.

Appendix A to PWNHRA Reconnaissance Reports

Scope of Reconnaissance (Level 2) Reports

Reconnaissance (Level 2) reports are primarily intended to identify whether post-wildfire hazards are likely to occur and need detailed investigation to protect identified elements at risk. Identified elements at risk are generally limited to public safety and infrastructure. Reconnaissance reports may also be used to assess safety conditions for wildfire fighters. In some cases, the MOF District Manager or other MOF personnel may request assessments for non-standard elements at risk or for other reasons.

Definitions of Hazard and Risk

Wildfire may produce conditions conducive to a suite of hazards. Debris flows, debris floods, and floods are often the most important hazards, but other types of landslide hazards including rockfall, debris slides and earthflows can also occur in response to wildfire. Wildfire can also cause snow avalanches and may affect water quality, cause erosion and result in sedimentation. Terrain, watershed, and channel conditions that produce post-wildfire hazards may also produce similar hazards in unburned conditions; these hazards may be mentioned but are not evaluated in this report.

P(H), P(S:H) and partial risk are presented for each identified elements at risk. Multiple types of channel hazards (debris flows, debris floods, floods) may affect an element at risk. These hazards are ranked by severity, with debris flow as the most damaging and destructive and flood as the least damaging and dangerous, and ratings are given for the highest rating hazard that may affect an element at risk. For example, where a channel has the potential for a debris flow and an element at risk may be affected, the lower ranking debris flood and flood hazards are not rated, since discharge and velocity are likely to be less than for a debris flow. These processes may cause erosion or sedimentation that affects the element at risk. Hazards that are unlikely to affect an identified element at risk are not discussed.

Table A1 shows the annual probability ranges for qualitative definitions of P(H). The probability of the hazard occurrence is for the post-wildfire period of elevated hazard, which in many cases may be less than five years, but in some cases may extend for several more years.

Table A1. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities.

Post-wildfire hazard rating	Description	Annual Probability Range
Very High	An event is expected to occur. Most of the catchment or face unit has burned with a significant proportion burned at moderate and/or high severity	>0.2
High	An event is probable under adverse conditions. Most of the catchment or face unit has burned with a significant proportion (i.e., >50 %) of terrain conducive to post-wildfire natural hazard initiation burned at moderate or high severity. Existing indicators of pre-fire terrain instability within stream channels, on fans or face units.	0.01 - 0.2
Moderate	An event could occur under adverse conditions. It is not probable but possible over a several year period. More than 20% of the terrain conducive to post-wildfire natural hazards in the catchment or on the face-unit has burned with moderate and/or high severity. Historic geomorphic indicators of instability are present.	0.002 – 0.01
Low	An event could occur under very adverse conditions. It is considered unlikely over a several year period. Only a limited proportion of the catchment or face unit has burned. Few or no signs of pre-fire instability present along stream channels, fans or face units.	0.0004 – 0.002
Very Low	An event will not occur or is conceivable though considered exceptionally unlikely. A limited proportion/none of the catchment was burned. No terrain instability indicators are present	<0.0004

Table A2 defines spatial impact to an element of risk. Post-wildfire event magnitude is considered when rating spatial impact.

Table A2. Post-wildfire spatial impact.

Likelihood of spatial impact	Description	Probability range
H	It is probable that the event will impact the element at risk.	>0.5
M	It is possible that the event will impact the element at risk.	0.5 - 0.1
L	It is unlikely that the event will impact the element at risk.	< 0.1.

Table A3 is a matrix which combines the hazard likelihood (Table A1) with the spatial impact likelihood (Table A2) to determine partial risk.

Table A3. Post-wildfire risk matrix partial risk matrix.

Hazard Likelihood P(HA) (Table 1)	Spatial Impact Likelihood (P(S:H)) (Table 2)		
	High	**Moderate**	**Low**
Very High	Very High	Very High	High
High	Very High	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Very Low
Very Low	Low	Very Low	Very Low

Report Standards

FLNRORD Land Management Handbook 69 is the primary standard followed in this report. LMH 69 describes the process to complete a detailed report. This reconnaissance report uses the framework of LMH 69 but does not follow it where detailed assessment procedures are described.

Land Management Handbook 69 Post Wildfire Natural Hazards Risk Analysis in British Columbia 2015
https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh69.htm

Additional guidance is provided in the MOF SOG for PWNHRA and the 2014 FLNRO Landslide Risk Management Procedure.

Other professional guidance standards that may be used for the preparation of reconnaissance reports are listed below. These guidelines have similar report content to this reconnaissance assessment, but are for different purposes, have different levels of appropriate effort, and do not recognize the potential emergency nature of this reconnaissance assessment. These guidelines include:

EGBC Guidelines for TSA in the Forest Sector 2010
https://www.egbc.ca/getmedia/684901d7-779e-41dc-8225-05b024beae4f/APEGBC-Guidelines-for-Terrain-Stability-Assessments.pdf.aspx

EGBC Guidelines for Legislated Landslide Assessments 2010
https://www.egbc.ca/getmedia/5d8f3362-7ba7-4cf4-a5b6-e8252b2ed76c/APEGBC-Guidelines-for-Legislated-Landslide-Assessments.pdf.aspx

Legislated Flood Assessments in a Changing Climate in BC 2018
https://www.egbc.ca/getmedia/f5c2d7e9-26ad-4cb3-b528-940b3aaa9069/Legislated-Flood-Assessments-in-BC.pdf

Watershed Assessment and management of hydrologic and geomorphic risk in the Forest Sector
https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMW2ATQA5BSODHJAKBAGZDYTRL6FJ/Watershed%20Assessment%20and%20Management%20of%20Hydrologic%20and%20Geomorphic%20Risk%20in%20the%20Forest%20Sect

Other standards may also apply, depending on the professional qualifications of the writer.

Statement of Limitations

Reconnaissance PWNH Level 2 assessments are typically done in constrained timelines where personnel, resources, data collection, and analysis methods are limited. Post-wildfire hydrogeomorphic hazards in BC are not well understood and therefore hazard and risk assessments are estimates only. While probabilities ranges are given in Tables A1 and A2, the state of the science in BC does not allow for precise assessments, particularly near the borders of classes. Numeric probabilities ranges do not imply precision.

Identification of elements at risk relies on BC government data layers, satellite imagery, and perhaps an overview flight. BCWS and the MOF district office may provide additional information. No further confirmation of elements at risk was conducted.

Comments, conclusions, and suggestions contained in this reconnaissance assessment reflect my experience and judgement considering the information available to me at the time that this report was prepared and are considered appropriate for the reconnaissance nature of the review. The review has been carried out in accordance with generally accepted professional practices. This assessment and its contents are intended for the sole use of post-wildfire hazard management by provincial agencies, First Nation governments and local governments. I do not accept any responsibility for the accuracy of any of the data, the interpretation, or the conclusions contained or referenced in the report when the report is used or relied on for any other purpose than specified. Any such unauthorized use of this report is at the sole risk of the user.

Appendix B Water Licence Holders

Source Name	Licence #	Client Name	Client Address	Purpose Use
Nemo Creek	C51695	LaPointe Fiduciary Management	In Trust, PO Box 4995, Jackson WY 83001, USA	Domestic
Nemo Creek	C51898	LaPointe Fiduciary Management	In Trust, PO Box 4995, Jackson WY 83001, USA	Power (residential)

MINISTRY OF FORESTS: POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS

KOMONKO CREEK - LEVEL 2 RECONNAISSANCE REPORT

NOTE: The results given on this form are reconnaissance in nature and are intended to be a warning of potential hazards and risks. ***A more detailed report will follow*** *and may alter the conclusions. Please read the appendix of this report for important limitations. Contact the author for more information.*

FIRE NUMBER: N51210 Komonko Creek	**FIRE YEAR: 2024**	**DATE OF REPORT:** September 11, 2024

AUTHOR: *Sarah Crookshanks, P.Geo., Ministry of Forests*

REPORT PREPARED FOR: Southeast Fire Centre, District Manager

FIRE SIZE, LOCATION, AND LAND OWNERSHIP: 4080 ha of provincially managed public land and private land south of Silverton

VALUES AT RISK:

1. Private residences and/or potentially occupied buildings along Highway 6 and Red Mountain Road
2. Domestic surface water quality on creeks originating from within the fire
3. Highway 6 and Red Mountain Road

WATERSHEDS AFFECTED	TOTAL AREA	AREA BURNED	BURN SEVERITY (% of watershed area)
Enterprise Creek	10541 ha	1169 ha (11%)	1% H, 5% M
Aylwin Creek	652 ha	431 ha (66%)	24% H, 27% M
Congo Creek	111 ha	104 ha (93%)	25% H, 29% M
Fingland Creek	237 ha	131 ha (55%)	5% H, 20% M
Baby Ruth Creek	221 ha	90 ha (41%)	5% H, 10% M
Vevey Creek	532 ha	175 ha (33%)	2% H, 12% M

SUMMARY OF POST-FIRE HAZARD AND RISK

1. Hazard = P(H), the probability of occurrence of a hazardous event
2. Probability of spatial impact, P(S:H), the probability of a hazard reaching or affecting an element at risk
3. Partial Risk, the probability of a hazard occurring and affecting an element at risk = P(H) x P(S:H)
4: Location with the highest risk rating given; at other locations the risk may be lower

Debris flow or flood on Allen/Cory Creek face impacting private residences or highway

Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = moderate Partial Risk[3,4] = high

The face unit south of Enterprise Creek burned extensively in the 2007 Springer Creek fire. In the Allen and Cory Creek drainages, the 2007 fire resulted in mostly low burn severity, with some patches of moderate burn severity. No debris flows occurred in these two creeks after the 2007 fire, but several post-wildfire events occurred on similar drainages with higher watershed burn severities to the south.

The 2024 Komonko Creek fire also burned the upper reaches of Allen and Cory Creeks at moderate to high severity. The rest of the face to the north of Allen Creek also burned at moderate to high severity, though this area had previously burned at high severity in 2007. No field verification of soil burn severity was undertaken in this area, and the reburn of the area complicates the assessment of hydrological impacts. This face is steep, and all drainages appear to be susceptible to debris flows.

There are six Regional District of Central Kootenay (RDCK) address points east of the highway potentially at risk. The spatial likelihood of a debris flow impacting any of these residences is estimated to be moderate but requires additional fieldwork to confirm their specific locations relative to the channels of Allen and

Cory Creeks. The closer a residence is to a channel, the higher the spatial likelihood of impact. The highway is also potentially at risk. The address points to the west of the highway are less likely to be at risk, as the slope flattens considerably here.

Debris flow or flood on south tributary to Enterprise Creek impacting Highway 6
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = high Partial Risk[3,4] = very high

At the Enterprise Creek hairpin on Highway 6, a small tributary to Enterprise Creek enters from the south. A debris flow in this channel is anticipated to impact the highway, though further field work is needed to confirm the probability of spatial impact. This drainage burned in the 2007 Springer Creek fire at high severity in the headwaters area. No debris flows are known to have occurred in this drainage after this fire. The burn severity mapping from the 2024 fire also shows high burn severity in this watershed. Given that the 2007 fire burned at high severity, there was likely limited fuel available to burn in 2024, though the cumulative impact of two fires on the soils is not well understood at this time. Additional work should be undertaken to confirm the crossing infrastructure. Regular inspection and maintenance at this site are recommended.

Rockfall impacting Highway 6 north of Slocan Lake View Point
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = high Partial Risk[3,4] = very high

Rockfall onto the highway occurred at this location during the fire. The rocks were mostly small, and likely came from surficial rocks being dislodged as the organic matter burned. It is likely that some additional rocks may be dislodged, particularly during periods of intense rainfall. MOTI is aware of this hazard and will be regularly inspecting and maintaining this section of road in the coming months.

Debris flow or flood on Johnson Creek, Highland View Creek, or Harte Creek impacting private residences or highway
Hazard P(H)[1] = low Probability of spatial impact P(S:H)[2] = moderate Partial Risk[3,4] = low

Debris flow or flood on Kegel Brook impacting private residences or highway
Hazard P(H)[1] = moderate Probability of spatial impact P(S:H)[2] = moderate Partial Risk[3,4] = moderate

The face between Enterprise and Aylwin Creeks was burned mostly at low severity, with a few small patches of moderate severity and high burn severity. Lidar hillshade imagery shows indistinct, parallel draws draining this face (from south to north: Johnson Creek, Highland View Creek, Harte Creek and Kegel Brook). Due to the low burn severity, the drainages to the south are rated as low hazard, whereas Kegel Brook at the north end has a patch of high burn severity in its headwaters and thus is rated as a moderate hazard.

There are seven RDCK address points east of the highway at the base of this slope that are potentially at risk. The spatial likelihood of a debris flow impacting these residences is estimated to be moderate based on a desktop assessment using satellite imagery and base mapping, but this rating requires additional fieldwork to confirm. The address points to the west of the highway are less likely to be impacted, as the slope flattens considerably here.

Debris flow or flood on Aylwin Creek impacting private structure
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = moderate

The Aylwin Creek watershed is composed of two parts: the lower portion is susceptible to debris flows, whereas the upper basin is a cirque-like feature with a small lake near the outlet that drains into the lower portion. The upper basin is only partially burned; therefore, the burned area of the entire watershed is only

66%. However, the burned area of the lower watershed area is almost 100%, most of which is moderate and high burn severity. Given the high burn severity over steep terrain, the likelihood of a post-wildfire debris flow is rated as high.

There is one structure on private property on the Aylwin Creek fan, but it has not been verified if it is a occupied residence. The structure is located away from the main channel, and on the lower third of the fan; therefore, the likelihood of spatial impact is rated as low. Field verification as part of a more detailed (level 3) assessment is recommended to confirm the location of the structure relative to potential avulsion paths.

Debris flow or flood on Aylwin Creek impacting Highway 6 or Red Mountain Road
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = high Partial Risk[3,4] = very high

Red Mountain Road and Highway 6 cross the Aylwin Creek fan mid-way down the fan. The creek flows under the highway in a large culvert (~ 1.5 m diameter), which is likely to be plugged in a debris flow or flood event. Furthermore, there is little to no channel confinement along the right bank immediately upstream of the culvert. The combination of these factors results in a very high potential for a diversion along the highway ditch line to the north.

Debris flow or flood on Congo Creek impacting private residences or Red Mountain Road
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = moderate

Congo Creek is a short, steep drainage with a high Melton ratio, which would indicate a susceptibility to debris flows. The southern fork in the upper watershed is mostly composed of high and moderate burn severity, whereas the northern fork in the upper watershed is composed of a mixture of high, moderate and low burn severity. Fan hazard mapping indicates there is one RDCK address point near the base of the fan, with several houses located just beyond the fan area. Red Mountain Road bounds the lower portion of the fan. Field investigation as part of a more detailed (level 3) assessment is recommended to confirm the hazard and probability of spatial impact.

Debris flow or flood on Fingland Creek impacting private residences or Red Mountain Road
Hazard P(H)[1] = moderate Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = low

The upper Fingland Creek drains steep sub-alpine terrain and could be susceptible to debris floods, or possibly debris flows. However, the channel's gradient moderates substantially upslope of private property, as it turns southwest to flow around a ridge. Given the patchy high, moderate and low burn severity in the upper watershed, the likelihood of a post wildfire debris flood or flow is rated as moderate. The likelihood of spatial impact to private property and Red Mountain Road is low given the channel configuration above the elements at risk.

Debris flow or flood on Baby Ruth Creek or Vevey Creek impacting private residences or Red Mountain Road
Hazard P(H)[1] = low Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = very low

Like Fingland Creek, Baby Ruth and Vevey Creeks have steep upper watersheds with tributaries that are likely to be susceptible to small debris flows or floods, but the main channel gradients moderate substantially before reaching elements at risk downslope. Therefore, the likelihood of spatial impact is rated as low. Baby Ruth's watershed is 41% burned and Vevey Creek's watershed is 33% burned (both a mixture of patchy high, moderate and low burn severities), resulting in low hazard of a debris flow or flood.

FURTHER ACTIONS

A more detailed (level 3) assessment for the Komonko Creek fire is recommended to verify the hazard and risk to private residences, infrastructure, and drinking water quality.

COMMENTS

The Komonko Creek and Aylwin Creek fires were identified on July 19, 2024 and burned over 4000 ha. They were subsequently amalgamated into one fire and will be treated as such in this assessment. Only limited field assessment was conducted for this fire (focused around Aylwin Creek fan), given that a more detailed assessment is forthcoming. This analysis relies heavily on vegetation burn severity mapping which was corroborated with visual observations made during helicopter overflight of the fire on August 23.

The fire burned the western facing drainages from Vevey Creek in the north to Enterprise Creek in the south, as well as flatter terrain to the west of Highway 6 immediately above Highway 6. Many of the drainages burned are steep and debris-flow prone. The southern portion of the Komonko Creek fire re-burned a portion of the 2007 Springer Creek fire, including several Enterprise Creek tributaries and two drainages (Cory Creek and Allen Creek) on the face south of Enterprise Creek. The burned area slopes range from lake level (~550 m) up to the alpine above 2000 m.

Due to the high risks identified in this report, further analysis of post-wildfire natural hazards for the Komonko Creek fire is recommended. A more detailed report will be released at a later date that will expand on the hazards and risks outlined here and may alter conclusions.

All members of the public, and specifically water users, should avoid spending time in debris flow prone creek channels during or immediately after intense rainstorms, or during periods of rapid snowmelt. Episodic water quality impacts to surface domestic water users on sources originating from within the fire perimeter are anticipated. More detail on this risk will be included in the Level 3 report.

SIGNATURE, SEAL, FIRM PRACTICE #

SCrookshanks

September.12, 2024

PROFESSIONAL PROVINCE OF S. D. I. CROOKSHANKS # 37362 BRITISH COLUMBIA GEOSCIENTIST

Sarah Crookshanks, P.Geo.
Ministry of Forests
Permit to Practice #1003022

Reviewed by: Gareth Wells, P. Geo

ATTACHMENTS

See attached map, photos and Appendix

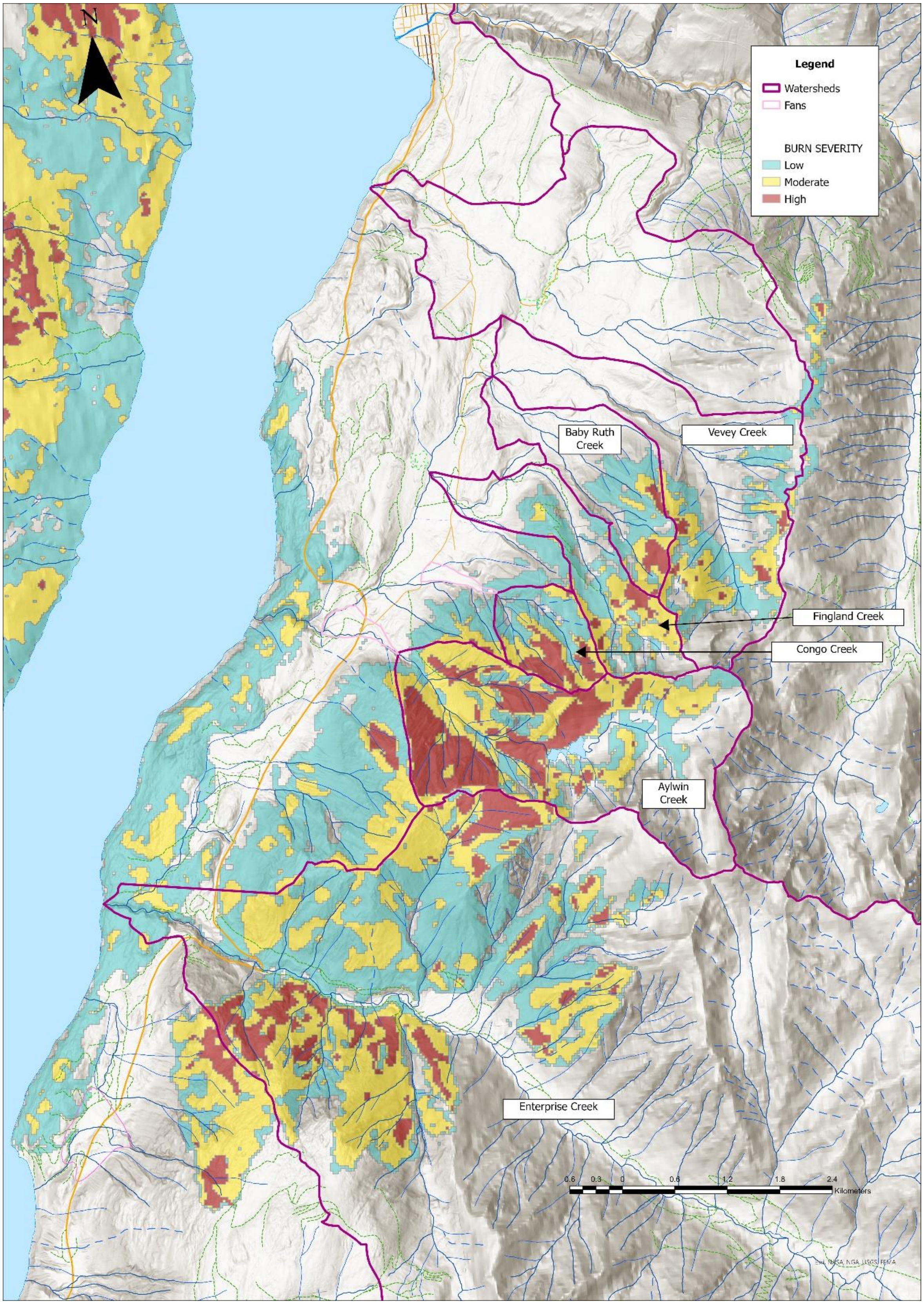


Figure 1. Burn severity map of the Komonko Creek fire showing estimated classes derived from Sentinel-2 imagery (prefire: July 11, 2024; post-fire: August 20, 2024). Further work may alter the estimated burn severity classes.

Figure 2. Enterprise Creek (Photo: T. Giles, SNT Geotechnical).

Figure 3. Headwaters of Cory Creek.

Figure 4. Photo of high burn severity in the Aylwin Creek watershed.

Appendix to PWNHRA Reconnaissance Reports

Scope of Reconnaissance (Level 2) Reports

Reconnaissance (Level 2) reports are primarily intended to identify whether post-wildfire hazards are likely to occur and need detailed investigation to protect identified elements at risk. Identified elements at risk are generally limited to public safety and infrastructure. Reconnaissance reports may also be used to assess safety conditions for wildfire fighters. In some cases, the MOF District Manager or other MOF personnel may request assessments for non-standard elements at risk or for other reasons.

Definitions of Hazard and Risk

Wildfire may produce conditions conducive to a suite of hazards. Debris flows, debris floods, and floods are often the most important hazards, but other types of landslide hazards including rockfall, debris slides and earthflows can also occur in response to wildfire. Wildfire can also cause snow avalanches and may affect water quality, cause erosion and result in sedimentation. Terrain, watershed, and channel conditions that produce post-wildfire hazards may also produce similar hazards in unburned conditions; these hazards may be mentioned but are not evaluated in this report.

P(H), P(S:H) and partial risk are presented for each identified elements at risk. Multiple types of channel hazards (debris flows, debris floods, floods) may affect an element at risk. These hazards are ranked by severity, with debris flow as the most damaging and destructive and flood as the least damaging and dangerous, and ratings are given for the highest rating hazard that may affect an element at risk. For example, where a channel has the potential for a debris flow and an element at risk may be affected, the lower ranking debris flood and flood hazards are not rated, since discharge and velocity are likely to be less than for a debris flow. These processes may cause erosion or sedimentation that affects the element at risk. Hazards that are unlikely to affect an identified element at risk are not discussed.

Table A1 shows the annual probability ranges for qualitative definitions of P(H). The probability of the hazard occurrence is for the post-wildfire period of elevated hazard, which in many cases may be less than five years, but in some cases may extend for several more years.

Table A1. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities.

Post-wildfire hazard rating	Description	Annual Probability Range
Very High	An event is expected to occur. Most of the catchment or face unit has burned with a significant proportion burned at moderate and/or high severity	>0.2
High	An event is probable under adverse conditions. Most of the catchment or face unit has burned with a significant proportion (i.e., >50 %) of terrain conducive to post-wildfire natural hazard initiation burned at moderate or high severity. Existing indicators of pre-fire terrain instability within stream channels, on fans or face units.	0.01 - 0.2
Moderate	An event could occur under adverse conditions. It is not probable but possible over a several year period. More than 20% of the terrain conducive to post-wildfire natural hazards in the catchment or on the face-unit has burned with moderate and/or high severity. Historic geomorphic indicators of instability are present.	0.002 – 0.01
Low	An event could occur under very adverse conditions. It is considered unlikely over a several year period. Only a limited proportion of the catchment or face unit has burned. Few or no signs of pre-fire instability present along stream channels, fans or face units.	0.0004 – 0.002
Very Low	An event will not occur or is conceivable though considered exceptionally unlikely. A limited proportion/none of the catchment was burned. No terrain instability indicators are present	<0.0004

Table A2 defines spatial impact to an element of risk. Post-wildfire event magnitude is considered when rating spatial impact.

Table A2. Post-wildfire spatial impact.

Likelihood of spatial impact	Description	Probability range
H	It is probable that the event will impact the element at risk.	>0.5
M	It is possible that the event will impact the element at risk.	0.5 - 0.1
L	It is unlikely that the event will impact the element at risk.	< 0.1.

Table A3 is a matrix which combines the hazard likelihood (Table A1) with the spatial impact likelihood (Table A2) to determine partial risk.

Table A3. Post-wildfire risk matrix partial risk matrix.

Hazard Likelihood P(HA) (Table 1)	Spatial Impact Likelihood (P(S:H)) (Table 2)		
	High	Moderate	Low
Very High	Very High	Very High	High
High	Very High	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Very Low
Very Low	Low	Very Low	Very Low

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Watershed Assessment and management of hydrologic and geomorphic risk in the Forest Sector
https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMW2ATQA5BSODHJAKBAGZDYTRL6FJ/Watershed%20Assessment%20a

nd%20Management%20of%20Hydrologic%20and%20Geomorphic%20Risk%20in%20the%20Forest%20Sect

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Identification of elements at risk relies on BC government data layers, satellite imagery, and perhaps an overview flight. BCWS and the MOF district office may provide additional information. No further confirmation of elements at risk was conducted.

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Suite #4, 385 Baker Street
Nelson, BC, V1L 4H6
250 509 1009

BC Ministry of Forests

POST-WILDFIRE NATURAL HAZARDS RISK ANALYSIS KOMONKO CREEK FIRE (N51210)

November 29, 2024

Report Number: 24.540.21
Distribution:
MoF – 1 copy
SNT Geotechnical Ltd. – 1 copy

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Attached:

Appendix A: Maps

Appendix B: Komonko Creek – Post-Wildfire Level 2 Reconnaissance Report

Appendix C: Landslide and Flooding Risk Awareness Brochures

1. Introduction and Objectives

The Komonko Creek Fire (N51210) started on July 19, 2024, and burned 4,082 hectares on the east side of Slocan Lake between Silverton and Slocan in southeastern B.C. (Figure 1). The western portion of the fire (west of Highway 6) was originally the Aylwin Creek Fire (N51065, a lightning strike discovered July 18) and the eastern portion of the fire (east of Highway 6) was the Komonko Creek Fire (N51210, a lightning strike discovered July 19). The two fires merged near Enterprise Creek in early August and were subsequently treated as one.

The Komonko Creek Fire started in the middle of the Aylwin Creek drainage and progressed north onto Mount Twigg and then later burned south through Enterprise Creek to the edge of the Memphis Creek watershed. The Aylwin Creek Fire started on lower Aylwin Creek on the shoreline of Slocan Lake and burned north to Bannock Point and south to the edge of the Cory Creek watershed (Photos 1 and 2).

The Komonko Creek Fire (the Fire) includes or is adjacent to several populated areas along the east shore of Slocan Lake and was considered by the Ministry of Forests (MoF) to be a high priority for a Post-Wildfire Natural Hazards Risk Analysis (PWNHRA). SNT Geotechnical Ltd. (SNTG) was retained by BC Wildfire Service (BCWS) to complete this work. The Fire is entirely within the Regional District of Central Kootenay (RDCK).

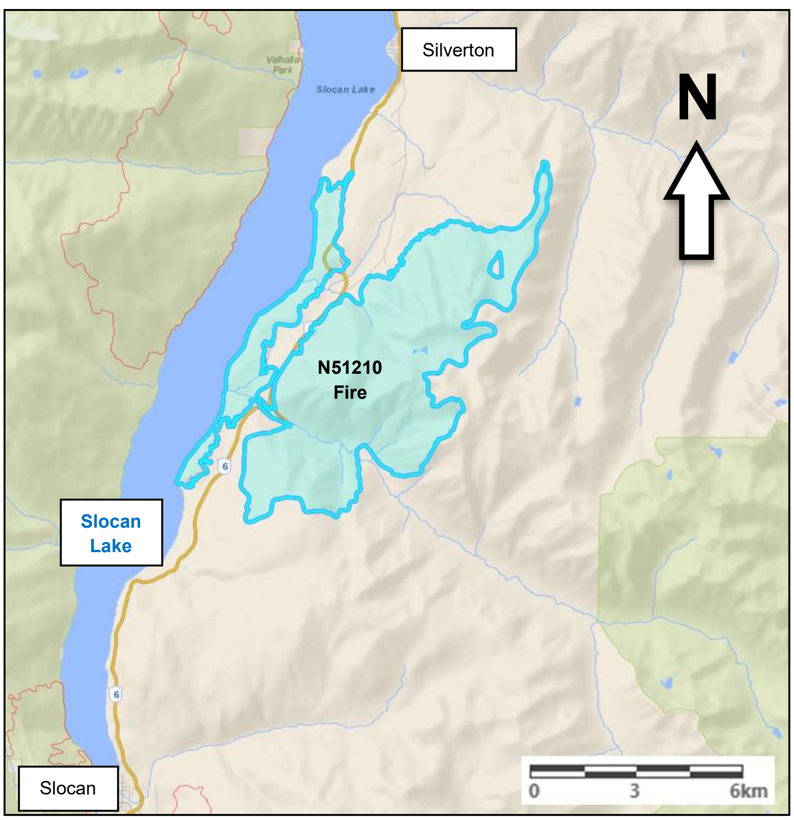

Figure 1: Location of the Fire (shaded blue) on the east side of Slocan Lake.

Photo 1: Sentinel-2 L2A Satellite imagery from August 1; the Fire is crossing the Enterprise Creek valley.

Photo 2: Sentinel-2 L2A Satellite imagery from August 31; the Fire appears to be out.

1.1. Reconnaissance Assessment

A Reconnaissance PWNHRA (Level 2) was completed by the MoF (Crookshanks, 2024[1]; attached in Appendix B). This analysis included a review of the preliminary burn severity map and a summary of post-wildfire natural hazards and risks (floods, debris flows or rockfall) to residences and roads, primarily Highway 6 (the Highway) and Red Mountain Road (RMR). A comprehensive assessment of the domestic water systems within or affected by the Fire was not completed. Table 1 summarizes the MoF assessment which determined the following preliminary partial risks to possible elements at risk within and adjacent to the Fire.

Table 1: Summary of the MoF Reconnaissance PWNHRA report.

Location	Hazard	Partial Risk	Elements at Risk
Allen/Cory Creek Face	Debris flow or flood	High	Private residences or Highway 6
South tributary of Enterprise Creek	Debris flow or flood	Very High	Highway 6
Highway 6 near Slocan Lake View Point	Rockfall	Very High	Highway 6
Johnson (Brahms), Highland View or Harte Creeks	Debris flow or flood	Low	Private residences or Highway 6
Kegel Brook	Debris flow or flood	Moderate	Private residences or Highway 6
Aylwin Creek	Debris flow or flood	Moderate	Private residence
Aylwin Creek	Debris flow or flood	Very High	Highway 6 or Red Mountain Road

[1] Crookshanks, S. 2024. *Komonko Creek – Level 2 Reconnaissance Report*. Prepared for the Ministry of Forests. Dated September 11, 2024.

Location	Hazard	Partial Risk	Elements at Risk
Congo Creek	Debris flow or flood	Moderate	Private residences or Red Mountain Road
Fingland Creek	Debris flow or flood	Low	Private residences or Red Mountain Road
Baby Ruth or Vevey Creeks	Debris flow or flood	Very Low	Private residences or Red Mountain Road

1.2. Detailed Assessment

The scope of the Detailed PWNHRA (Level 3), as defined by the MoF, is to:

- Identify any elements at risk from potential post-wildfire hazards. These are defined as:
  - residences or occupied buildings on private property or occupied public or private buildings;
  - public highways and arterial roads, public infrastructure, utilities, and industrial infrastructure (i.e., railways, pipelines, tele-communication infrastructure and industrial access roads);
  - registered active points-of-diversion for domestic, irrigation, and community water supplies, including reservoirs and related infrastructure;
  - recreational sites as determined by the MoF or local authorities; and
  - discrete cultural sites as designated by MoF specialists.
- Identify potential post-wildfire natural slope hazards which might affect the elements at risk. These hazards include landslides, debris avalanches, rockfall, debris flows, debris floods, clearwater flooding or water quality effects;
- Conduct a partial risk analysis for each hazard and for each individual element at risk; this will include the background (i.e., pre-wildfire) likelihood of that specific hazard and the incremental increase in hazard likelihood due to the wildfire[2]. Clearly indicate hazard or likelihood of occurrence of a specific natural hazard (i.e., P(H)), spatial probability or likelihood of a spatial effect if a specific hazardous event occurs (i.e., P(S:H)), and the resulting partial risk (i.e., P(HA)) for each hazard and element at risk; and
- Provide conceptual risk mitigation options or strategies for elements at risk with partial risk ratings moderate or higher.

We understand that the intended use of the detailed risk analysis is to communicate the general post-wildfire risk to potential stakeholders so that they can undertake specific risk assessments to mitigate the risk, if deemed unacceptable to them.

The detailed risk analysis was completed in general conformance with the guidance provided in:

- Land Management Handbook 56 (LMH56) – *Landslide risk case studies in forestry development planning and operations* (2004), BC Ministry of Forests[3]

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[2] The pre-wildfire likelihood of specific hazards and the incremental increase in the hazard likelihood due to the wildfire is not included as this would require extensive review and investigation which is simply not possible due to the urgency and short timelines of the project.

[3] Wise, M.P., G.D. Moore, and D.F. VanDine (editors). 2004. *Landslide risk case studies in forest development planning and operations*. B.C. Ministry of Forests, Land Management Handbook 56. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH56.htm.

- Land Management Handbook 69 (LMH69) – *Post-wildfire Natural Hazards Risk Analysis in British Columbia* (2015), BC Ministry of Forests, Lands, and Natural Resource Operations[4], and
- Risk Analyses Tables provided by the MoF (Tables 2 through 4 in Section 3.5).
  - Table A1. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities,
  - Table A2. Qualitative descriptions of the likelihood of spatial interaction and related quantitative probabilities, and
  - Table A3. Matrix of post-wildfire natural hazard partial risk.

2. Potential Hazards as a Result of the Fire

2.1. Ground Effects

Wildfires can impact the initiation of potential slope hazards in several ways. Depending on the burn severity, wildfire-induced water repellency (i.e., hydrophobicity), which can reduce infiltration rates, may develop within the upper soil layers. This, combined with the loss of vegetative ground cover, results in a significant increase in the potential for runoff to develop during rainfall events, thereby creating a much faster hydrologic response (i.e., a “flashier” runoff regime). The loss of tree canopy also leads to increases in snow accumulation and snowmelt rates, especially during sunny day (radiant) snowmelt events. The effect of these conditions typically lessens as the vegetative ground cover re-establishes and the water repellency breaks down, returning to the pre-wildfire levels; this generally occurs within 2 to 5 years following a wildfire.

Water repellency is often observed in areas of moderate and high soil burn severity, and although not a necessary condition, water repellency makes it more likely that overland flow will be generated during high-intensity summer or early fall rains (generally following dry spells when water repellency is greatest). High soil burn severity also causes reduced infiltration capacity, even without water repellency, and therefore can increase susceptibility to overland flows even in areas where water repellency was not observed. In areas of moderate vegetation burn severity, needle fall from the dead trees can create an effective mulch, which tends to slow down surface runoff and promote infiltration. The partial or total loss of forest litter and duff layer in moderate and high soil burn severity areas results in a reduction in water storage capacity and increased surface run-off flow velocity.

Soil erosion can be a significant process in high soil burn severity areas due to exposed bare soil and lack of protective litter and duff layers. Increased sediment load during flood events can contribute to flood damage, by blocking culverts and ditches. It can also contribute to the likelihood of debris flows in steep watersheds. Erosion from burned areas may result in adverse impacts to water quality in the creeks affected by the fire. In addition, peak flow in some extensively burned watersheds could result in additional sediment entrainment from bank erosion or through tributary debris deposition. In the first few rainstorms and snowmelt events after the fire, ash and soot can be washed downstream and enter water

[4] Hope, G., P. Jordan, R. Winkler, T. Giles, M. Curran, K. Soneff, and B. Chapman. 2015. *Post-wildfire natural hazards risk analysis in British Columbia*. B.C. Ministry of Forests, Lands and Natural Resource Operations, Land Management Handbook 69. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH69.htm

intakes. In addition to ash and sediment entrainment there have been documented increases of other types of water contamination including an increase in heavy metal concentrations post-wildfire (Silins et al., 2016[5], Bladon et al., 2014[6])

Snow avalanche hazard is increased for 15-20 years post-wildfire (Germain et al., 2005[7]). The hazard is increased due to a combination of the reduced number of trees anchoring the snow mass to the slope and increased accumulation of snow due to the loss of snow interception provided by living timber (LMH69). In addition, blackened trees tend to absorb an increased amount of solar radiation during the spring, heating the snowpack adjacent to the trunk and creating weak points within the snowpack which can also lead to increased snow avalanche frequency. Increased magnitude and/or frequency of snow avalanche events may transport an increased amount of debris (primarily trees and woody debris) to streams in the area.

2.2. Natural Hazards

On slopes burned to a moderate and/or high severity, there is often substantial ash, sediment and woody debris available to be mobilized by runoff generated from short-duration/high-intensity rainfall. When these are mobilized by runoff, the flow becomes “bulked up” (i.e., more viscous) and erosional scour can occur on the open slope surface or within gullies or draws. When this occurs on face unit slopes, the resulting hazard is generally referred to as a sediment-laden flow. When the “bulked up” runoff becomes channelized in gullies and draws, debris flows, debris floods or floods can be triggered. These events can travel farther than sediment-laden flows, extending across fan surfaces at the outlets of watersheds. Research[8] suggests that once these events have been triggered from slopes burned by a wildfire, the likelihood of them occurring a second time from the same slopes is significantly reduced.

These post-wildfire debris flows, debris floods, sediment-laden flows and floods (collectively referred to as hydrogeomorphic processes) which can occur as a result of high-intensity rainfall on severely burned and/or water-repellent soils, are typically triggered in mid to late summer within the first two years following a wildfire (Cannon and Gartner 2005)[9]. Examples in B.C. include the 2004 Kuskonook Creek and Jansen Creek debris flows near Creston, debris floods and flows following the 2017 Elephant Hill Fire (91 events, one causing a fatality on Highway 99) and debris floods in Kelowna and near Falkland, which followed the 2003 wildfires. Cannon and Gartner (2005) note that the rainfall conditions required to trigger a post-wildfire debris flow can be at least an order of magnitude smaller than those required for debris flow generation in an unburned setting.

Debris flows and floods can also occur during spring runoff as a result of rapid snowmelt in burned areas. Examples include several debris flows that followed the 2007 Springer Creek Fire near Slocan (one causing a fatality) and debris flows that followed a 2009 fire at Kelly Lake. They can also occur, although

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[5] Silins, U., Anderson, A., Bladon, K., Emelko, M., Stone, M., Spencer, S., Williams, C., Wagner, M., Martens, A. and Hawthorn, K. 2016. *Southern Rockies Watershed Project*. The Forestry Chronicle, v92-1.

[6] Bladon, K., Emelko, M., Silins, U. and Stone, M. 2014. *Wildfire and the Future of Water Supply.* Environ. Sci. Technol. 2014, 48, 8936−8943.

[7] Germain, D, Filion, L, Hétu, B. 2005. *Snow avalanche activity after fire and logging disturbances, northern Gaspé Peninsula, Quebec, Canada.* Canadian Journal of Earth Sciences, v42: 2103- 2116

[8] Rengers, F.K., McGuire, L.A., Oakley, N.S., Kean, J.W., Staley, D.M. and Tang, H. 2020. *Landslides after wildfire: initiation, magnitude, and mobility*. Landslides, DOI 10.1007/s10346-020-01506-3

[9] Cannon, S.H. and Gartner, J.E. 2005. *Wildfire-related debris flow from a hazards perspective*. In: Debris-flow Hazards and Related Phenomena. https://doi.org/10.1007/3-540-27129-5_15

less commonly, during fall (2005 Mt. Ingersoll Fire with 15 channel failures and seven hillslope landslides) or early winter rain-on-snow events. The springtime hazards are due to increased snow accumulation, more rapid snowmelt, and higher groundwater levels in burned areas, and can persist for several years or decades until revegetation occurs.

In August 2018, in the area burned by the 2017 Elephant Hill Fire near Cache Creek, there were several unusually intense, short-duration rainstorms which caused severe flooding and erosion in many small, steep creeks (SNTG, 2018[10]). Overland flow and flood damage occurred even in watersheds which drained moderate and low burn severity areas, including grassland. Some flooding also occurred in unburned watersheds, but it was much more extensive and severe in burned areas. These rainstorms were estimated to have a return period of 100 years or more in the most severely affected areas (that is, in any given year, the probability of occurrence is 0.01, based on historical data). Extreme rainstorm events are likely to cause widespread flooding and possibly landslides in all areas, burned or unburned; however, the Cache Creek events illustrate that burned areas are more susceptible to damaging events. In the post-wildfire risk analysis procedure, the hazard ratings are generally assumed to apply to flood or erosion events that may occur as a result of rainfall or snowmelt events that are likely in the two-to-five-year period after a fire. Although the risk analysis focuses on a two-to-five-year time horizon, lingering hazards can extend for decades until forest regeneration occurs.

In the Fire area, potential debris flow, debris flood, sediment-laden flows and flood hazards are possible due to short-duration, high-intensity rainfall events, rain-on-snow events, or rapid snowmelt runoff events. These hazards are described in more detail below:

2.2.1. Debris Flows

Debris flows are very rapid to extremely rapid, surging flow of saturated non-plastic and sometimes organic debris in a steep channel; they commonly have the consistency of wet concrete and are very destructive. Debris flows initiate in the steep headwaters of a drainage and transport material along the channel (Hungr et al., 2014[11]). They can consist of bouldery fronts of up to 70% sediment by volume, followed by lower sediment concentration slurries. Flow velocities of up to 20 m/s can be attained and they may have instantaneous peak discharges up to 50 times greater than floods. Debris flows require a channel gradient in excess of 27% for prolonged transport (Takahashi 1991[12]). Transport continues at lower gradients (under 20%) but tends to lose momentum and begin deposition. Although much less common, long run-out debris flow events have been documented extending considerable distances through fan gradients as low as 6%, particularly when the local surficial material is fine grained[13]. In burned watersheds, the runoff process of progressive sediment bulking (Cannon 2001[14]), where overland flow concentrates rapidly into channels, readily eroding the bed, is common.

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[10] SNTG. 2018. *Post-Wildfire Natural Hazards Risk Analysis, Elephant Hill Fire (K20637, 2017)*. Report prepared for the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Dated December 20, 2017.
[11] Hungr, O., Leroueil, S. and Picarelli, L. 2014. *The Varnes classification of landslide types, an update*. Landslides 11: 167-194.
[12] Takahashi, T. 1991. *Debris flow*. Monograph of IAHR, Balkema, Rotterdam: 1–165.
[13] Jordan, P., Nicol, D., and Turner, K. 2011. *Debris flow hazards in the southern interior of British Columbia: the problem of events with unusually long runout.* GeoHazPaper124. Proceedings of the 5th Canadian Conference on Geotechnique and Natural Hazards; Kelowna, May 15 to 17, 2011.
[14] Cannon, S.H. 2001. *Debris-flow generation from recently burned watersheds*. Environmental and Engineering Geoscience 7 (4):321-341.

2.2.2. Debris Floods

Debris floods are a very rapid, sediment-charged flow of water in a steep channel with abundant fines in suspension and gravels, cobbles and boulders transported as bedload. Debris floods may have instantaneous peak discharges up to 5 times that of a clearwater flood (Hungr et al., 2001[15]). Debris floods have increased sediment volumes but continue to be propelled by the tractive forces of water; objects impacted by debris floods are generally buried or surrounded by debris but are often undamaged or only slightly damaged.

2.2.3. Sediment-laden flows

Sediment-laden flows are hydrologic processes that are common on open slopes (also known as face units) following wildfire. They are a smaller-scale runoff process that transports ash, soil and woody debris downslope, but can transition into debris floods or debris flows in channelized settings.

2.2.4. Floods

Floods occur on rivers and lakes when there is inundation due to an excess of clearwater discharge in a watercourse or body of water, such that land outside the natural or artificial banks, which is not normally under water, is submerged. While sometimes called “clearwater floods,” such floods still transport sediment.

3. Methods

The methodology adopted for the analysis included the following:

3.1. Review of existing information

Review of available background information, including previous post-wildfire reports, other geological and geotechnical reports, geology and geomorphology maps, biogeoclimatic data and natural disturbance types, aerial photographs and satellite imagery, LiDAR imagery, hydrometric data, local weather patterns, historic wildfire information and burn severity mapping.

3.2. Watershed Morphometrics

Assessing the watershed morphometrics to determine the potential hydrogeomorphic hazards that could be triggered within them. An analysis of the longitudinal profile of the mainstem creeks within the watersheds was also completed to identify reaches that may be prone to initiation, transport and deposition.

3.3. Fieldwork

Fieldwork was completed to:

- compare the preliminary satellite-derived Vegetation Burn Severity (VBS) with on the ground observations of the Soil Burn Severity (SBS) and describe the relationship between the VBS and the SBS observed at plot sites within the fire perimeter;

[15] Hungr, O., Evans, S.G., Bovis, M. and Hutchinson, J.N. 2001. *Review of the classification of landslides of the flow type*. Environmental and Engineering Geoscience 7 (3): 221-238.

- observe terrain conditions, sediments or indicators of slope stability and review the runout from historic landslides (i.e., open slope failures, rockfall or talus cones) or channel instability (i.e., evidence of previous debris flows, debris floods or floods);
- observe the condition of the mainstem channels and riparian zones, including a review of the channel and floodplain characteristics and the extent of the riparian areas that burned;
- review the fluvial or alluvial fans at the base of the slopes to determine their genesis, potential for post-wildfire events and expected runout distances of any such events;
- review the hazard estimates developed from modelling;
- identify and make observations of the elements that could be at risk should an event occur; and
- identify any roads or fireguards that could increase the potential of post-wildfire slope hazards occurring.

A helicopter reconnaissance flight to review the general slope conditions within the fire perimeter and to identify existing landslides within the Fire was completed on August 23, 2024, by Sarah Crookshanks, P.Geo. (MoF), Doug Nicol, P.Eng. (SNTG), Ryan Williams, P.Geo. (SNTG) and Tim Giles, P.Geo. (SNTG).

Fieldwork was completed by Jacqueline Cormier, P.Eng. (SNTG) and Tim Giles between September 23 and September 30, 2024. Upslope field work was focused on the creeks, channels and fans of Cory, Allen, Enterprise, Aylwin, Congo, Fingland and Vevey watersheds as these were thought to have the highest risk (the combination of steep slopes with significant burned areas and downslope values). Foot traverses were completed to review low, moderate and high vegetation burn severity areas and determine the relationship between the vegetation burn severity and the soil burn severity. Assessment of soil burn severity was completed by examination of the burned surface and shallow excavation to view the soil profile and complete water repellency testing. Field observation sites are plotted on Maps 1 and 2 in Appendix A.

The weather was generally sunny and warm, with the exception of September 29, 2024, when steady rain occurred in the afternoon.

Information on the surficial sediments, slopes, soil drainage characteristics and geomorphological processes was obtained from site observations; no subsurface investigation (i.e., test pits, trenching or drilling) or laboratory testing was completed. Slope gradients were measured using a handheld clinometer, and relevant observations were recorded as field observation sites using an iPhone equipped with an in-built GPS, which typically has a horizontal accuracy of ±5 m.

3.4. HEC-RAS Flow Modelling

The 2-dimensional variant of HEC-RAS[16] (v6.2) was used to model flow paths on select watersheds where SNTG identified elements at risk close to the creek channels or where there was possibility of channel avulsion. The channel roughness was estimated to be equivalent to a Manning's n value of 0.07. Debris flow parameters were selected based on the author's experience with modelling of other local channels, i.e., Van Tuyl Creek debris flows after the 2007 Springer Creek Fire. The model results appear

[16] HEC-RAS is the US Army Corps of Engineers, Hydrologic Engineering Center, River Analysis System. The software allows 1-dimensional steady flow and 1 and 2-dimensional unsteady flow calculations and sediment transport/mobile bed computations.

credible based on field observations. **The results of the flow modelling are preliminary in nature and should not be used for design**.

The model geometry was developed using the LiDAR base data; Aylwin Upper, Cory Middle and Cory North Creeks and Kegel Brook were modelled. Cory Middle and Cory North Creeks were identified as having residences close to the channel on the fan and were also noted to have had previous debris flows; field observations indicated that debris flows could reach the upper fan. Kegel Brook was identified to have a steep and confined draw leading onto a moderately steep fan with a residence adjacent to the fan.

A representative model output of the Aylwin Upper Creek is shown in Figure 2. The Aylwin Upper model illustrates the dispersion plume of water and sediment. The debris crosses most of the fan in a well-confined channel and spreads out as the gradient drops near the Highway. At the Highway, the debris overflows in both directions along the road, with the majority of the flow across the RMR junction and the southbound pullout further north. Below the road, the flow finds several old channels but would likely return to the main channel relatively quickly. It is noted that debris flow events of greater volumes, or that behave differently than assumed (based on model input parameters), may runout further or into different areas. The model use was primarily as a check of field observations.

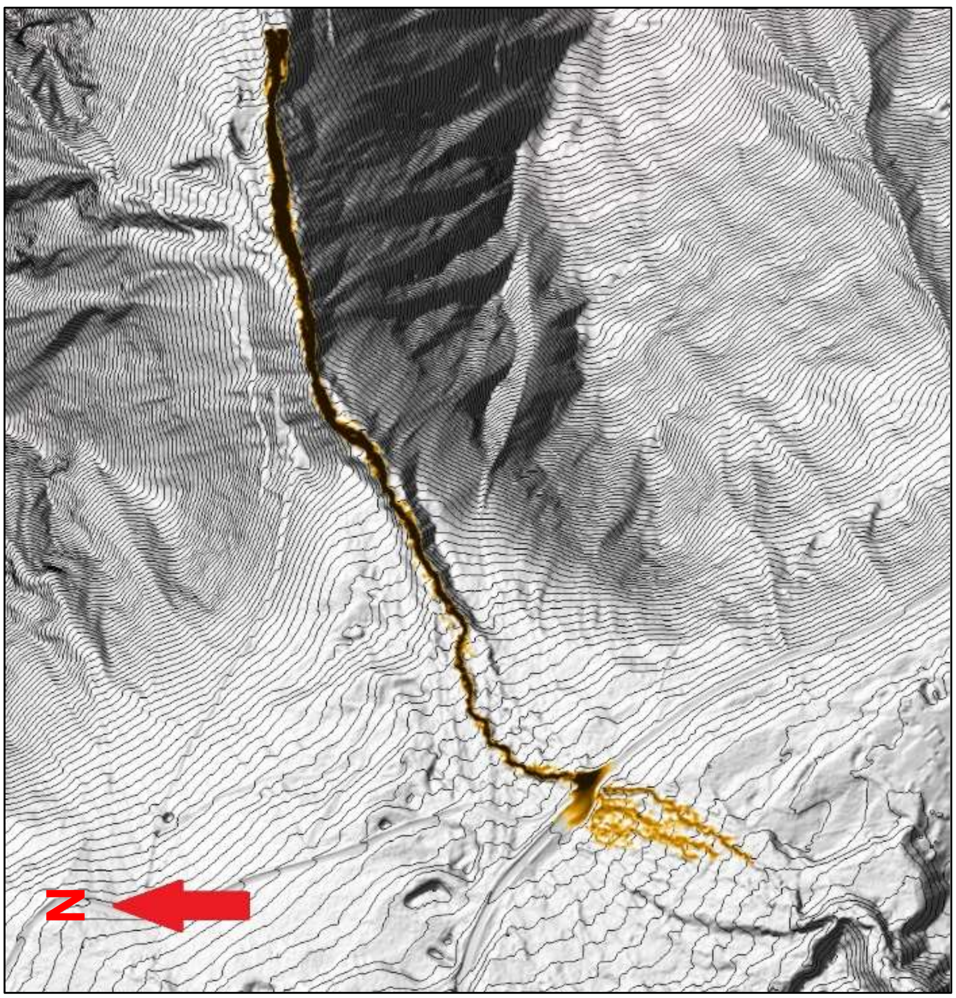

Figure 2: Modelled flows on Aylwin Upper Creek above the Highway. North is to the left of image.

3.5. Analysis and Partial Risk Estimation

Mapping of potential post-wildfire hazards and the analysis of risks followed the general methodology outlined in LMH69. In the simplest terms, risk is the product of hazard and consequence.

Partial risk is defined as the probability (or likelihood) of a specific hazardous event affecting an element at risk and can be expressed as:

$$P(H:A) = P(H) \times P(S:H) \times P(T:S)$$

where:

- P(H:A) is the partial risk.
- P(H) is the likelihood of a hazardous event occurring.
- P(S:H) is the spatial likelihood that the hazardous event will reach the element at risk.
- P(T:S) is the temporal likelihood that the element at risk will be at the site if the hazardous event occurs.

For fixed structures, such as buildings and roads, the temporal probability is numerically 1. The partial risk then reduces to:

$$P(H:A) = P(H) \times P(S:H)$$

Effectively, the partial risk rating is an "encounter probability" and it does not include an assessment of the degree of damage (vulnerability) to the element at risk.

Qualitative ratings, i.e., low, moderate, and high, are used to describe the hazard levels and spatial likelihood levels in this assessment, although the qualitative descriptions can be associated with quantitative ranges as described in Tables 2 and 3. The hazard and spatial likelihood ratings are then combined in a matrix (Table 4) to estimate the partial risk.

For the purpose of post-wildfire risk analysis level 3 reports, only partial risk is considered; this is the probability that a hazardous event (e.g., a debris flow) will occur and that it will reach or affect the site of the element at risk (e.g., a house or highway) with consideration to the spatial and temporal probability but not the value or vulnerability of the elements at risk. More detailed specific risk analysis generally involves ground inspections of high value elements exposed to considerable hazards.

The partial risk was considered in an incremental context and not as an absolute risk which would also consider pre-existing natural hazards. For example, an element at risk may have been considered to be at high partial risk pre-fire, but if there is no significant increase in the assessed risk at the location of the element considered, the post wildfire risk would be assessed as low or non-existent.

The background information review, modelling results and field observations were then compiled and analyzed. Based on this analysis, the partial risk was estimated for the identified elements at risk.

Table 2. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities as defined by the Ministry of Forests.

Hazard Likelihood P(H)	Description	Hazard Criteria	Annual Probability Range	Five Year Cumulative Probability
Very High	An event is expected to occur over a 5-year period.	▪ Most of the catchment has burned with a significant proportion burned at moderate and/or high severity. ▪ Evidence of pre-fire terrain instability within stream channels, on fans or face units. ▪ Post-fire instability observed on similar terrain nearby.	>0.2 (> 1:5)	>67%
High	An event is probable under adverse conditions.	▪ Most of the catchment has burned with a significant proportion (i.e., >50%) of terrain conducive to post-wildfire natural hazard initiation burned at moderate and/or high severity. ▪ Indicators of pre-fire terrain instability within stream channels, on fans or face units.	0.01 - 0.2 (1:100 to 1:5)	5 - 67%
Moderate	An event could occur under adverse conditions- it's not probable, but possible over a 5-year period.	▪ More than 20% of the terrain conducive to post-wildfire natural hazards in the catchment area was burned with moderate and/or high severity. ▪ Historic geomorphic indicators of terrain instability are present.	0.002 – 0.01 (1:500 to 1:100)	1 - 5%
Low	An event could occur under very adverse conditions - it's considered very unlikely to occur over a 5-year period.	▪ Limited proportion of the catchment was burned during the fire. ▪ No signs of pre-fire instability are evident within stream channels, on fans, or face units.	0.0004 – 0.002 (1:2,500 to 1:500)	0.2 - 1%
Very Low	An event will not occur; or is conceivable though considered exceptionally unlikely to occur over a 5-year period.	▪ A limited proportion/none of the catchment was burned during the fire. ▪ No terrain instability indicators are present.	< 0.0004 (< 1:2,500)	<0.2%

Table 3. Qualitative descriptions of the likelihood of spatial interaction and related quantitative probabilities as defined by the Ministry of Forests.

Likelihood of spatial impact	Description	Criteria	Probability Range
High Likelihood	The element at risk will be impacted by the hazard.	▪ The element at risk is within or immediately adjacent to a stream channel, at the apex of a fan, or at the foot of a face unit slope, and there are no natural or artificial barriers preventing the hazardous event from impacting the element.	>0.5
Moderate Likelihood	It is possible that the element at risk will be impacted by the hazard.	▪ The element at risk is located outside the zone of direct impact, but within a zone of potential impact based on the geomorphic processes associated with the specific hazard. ▪ There are no natural or artificial barriers preventing the hazardous event from impacting the element.	0.5 - 0.1
Low Likelihood	It is unlikely that the element at risk will be impacted by the hazard.	▪ The element at risk at the distal end of a runout zone for the specific hazard. Natural or artificial barriers exist that are anticipated to prevent the hazardous event from impacting the element.	< 0.1

Table 4. Matrix of post-wildfire natural hazard partial risk.

Hazard Likelihood P(HA) Table 1	Spatial Impact Likelihood P(S:H) (Table 2)		
	High	**Moderate**	**Low**
Very High	Very High	Very High	High
High	Very High	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Very Low
Very Low	Low	Very Low	Very Low

3.6. Report

The results of this work were then detailed in this report, addressing the scope and providing conceptual recommendations to reduce the post-wildfire natural hazard risk where appropriate.

4. Background Information

The following information was used in the Analysis:

- Aerial photographs covering the Fire in various years were reviewed to understand the recent changes to the landscape and occurrence of landslides in the general area.

- Google Earth ProfessionalTM imagery dated 1985, 2004, 2009, 2011, 2014, 2018, 2020 and 2023 including relevant applications provided by DataBC Public Web Map Service (i.e., TRIM elevation contours and Freshwater Atlas).
- An undated orthoimage from Bing Maps (estimated age 2022) was also reviewed to understand the recent changes to slopes in the general area.
- Hoy, T., Church, B., Legun, A., Glover, K., Gibson, G., Grant, B., Wheeler, J., Dunne, K., Cunningham, J., and Desjardins P. 1994. *The geology of the Kootenay Mineral Assessment Region*, British Columbia Geological Survey Open File 1994-08.
- Bedrock Geology spatial data obtained from the BC Data Catalog. Accessed from: https://catalogue.data.gov.bc.ca/dataset/ef8476ed-b02d-4f5c-b778-0d44c9126144.
- Nicol, D., Jordan, P., Deschenes, M., Curran, M. and Covert A. 2007. *Springer Creek Fire Number 50372 Post-Wildfire Risk Analysis*. Prepared for the BC Ministry of Forests and Range. Dated September 14, 2007.
- D.R. Nicol Geotech Engineering Ltd. 2008. *Springer Creek Fire Number 50372 Long-term Risk Analysis*. Prepared for the BC Ministry of Forests and Range. Dated March 18, 2008.
- Nicol, D, Jordan, P. and Curran, M. 2008. *Assessment of the Middle Van Tuyl Landslide Event of May 2008*. Prepared for the BC Ministry of Forests and Range. Dated April 2009.
- D.R. Nicol Geotech Engineering Ltd. 2009. *Springer Creek Fire Number 2007-N50372 2009 Update to Short-term and Long-term Risk Analyses from post-wildfire related natural hazards*. Prepared for the BC Ministry of Forests and Range. Dated May 2009.
- SNT Geotechnical Ltd. and Sitkum Consulting Ltd. 2022. *Post-wildfire Natural Hazards Risk Analysis – Trozzo Fire (N5170).* Prepared for the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development. Date February 4, 2022.
- LiDAR – data was acquired from the Regional District of Central Kootenay.
- Historic climate data obtained from the Pacific Climate Impacts Consortium online data portal. Accessed from: https://pacificclimate.org/data.
- Climate analysis using the 1971-2000 dataset from the ClimateBC website. Accessed from: http://www.climatebc.ca/.

4.1. Aerial Photograph Review

There are over 10 years of aerial photography available over some or all of the Fire area (Table 5). Four years of aerial photographs were selected to be reviewed to determine the state of the forest, including previous wildfire scars, natural landslide occurrences and the history of land development, including forestry and agricultural development.

The photographs selected were from:

- 1966: these are earliest comprehensive images of the entire Fire;
- 1990 and 1997: these show the early years of development on the upper slopes; and
- 2005: these are latest complete coverage prior to the 2007 wildfire.

Table 5: Aerial Photographs covering the Fire

Flight Line	Photograph Numbers	Year
BC4378	170-172, 231-232	1966
BC4379	27-29, 110-112, 157-159;	1966
BC5725	136	1976
BC78108	209-210	1978
BC78143	159-161, 189-190	1978
BC79026	149-156	1979
BC80118	91-93, 124-125	1980
BC82034	239-240, 255-257	1982
BCB90142	73-77, 107-110, 119-121, 152-154, 164-165	1990
BC95064	127-128, 287	1995
BCB97094	1-3, 90-93, 136-138, 146-148	1997
BCB00030	7-8, 30-31	2000
BCC05003	50-51, 68-70, 166-168	2005

The following is a summary of the relevant observations from the aerial photograph imagery.

4.1.1. 1966 Imagery

Development

In this imagery, the Highway is a gravel road with approximately the same alignment as present. Crossings at Memphis, Enterprise and Vevey Creeks are located further upstream than the present alignment. RMR is present and appears as a narrow road which accesses small selective timber harvesting operations and several agricultural holdings. Aylwin Creek has one narrow trail on the north side which reaches up to where the future mine site will be located. There is no development upslope of the Highway between Aylwin and Enterprise Creeks, and only several agricultural holdings and some minor forestry development below it. A forestry road has been built on the south side of Enterprise Creek from the Highway north for 1.5 km, it then crosses the creek and continues on the north side. South of Enterprise Creek, there are few forestry or agricultural developments on the downslope side of the Highway and no development above.

Fire Scars and Landslides

A large fire scar can be seen on the south side of Enterprise Creek; the year of the fire is unknown. The fire was fairly continuous on the north facing slope into Enterprise and extended onto the plateau surface. It also burned along the west facing slope into the headwaters of Allen and Cory Creeks where it was a more patchy, intermittent burn. Other small fires are identified on iMap[17], but only the headwater scar in Beaverton Creek (tributary to Enterprise Creek) is notable.

[17] iMapBC, https://maps.gov.bc.ca/ess/hm/imap4m/

Several landslides can be seen within the large fire scar along Enterprise Creek; these are confined to the steep north-facing gullied slopes and were likely small debris flows. The west facing slope on which Cory and Allen Creeks descend does not appear to have any landslides in these images.

On the face between Enterprise and Aylwin Creeks, several debris flow tracks are visible in the upper watersheds of Highland View and Harte Creeks and Kegel Brook. The tracks runout on the mid-slope and none reach the Highway (tracks end between 300 and 450 m upslope of the Highway); however, it is expected that these tracks also had floodwaters that did runout through the creeks and likely reached the Highway.

Aylwin, Congo and Fingland Creeks all have numerous scree slopes and debris flow tracks in their headwaters. On Aylwin Creek, a linear track extends down onto a confined alluvial fan and terminates within 200 m of the Highway. On Congo Creek, a track is visible onto the upper portion of the confined fan and ends about 250 m above RMR. In Fingland Creek, the tracks extend down onto a broad mid-slope fan which is well above any development.

No landslides were observed below the Highway or on the steep bedrock slopes immediately above Slocan Lake. No snow avalanche tracks were observed above the Highway or RMR in this imagery.

4.1.2. 1990 and 1997 Imagery

Development

In this imagery, the Highway has been paved and straightened in several locations. The crossings at Memphis and Vevey Creeks have been upgraded, but Enterprise Creek is still crossed by a bridge upstream of the present road location. RMR is now connected at both ends to the Highway. Numerous small agricultural holdings and residences are located along the road and there are several roads leading to patches of forest harvesting. One road, likely for mining exploration, has been constructed up and across Fingland Creek into the alpine headwaters area.

A road leads into the mine site on Aylwin Creek and there are several small trails upslope of the main workings. A large clearcut with numerous skid trails is present across Aylwin and Vevey Creeks below the Highway. A second parcel of private land has been clearcut along Vevey Creek above the Highway.

There is one small gravel pit and limited forestry development upslope of the Highway between Aylwin and Enterprise Creeks; downslope, there has been extensive private land forestry development.

The original Enterprise Creek road has been abandoned and a new alignment is present on the north side of the creek. A cutblock has been logged above the Highway on the south approach into Enterprise Creek.

On the face slope south of Enterprise Creek, there has been some small-scale selective logging on private land upslope of the Highway. There is a large clearcut below the Highway across lower Cory and Allen Creeks. The plateau surface between Memphis Creek and Enterprise Creek has been extensively harvested for timber between the 1970’s and the 1990’s. Large portions of Cory North, Middle and South Creek tributary watersheds were logged with conventional skid trail techniques.

Fire Scars and Landslides

The large fire scar (pre-1966) on the south side of Enterprise Creek is still visible as a uniform stand of immature trees. There were no new fires between 1966 and 1997.

The gullied slopes above Enterprise Creek continue to show signs of debris flow activity and there is a clearly defined linear track on Cory South Creek. This appears to be a debris flow path which initiates in standing timber below several converging roads and a landing within the harvested area. The track runs out to immediately above the Highway and streamflow is expected to have impacted the Highway. This landslide was not present in 1976 aerial photographs and is first visible in the 1978 imagery; this coincides with the initiation of logging in the upper Cory watersheds.

The debris flow tracks on the face between Enterprise and Aylwin Creeks are still visible but none of them reach the Highway.

There appears to be no change to the previously identified scree slopes and debris flow tracks in Aylwin, Congo and Fingland Creeks.

4.1.3. 2005 Imagery

Development

The Highway remains the same as in the 1997 imagery with Enterprise Creek still being crossed by a bridge upstream of the present road location. RMR now has more small agricultural or residential developments along it. Forestry development has occurred above the road along the base of the steeper slopes into upper Vevey and Hasty Creeks.

The Aylwin Creek mine site appears to have been abandoned and the roads are overgrown. Harvested cutblocks across lower Vevey and Aylwin are beginning to revegetate.

Upslope of the Highway between Aylwin and Enterprise Creeks there are more small openings, likely for residences but no further forestry development. Downslope of the Highway, the extensive private land logging is regenerating but there are several new openings for agricultural and residential development.

There is no significant change on Enterprise Creek. The cutblock on the south approach is regenerating.

On the face slope south of Enterprise Creek, there has been more small-scale selective logging on private land upslope of the Highway and the large clearcut below the Highway is regenerating.

Fire Scars and Landslides

The large fire scar (pre-1966) on the south side of Enterprise Creek remains visible as a uniform stand of immature trees. There were no new fires between 1997 and 2005.

The gullied slopes within the fire on the south side of Enterprise Creek have a couple of very small recent landslides within the gullies.

Clearly defined linear tracks are visible on the slopes within Allen and Cory drainages. These tracks initiate high on the slopes and appear to end on the upper fan surfaces within the recent private land logging. There are no signs of recent activity impacting the Highway.

The debris flow tracks on the face between Enterprise and Aylwin Creeks are still visible but none of them reach the Highway.

There appears to be no change to the previously identified scree slopes and debris flow tracks in Aylwin, Congo and Fingland Creeks.

4.2. Google Earth and Bing Satellite Imagery

4.2.1. 2014 Google Earth Imagery

These orthoimages show the area 7 years after the 2007 Springer Creek Fire burned across Enterprise Creek and the face unit south of Enterprise including Allen, Cory, Van Tuyl and Memphis Creeks. Several fireguards were established in and around the Springer Creek Fire. The Highway crossing over Enterprise Creek was reconstructed between 2005 and 2011.

There is no change in the road network within the fire area between 2005 and 2014. There are several new residential developments along RMR and a group of new houses in the lower Braille Creek watershed. There are also some agricultural developments that have been expanded.

Several new landslides have occurred within the Springer Creek Fire scar, on both the north-facing and south-facing slopes of Enterprise Creek and on the Van Tuyl Creek tributaries.

One small fire scar (2014) is visible along the ridge between Highland View and Beaverton Creek. No machine fire guards were constructed and there are no landslides associated with this fire.

4.2.2. 2022 Bing Maps and 2023 Google Earth Imagery

These orthoimages show the region prior to the Fire. There has been no change to the road network. Several new residences have been constructed across the area on RMR or off the Highway. The flat benched area below the Highway in Braille Creek was logged with scattered residual trees.

Two other fires have also occurred in upper Aylwin Creek and in upper Brahms Creek. Both were small and had no machine fire guards constructed around them. No landslides are associated with these fires.

4.3. LiDAR[18]

LiDAR was obtained from the RDCK for the area surrounding the Fire. Review of the LiDAR imagery provides better identification of critical features, including creeks, alluvial fans, rock outcrops and allows better definition of watershed boundaries.

4.4. Debris Flood and Debris Flow Susceptibility Maps

Debris flood and debris flow susceptibility maps on the Cambio Community web application[19] were reviewed. These maps were commissioned by the RDCK to assist with the identification and prioritization of hazardous areas within their jurisdictional area (BGC Engineering Ltd., 2019[20]). The maps were created using a combination of digital elevation model metrics (20 m contour intervals) to identify potential debris source zones within creek channels/gullies and flow propagation modelling to plot potential downslope flow paths; in most cases the maps are not field verified. The susceptibility maps (Figures 3 and 4) indicate that moderate to high debris flood and debris flow susceptibility is present on most of the smaller tributary creeks upslope of the Highway.

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[18] Lidar (*Light Detection and Ranging)* is a remote sensing method that uses light in the form of a pulsed laser to measure variable distances to the Earth. These light pulses generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

[19] https://communities.bgcengineering.ca/Index.aspx

[20] BGC Engineering, 2019 RDCK Floodplain and Steep Creek Geohazards Risk Prioritization

Figure 3: Excerpt from the Debris Flood Susceptibility Mapping (Source RDCK Cambio Communities Map). The darker the green coloration the higher the likelihood of debris flood occurrence.

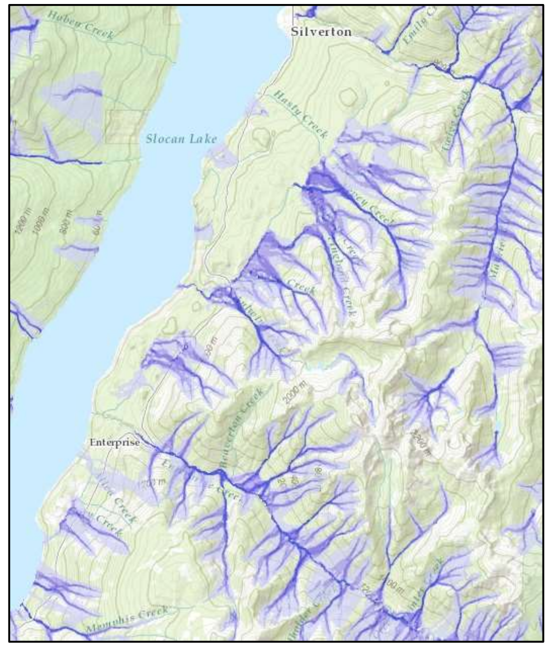

Figure 4: Excerpt from the Debris Flow Susceptibility Mapping (Source RDCK Cambio Communities Map). The darker the blue coloration the higher the likelihood of debris flow occurrence.

Debris floods and debris flows are quite similar hydrogeomorphic[21] processes and these maps tend to be quite similar in their output. The majority of the creeks within the fire show on both maps as having some potential for hydrogeomorphic events. It is interesting to note that Allen Creek, on which no visible channels or active streamflow on the lower slopes above the Highway were identified during fieldwork, shows as being prone to debris floods in one channel and debris flows in another. Cory Creek, which has at least 3 channels appears to only be prone to debris flows. This lack of consistency of output suggests that these maps are limited by the level of topographic data input to their modelling.

The authors of the debris flow and debris flood susceptibility report and maps caution that the maps are not suitable for undertaking site-specific hazard assessments (Sturzenegger et al., 2021[22]). While the maps are not intended to be used for detailed, site-specific hazard assessments, they do provide an indication, and initial office-based screening method, for where debris flow or debris flood hazards may be of concern. The hazard ratings do not have a physical meaning and the methodology does not compute or provide debris flow or debris flood volumes, mass depths, velocities, peak discharges, or impact forces. They are intended to be used for a regional comparison between sites to determine areas with higher hazard potential.

Given the limitations of the hazard susceptibility mapping, the site-specific observations and hazard assessments contained in this report take precedence over the hazard susceptibility maps.

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[21] Hydrogeomorphic processes such as floods, debris floods or debris flows move sediment, water and organic debris from the hillslopes of a watershed through channels to the depositional areas.

[22] Sturzenegger, M., Holm, K., Lau, C-A., Jakob, M. 2021. Debris-Flow and Debris-Flood Susceptibility Mapping for Geohazard Risk Priorization. Environmental and Engineering Geoscience, 27(2), 179-194. https://doi.org/10.2113/EEG-D-20-00006

5. Terrain and Watershed Conditions

The Fire is situated in the Kokanee Range of the Selkirk Mountains, within the Columbia Mountains in southeastern British Columbia. The general physiography of the region consists of serrated ridges and peaks above approximately 2100 m elevation and with rounded ridge crests and steep valley sides below 2100 m. Summit levels generally lie between 2100 m and 2500 m, and relief is roughly 2000 m, ranging from 540 m along Slocan Lake to 2521 m at the summit of Mount Aylwin.

Along the shoreline of Slocan Lake to between 1500 m and 1600 m elevation, depending on aspect (higher on south facing slopes), the biogeoclimatic mapping has identified the Slocan variant of the Moist Warm subzone of the Interior Cedar – Hemlock zone (ICHmw2). Upslope of the ICHmw2, the mapping indicates a thin elevation band (roughly between 1500 m and 1700 m elevation) of the Columbia variant of the Wet Hot Engelmann Spruce – Subalpine Fir zone (ESSFwh1). This then changes to the Selkirk variant of the Wet Cold Engelmann Spruce – Subalpine Fir zone (ESSFwc4) through to 1950 m to 2000 m elevation where it transitions into the Wet Cold Parkland Engelmann Spruce – Subalpine Fir zone (ESSFwcp) to the ridgetops and peaks.

Based on the precipitation modeling available from ClimateBC Map, the mean annual precipitation (MAP) within the burn area ranges from approximately 750 mm along Slocan Lake to 1480 mm at the peak of Mount Aylwin. On the mid-slope bench above Slocan Lake (at elevations between 650 m and 900 m), where most of the agricultural and residential development has occurred, the MAP rises upslope from 800 mm to 950 mm; a slight increase in precipitation is noted moving northwards. The headwaters of most of the west-facing creeks along the mid and upper slopes (between 1500 m and 1800 m) receive between 1000 mm and 1200 mm MAP. This is generally consistent with reference data available from weather stations throughout the region.

The regional geology mapping as viewed in iMapBC indicates the Fire area is underlain primarily by the Middle Jurassic Nelson granodiorite intrusive batholith. Along the shoreline of Slocan Lake near Enterprise Creek, Carboniferous to Permian aged gneisses (metamorphic rocks) are mapped as a thin unit which forms the steep bedrock face above the lake. Another thin unit of Paleocene to Eocene granitic intrusives are mapped along the lower slopes between the gneisses and the granodiorites. In the Aylwin Creek drainage, basalt volcanic rocks of the Rossland Group are mapped beside felsite intrusives; both are of Early Jurassic age. These rocks are likely the host rock for mineralization in the abandoned mine located 1 km upslope of the Highway.

Most of the steep slopes on Crown Land above Highway have some form of terrain stability mapping. Many of the steeper open slope areas are classified as Potentially Unstable while the majority of the main gully systems (including Cory, Highland View, Harte, Aylwin, Congo, Fingland) are classified as Unstable. Steep ridges, rock faces and alpine talus cones are frequently mapped as Unstable. Lower gentler slopes and plateau areas are generally mapped as stable. Unmapped areas include the slopes on the south side of Enterprise Creek near Allen Creek, Kegel Brook and lower Aylwin Creek.

6. Watershed Hazards

Watershed morphology is analyzed to confirm the expected hydrogeomorphic hazards within a watershed (i.e., floods, debris floods or debris flows) that could potentially affect downstream areas. Watershed boundaries in the area were delineated using LiDAR-derived 5 m contours for small drainages, and TRIM based 20 m contours for the large watersheds where LiDAR was unavailable. Watersheds were subdivided into smaller units to delineate drainage basins above alluvial fans. Many streams are not named on published maps, so some names used for watershed identification in this report may be arbitrary. Key characteristics of the watersheds are provided in Table 6.

Table 6. Characteristics of watersheds in the Fire. The Melton ratios are plotted versus watershed length on Figure 5 and stream length on Figure 6; coloration in the table reflects the zone in which they plot on Figure 6. The numbers in the left column refer to labels in Figure 6.

#	Watershed	Area (km^2)	Min elev (m)	Max elev (m)	Watershed Length (km)	Melton Ratio	Stream Length (km)	Stream Gradient (%)
8	Allen	3.12	545	1720	2.885	0.67	1.200	11
3	Aylwin Main	24.33	545	2525	6.705	0.40	7.715	22
7	Aylwin Upper	6.44	950	2525	4.510	0.62	2.150	40
6	Brahms	5.29	610	1810	3.770	0.52	4.360	25
16	Cabin	0.49	840	1815	1.580	1.39	1.580	58
12	Congo	1.11	1060	2135	1.730	1.02	1.800	49
9	Cory Main	2.95	545	1925	3.390	0.80	2.840	37
21	Cory Middle	0.40	785	1880	2.190	1.73	0.900	64
13	Cory North	1.10	740	1925	2.600	1.13	1.520	57
19	Cory South	0.57	710	1900	2.605	1.58	1.420	56
15	Enterprise Gully	0.55	740	1705	1.695	1.30	1.540	52
1	Enterprise Main	73.00	545	2620	19.500	0.24	21.410	7
11	Fingland	2.12	1120	2305	3.490	0.81	2.280	38
18	Harte	0.31	810	1640	1.380	1.49	1.230	51
4	Hasty	8.27	545	2015	5.570	0.51	6.500	20
17	Hemlock	0.31	900	1700	1.590	1.44	1.350	40
14	Highland View	0.62	870	1810	1.550	1.19	1.505	54
20	Kegel	0.28	840	1700	1.345	1.63	1.160	59
2	Maurier	24.53	900	2510	8.925	0.33	8.970	12
10	Twigg	1.94	840	1965	3.010	0.81	2.170	42
5	Vevey	7.47	1080	2305	4.410	0.45	3.790	26

Watershed areas are as depicted on Maps 1 and 2 in Appendix A. Minimum watershed elevation is the elevation at the fan apex, creek confluence or outlet into Slocan Lake, taken from Maps 1 and 2. Maximum elevations are sourced from iMapBC. Watershed length is measured in a straight line from the location of the minimum elevation of a watershed to the most distant point in a watershed. Stream lengths are the measured distance from the location of the minimum elevation to the end of the stream channel (following the stream channel). The stream gradient is the average gradient of the stream on the dominant stream channel within the Fire.

Differentiation between the hydrogeomorphic processes in a watershed is important from a landslide hazard perspective, as each process has different characteristics and impacts. The combination of the watershed length and Melton ratio[23] has been shown to reasonably predict the dominant hydrogeomorphic hazard that can be expected within a watershed (Figure 5; Wilford et al. 2004[24]):

- Watersheds with a Melton ratio less than 0.3 are susceptible to flood processes,
- Watersheds with a Melton ratio greater than 0.6 and a watershed length of less than 2.7 km are susceptible to debris flows, and
- Those not meeting either of these criteria are susceptible to debris floods. i.e., Melton ratios between 0.3 and 0.6.

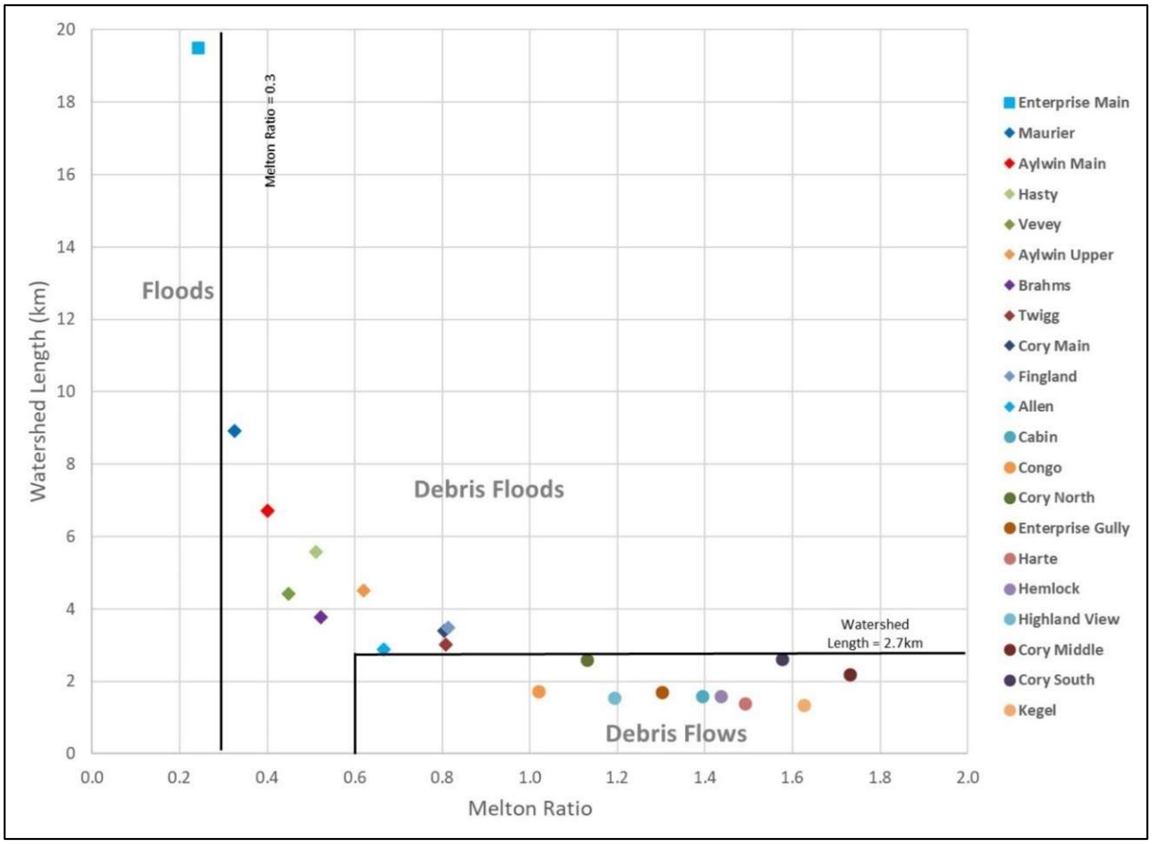

Figure 5: The hydrogeomorphic processes of creeks in the Fire plotted as a function of the Melton ratio and watershed length (Wilford et al. 2004).

[23] Watershed relief divided by the square root of the watershed area.
[24] Wilford, D.J., Sakals, M.E., Innes, J.L., Sidle, R.C., and Bergerud, W.A. 2004. *Recognition of debris flow, debris flood and flood hazard through watershed morphometrics*. Landslides, 1(1), 61-66. https://doi.org/10.1007/s10346-003-0002-0.

Enterprise Creek is a large watershed in which flooding is the expected hydrogeomorphic process. All of the mid-sized watersheds between 2 and 25 km^2 in area and 2.7 and 10 km in watershed length (Maurier, Aylwin (Main), Hasty, Vevey, Aylwin (Upper), Brahms, Twigg, Cory (Main), Fingland and Allen), plot within the region where a debris flood is the expected hydrogeomorphic process. All of the small watersheds are short and steep and plot within the region where debris flows are the expected hydrogeomorphic process.

Church and Jakob (2020) use a different metric to differentiate between hydrogeomorphic processes; they plotted the Melton ratio versus stream length for a large dataset from watersheds across BC and Alberta (Figure 6). Due to greater relief along shorter streams, the Melton ratios in steep face unit streams have higher Melton ratios; these are shaded in green in Table 6. All of the small face unit streams plot in the "*Mostly prone to debris flows*" zone. The mid-sized watersheds, shaded orange in Table 6, have lower Melton ratios and plot in the "*Mixed debris floods and debris flows*" zone. Enterprise and Maurier Creeks have large watersheds with long moderate-gradient streams that plot in the "*Mixed floods and debris floods*" zone. None of the creeks in the Fire plot in the "*Mostly prone to floods"* zone as the physiography of the region is typically mountainous with steep slopes.

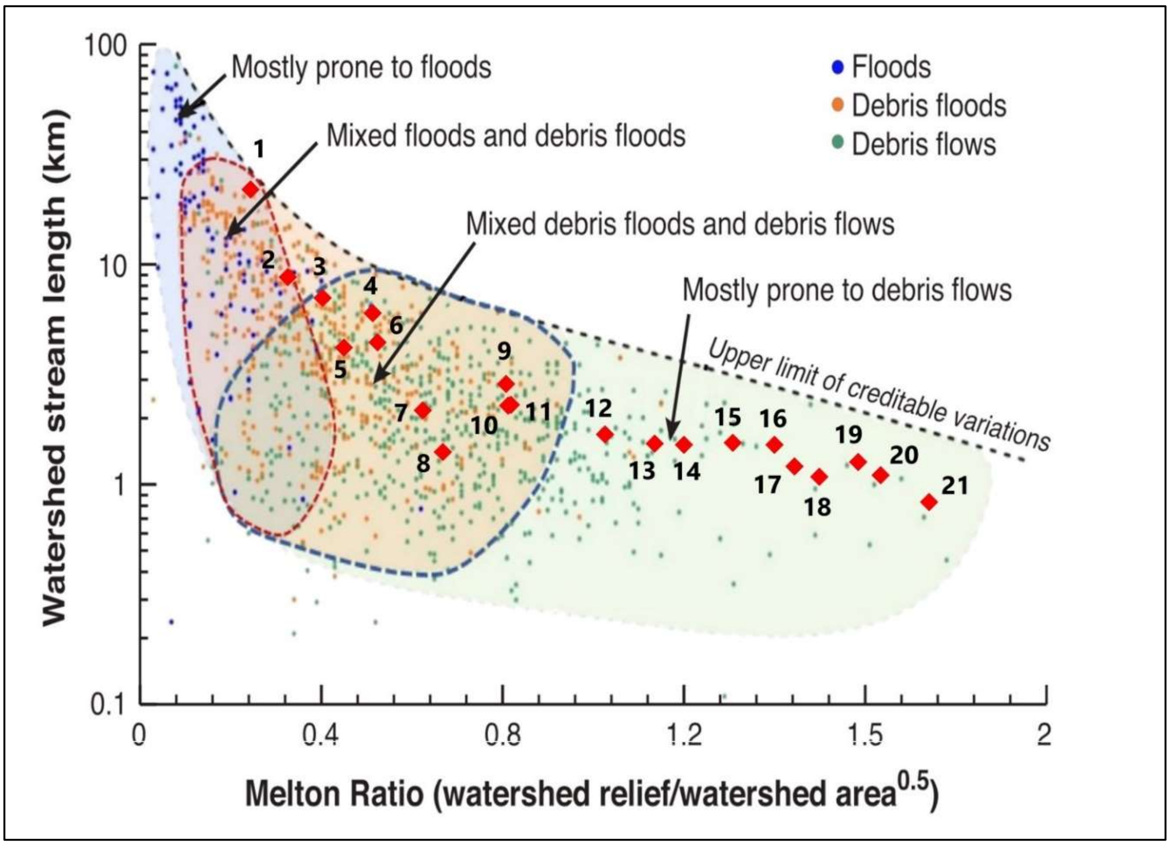

Figure 6: The Fire creeks plotted on a figure of the steep creek processes as a function of the Melton ratio and stream length, from Church and Jakob (2020[25]). The numbers refer to the watersheds in Table 6.

[25] Church, M., and Jakob, M. 2020. *What is a debris flood?* Water Resources Research, 56, e2020WR027144. https://doi.org/10.1029/2020WR027144.

The two methods of differentiating the hydrogeomorphic processes illustrate the complexity of classification of events. The Wilford method is inflexible in terms of numerically defined boundaries separating the events whereas the Church and Jakob method allows overlap of the event types and is less definite on the expected event. For instance, the watersheds defined as debris floods by Wilford (Maurier, Aylwin (Main), Hasty, Vevey, Aylwin (Upper), Brahms, Twigg, Cory (Main), Fingland and Allen) plot within the "*Mixed floods and debris floods*" zone or "*Mixed debris floods and debris flows*" zone of Church and Jakob. Use of both methodologies is useful in estimation of the expected hydrogeomorphic event.

Note that the predictive methods described above are typically relevant to well-graded watersheds, i.e., watersheds with gradually increasing slope gradients when moving from the bottom to the top of the watershed. Watersheds which feature an upper, gentle plateau area over a steep lower slope are not well-graded (i.e., Aylwin Upper Creek) and the predictive methods described above may erroneously determine that such watersheds are only prone to flood or debris flood events when in reality debris flow processes are present. As is common with natural systems, on the ground, site-specific field observations take precedence over the empirical, office based predictive methods described above.

7. Burn Severity Mapping

Burn severity is an important factor in determining the potential for post-wildfire natural hazards to occur. Burn severity is derived from:

- The vegetation burn severity mapping which uses satellite images to process reflectance data and estimate the change to the vegetation cover, and
- The soil burn severity, which relies on field tests and observations of the effects of fire on soils to determine loss of ground cover, loss of soil structure and increases in water repellency (Curran et al 2006)[26].

The vegetation burn severity or Burned Area Reflectance Classification (BARC) map was prepared by he MoF based on comparative (pre and post fire) satellite images taken on July 11 and August 20, 2024.

Burn severity maps are used to assess the potential hydrologic effects of the fire in each watershed due to forest cover and soil changes. The definitions of high, moderate, and low vegetation burn severity (VBS) are given in LMH69 and Parsons et al. (2010[27]), as well as the procedure for preparing a burn severity map. Briefly, the vegetation burn severity categories are:

- High – trees dead (black); needles, twigs, and understory consumed
- Moderate – trees dead (orange); scorched needles remain on trees, understory burned
- Low – trees live (green); canopy mostly unburned, understory lightly burned.

Soil burn severity (SBS) is similarly classified as high, moderate, or low, and is based on the extent of consumption of the forest floor and fuels on the ground, and on the extent of exposed bare soil:

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[26] Curran, M.P., Chapman B., Hope G.D., and Scott D. 2006. *Large-scale Erosion and Flooding after Wildfires: Understanding the Soil Conditions,* BC Ministry of Forests and Range, Technical Report 030.
[27] Parsons, A, Robichaud, P.R, Lewis, S.A, Napper, C, and Clark, J.T. 2010. *Field guide for mapping post-fire soil burn severity.* USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-243.

- High – forest floor and near-surface roots consumed, mineral soil structure altered
- Moderate – litter consumed, duff partly consumed or charred, mineral soil unaltered
- Low – litter scorched or partly consumed, often with patchy forest floor burn.

Moderate and high burn severities correspond to a higher rate of vegetation consumption (i.e., loss of canopy, groundcover and organic soil layer) during a fire and the presence of typically stronger and more prevalent water repellency conditions. This is important because the hydrologic response (i.e., increased peak flows and runoff volumes) in a watershed following rainfall events can be significantly altered on slopes burned to these severities.

Remotely sensed vegetation burn severity maps are intended to be modified by fieldwork to ascertain soil conditions on the ground and to produce verified soil burn severity mapping[28]. Normalized Burn Ratio (NBR) is sensitive primarily to living chlorophyll and the water content of soils and vegetation, with lesser response to lignin, hydrous minerals, ash and char. Where pre-fire images are available, the post-fire NBR can be subtracted from the pre-fire NBR to give the differenced NBR (dNBR). The dNBR data are separated into four categories of severity (unburned, low, moderate, high), and the resulting map has become the most commonly used remotely sensed illustration of fire severity. The final soil burn severity map is a modification of the preliminary remotely sensed vegetation burn severity map that incorporates the field-verified effects of the fire on the soil.

Vegetation and soil burn severity are usually, but not always, fairly well correlated. For example, a high VBS site most commonly has a high SBS, though may have moderate SBS but is unlikely to have a low SBS. Water repellency is often, but not always, present on high SBS sites. Where SBS is high, the infiltration capacity of the soil and storage capacity of the forest floor is often significantly reduced, and overland flow may be generated during heavy rain. If this occurs over large areas, soil erosion and downstream flooding can occur. If water repellency is present, the amount of overland flow can be considerably greater. Where VBS is moderate, dead needles remain on the trees. These soon fall, often covering the ground with an effective mulch which promotes infiltration and reduces erosion and the likelihood of overland flow. Therefore, fire related flood and debris flow hazards from rainstorms are generally very high only where both VBS and SBS are high.

Increased flood hazard during spring snowmelt is due to loss of the forest canopy, which results in both a higher winter snowpack and more rapid snowmelt. The effect is similar to that of clearcutting. However, in the first one or two years, the effect of fire may be greater than clearcutting, due to the black colour of burned tree trunks and the soot and debris which falls on the snow. The reduced water storage and run-off attenuation from the loss of the litter and/or duff may also contribute to increased freshet related flood hazard although this is less of a factor during freshet as the litter/duff storage capacity is typically reduced in the during freshet. Also, because there is no longer transpiration from trees and understory vegetation, the water table and soil moisture may be higher when winter comes. The flood hazard in a watershed is a function of the area burned at high and moderate VBS; low VBS sites (in which many trees and shrubs have survived) generally do not contribute significantly to flood hazard.

[28] Safford, H.D. Miller, J., Schmidt, D. Roath, B. and Parsons, A. 2008. *BAER Soil Burn Severity Maps Do Not Measure Fire Effects to Vegetation: A Comment on Odion and Hanson (2006).* Ecosystems 11: 1-11; DOI: 10.1007/s10021-007-9094-z

Field data on vegetation and soil burn severity were collected at a limited number of ground plots, with more general visual observations made throughout the field assessments. Five of each unburned, low and moderate burn severity plots were completed, but only 1 high burn severity plot was completed due to poor access to the more severely burned terrain.

The field observations were used to check the accuracy of the high, moderate, low, and unburned categories on the BARC map and were found to correspond reasonably well to the BARC map categories. In addition, comparison of the vegetation burn severity and soil burn severity was found to be in close agreement; the BARC map is considered to be suitably representative of the vegetation burn severity and soil burn severity for the purpose of this assessment and is shown on Map 1 in Appendix A. Minor discrepancy between the vegetation burn severity map and observed soil burn severity was noted where bedrock was exposed or where deciduous trees were burned; in these cases the vegetation burn severity tended to be over-conservative and rated the burn severity higher than was proven during the ground investigation.

Investigation of unburned terrain to compare with burned sites indicated that, in general, the steeper slopes above the Highway are well drained and lack thick organic LFH accumulations. Lower gradient slopes above and below the Highway had much thicker moss, LFH and organic soils and were generally, due to longer moisture retention, wetter sites.

Photos 3 through 6 are overview images of the Fire. These images were taken on August 23, 2024, while the fire was still active and smoke impeded visibility.

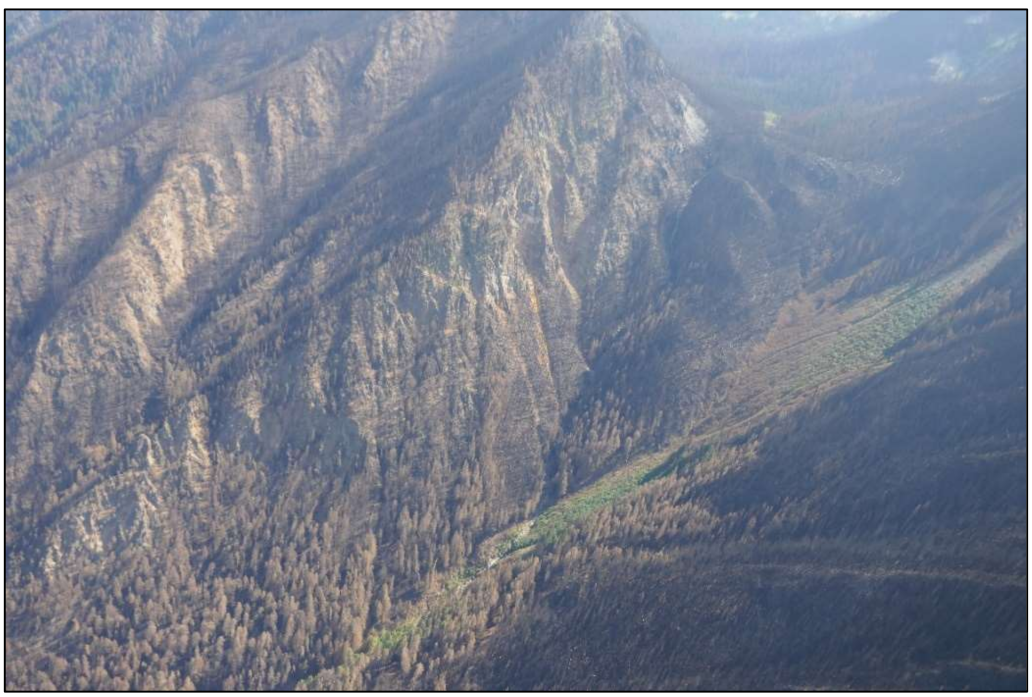

Photo 3: Moderate and high VBS within the mid-slope canyon of Aylwin Creek watershed.

Photo 4: View of the south-facing slope of Enterprise Creek which has mostly mixed moderate and low VBS (see Map 1). The Highway can be seen at left, Enterprise Creek FSR cuts across the lower portion of the slope in the area of mixed low VBS and unburned forest.

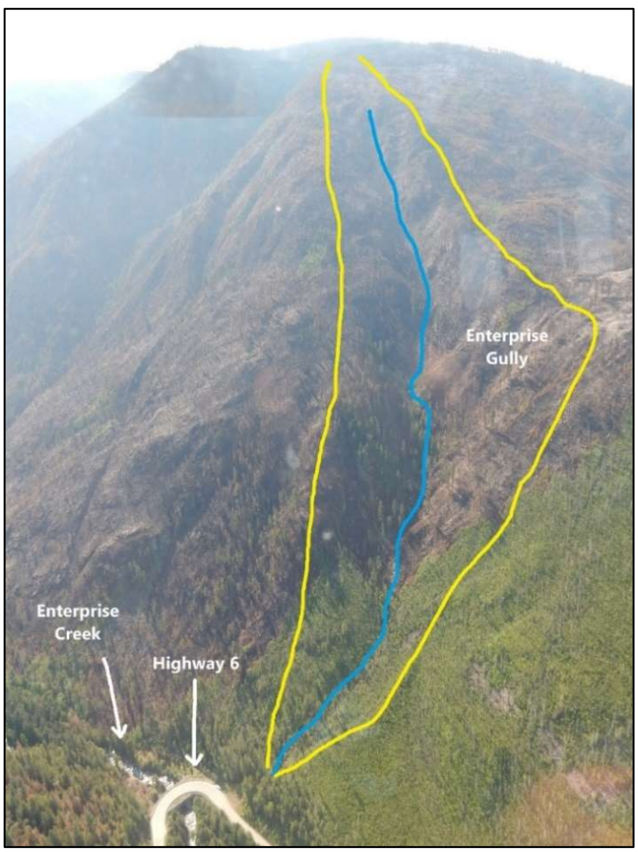

Photo 5: View of the steep gullied draw on the south side of Enterprise Creek at the Highway crossing. Much of the drainage burned at high VBS and is a reburn of ground burned during the 2007 Springer Creek Fire.

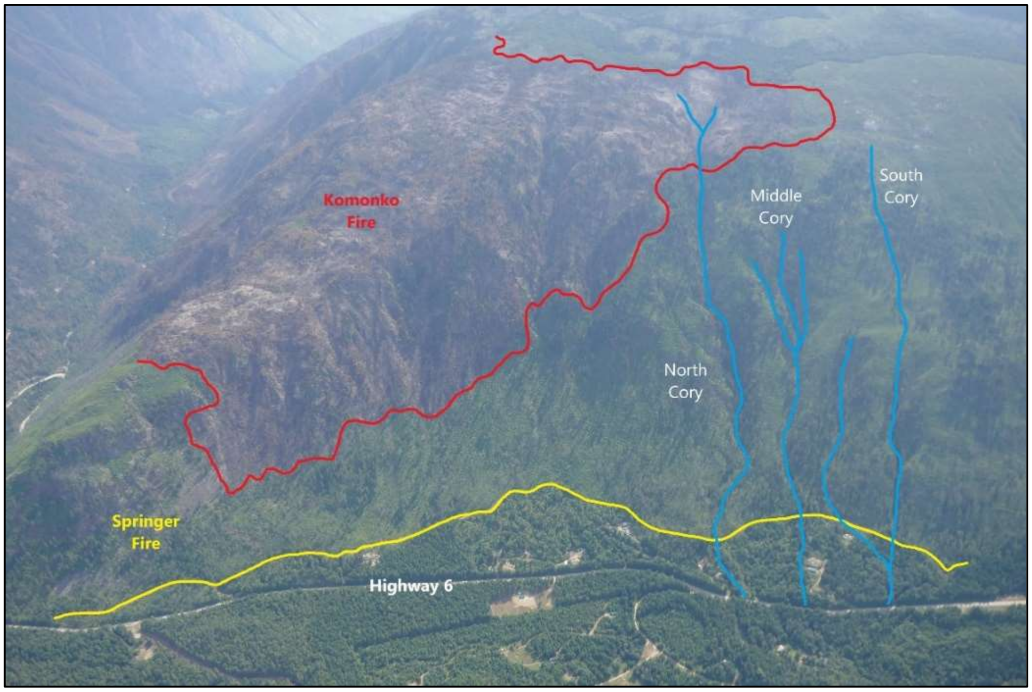

Photo 6: View of the Fire (outlined in red) on the Allen and Cory Creek face above The Highway. The Springer Creek Fire (outlined in yellow) burned much of this slope in 2007 and immature regrowth covers much of the lower slopes. The various Cory Creeks are shown as blue lines.

In addition to the low, moderate, and high drainage VBS categorization, a weighted burned area classification (referred to as the effective burn severity index (EBSI)) was also used to assess the landslide and flood hazard. The EBSI is calculated as the sum of 100% of the area of the high burn severity (in km^2) plus 50% of the area of moderate burn severity (in km^2) divided by the drainage area (in km^2). Base EBSI values and the qualitative ratings are shown in Table 7. Calculated base EBSI values for each watershed are provided in Table 8.

Table 7. EBSI values and corresponding ratings of potential increase in landslide hazard.

EBSI Value	Potential Increase in Landslide Hazard
0 - 15	Very Low
15 - 30	Low
30 - 50	Moderate
50 - 75	High
> 75	Very High

Table 8. Vegetation Burn Severity and calculated EBSI by watershed. Coloration of the base EBSI values reflect the ratings shown in Table 7.

Watershed	Area (km^2)	Vegetation Burn Severity				Base EBSI Value
		Area Unburned within Drainage (%)	Area Low Burn Severity within Drainage (%)	Area Moderate Burn Severity within Drainage (%)	Area High Burn Severity within Drainage (%)	
Allen	3.12	54	16	26	4	16.6
Aylwin Main	24.33	55	21	15	9	16.6
Aylwin Upper	6.44	34	14	27	24	37.9
Brahms	5.29	31	49	18	2	10.7
Cabin	0.49	0	61	39	0	19.8
Congo	1.11	6	40	28	25	39.4
Cory Main	2.95	87	2	7	4	7.4
Cory Middle	0.40	82	3	6	9	11.9
Cory North	1.10	74	3	16	8	15.5
Cory South	0.57	100	0	0	0	0.0
Enterprise Gully	0.55	5	11	40	44	64.0
Enterprise Main	73.01	79	11	8	2	6.0
Fingland	2.12	44	30	21	5	15.7
Harte	0.31	9	73	18	0	9.2
Hasty	8.27	99	1	0	0	0.0
Hemlock	0.31	53	44	2	1	1.9
Highland View	0.62	8	55	37	0	18.5
Kegel	0.28	4	37	25	35	47.2
Maurier	24.53	99	1	0	0	0.1
Twigg	1.94	95	3	2	0	1.4
Vevey	7.47	65	21	12	3	8.6

Calculation of the base EBSI rating for each watershed is straightforward, but there are several judgement factors which individually or in combination with others, can increase the rating depending on the severity of the effect, including:

- presence of an older burn which is still affecting the watershed,
- burning of the gentle slopes in a gentle-over-steep watershed configuration,

- burning of the riparian zone, and
- concentration of the high burn severity in one elevation band, particularly in the steeper portions of a watershed where debris flow initiation is elevated due to increased sediment availability and decreased channel stability.

Table 9. The Base EBSI Value Rating is adjusted based on review of the several factors noted above. The Adjusted EBSI Ratings are colored if they have been altered from the Base EBSI Value Rating.

Watershed	Base EBSI Value Rating	Old Fire Effects	"Gentle-over-steep"	Riparian Zone Burned	Burn Concentration	Adjusted EBSI Rating[29]
Allen	Low	Yes			Upper steep	Moderate
Aylwin Main	Low		Partially	Partially	Upper steep	Low
Aylwin Upper	Moderate		Yes	Yes	Lower steep	High
Brahms	Very Low			Yes	Upper and Lower	Very Low
Cabin	Low			Yes	All	Low
Congo	Moderate			Yes	Upper steep	Moderate
Cory Main	Very Low	Yes	Partially	Minor	Upper steep	Low
Cory Middle	Very Low	Yes	Partially	Upper	Upper steep	Low
Cory North	Low	Yes	Partially	Upper	Upper steep	Moderate
Cory South	Very Low	Yes	Partially		Upper steep	Low
Enterprise Gully	High	Yes		Yes	Upper steep	High
Enterprise Main	Very Low	Yes		Light		Very Low
Fingland	Low			Partially	Upper steep	Low
Harte	Very Low			Light	All	Very Low
Hasty	Very Low					Very Low
Hemlock	Very Low					Very Low
Highland View	Low			Light	All	Moderate
Kegel	Moderate			Yes	Upper steep	High
Maurier	Very Low					Very Low
Twigg	Very Low					Very Low
Vevey	Very Low			Yes	Upper steep	Very Low

The adjusted EBSI rating is considered equivalent to the qualitative "Hazard Likelihood" as described in Table 2 and is therefore used in the calculation of partial risk as shown in Table 10 in Section 9.

[29] The Adjusted EBSI Ratings are considered to be equivalent to the MoF Hazard Descriptions as described in Table 2.

8. Elements at Risk and Partial Risk for Drainages of Interest

Property, infrastructure, and water supplies are often at risk from post-wildfire hazards, such as flooding or landslides. These areas or sites are referred to as "elements at risk" and include the following:

- damage to residential structures and out-buildings;
- damage to, and loss of access on highways and other transportation infrastructure (subsidiary Ministry of Transportation and Transit (MoTT) roads and forest access roads);
- public safety for houses and other occupied structures;
- public safety of users on highways and other transportation infrastructure (subsidiary MoTT roads and forest access roads);
- domestic water supplies ;
- linear infrastructure including hydro transmission lines; and
- campgrounds and parks.

Some general information on potential risks is given here and more specific analyses of risks are described in the following sections and the accompanying tables. If any particular elements are not given any further mention, it is because no moderate or high risks were identified.

Houses and other buildings are shown on maps, based on TRIM data with additional information added from available imagery (Google Earth and RDCK web mapping service). Houses and other structures were considered to be at risk if they are located on alluvial or debris flow fans, near stream channels, or at the base of steep slopes below burned areas. Such sites comprise most of the risk elements in this study.

Water license information was obtained from the BC Government water license query page, and from the POD (points of diversion) shown on iMap BC. There are numerous domestic licenses on many of the creeks. A partial risk assessment was not completed for every water intake or point of diversion. Instead, Table 10 should be referenced to determine the hazard relating to any one water intake.

During firefighting, roads and trails are reopened to gain access to the fire and numerous fireguards are built in efforts to control the spread of fire. It is assumed that these roads, trails and fireguards will be fully deactivated by the MoF or BCWS.

A Fortis BC transmission line is located adjacent to Highway 3A. The location/risk relating to individual power poles were not reviewed as part of this assessment.

8.1. Allen Creek

Allen Creek is a small watershed (3.12 km^2) with a Melton ratio of 0.67 and a length of 2.885 km. Based on the Melton ratio the creek is considered to be able to initiate and transport post wildfire debris flows on the steep slopes above the Highway. Allen Creek was burned on the 2007 Springer Creek Fire[30] with a mix of high, moderate and low burn severities; no landslides were observed on the upper slopes of the Allen Creek watershed after the fire.

[30] Nicol, D.R., Jordan, P., Deschenes, M, Curran, M and Covert, A. (Assessment Team) 2007. *Springer Creek Fire Number 50372 Post-Wildfire Risk Analysis*. Prepared for the Ministry of Forests and Range, dated September 1, 2007.

The 1:20,000 topographic map and bare earth LiDAR map (Map 2 Appendix A) show drainage paths on the slopes, however, no clearly defined creeks were observed during fieldwork. Property owners within the watershed (at 9470 and 9480 Highway 6) indicate that there is minor flow during spring freshet, but most of the water comes from small springs on the lower slope. The property owner at 9470 Highway 6 is located where the creek is mapped on the topographic map, but they get their water from a domestic use well. Based on our fieldwork, the most likely post wildfire natural hazard is considered to be an open slope landslide, but small debris flows might still occur in shallow draws if slope drainage conditions permit. Below the Highway, there is a low gradient creek which flows northwards on the broad terrace surface.

The fire burned 46% of the watershed with 26% moderate and 4% high burn severity; the calculated EBSI is 16.6 which is considered to be low. This watershed is still recovering from the 2007 Springer Creek Fire, thus the EBSI is adjusted to moderate, and the incremental post wildfire hazard is likely to be moderately elevated.

Elements at risk are the Highway and three residences (9460, 9470 and 9480 Highway 6) above the Highway along the lower slope. Should an open slope landslide occur in this drainage it is unlikely that it could transport debris over the moderately graded lower slopes above the Highway and is unlikely to impact residences or the Highway. Should a small debris flow initiate on the upper slopes, it is expected to runout on the forested, lower gradient slopes above the Highway and is unlikely to impact the residences or Highway. Residences below the Highway are on lower gradient slopes more distant from the hazards and are not considered to be at risk.

Allen Creek has been rated as having a MODERATE incremental post wildfire hazard with a LOW likelihood of spatial impact from open slope landslides to the residences or the Highway; the overall partial risk from open slope landslides to the residences or the Highway is rated as LOW.

Allen Creek has been rated as having a MODERATE incremental post wildfire hazard with a LOW likelihood of spatial impact from debris flows to the residences or the Highway; the overall partial risk from debris flows to the residences or the Highway is rated as LOW.

8.2. Aylwin Main Creek

Aylwin Creek is a relatively large and complex watershed with numerous steep slope tributaries leading down to a broad gently sloped bench. The watershed is 24.33 km^2 in size, has a Melton ratio of 0.40 and a length of 6.705 km. The steep tributary watersheds (Aylwin Upper, Congo, Hemlock, Fingland and Vevey are discussed individually below) are considered to be able to initiate and transport post wildfire debris flows and debris floods, but the main watershed is considered to be a flood or debris flood watershed.

The fire burned 45% of the watershed with 15% moderate and 9% high burn severity; the calculated EBSI is 16.6 which is considered to be low, and the incremental post wildfire hazard is likely to be only slightly elevated.

The fire occurred dominantly in the upper portions of the watershed, with a strip along the lower steep face into Slocan Lake (Photo 7); the gently sloped bench between the burned upper and lower areas was unburned.

The elements at risk are a residence on the lower fan below the Highway and the two Highway crossings on lower Vevey Creek and Aylwin Creek (Field Observation Site K8) which have potential for floods and increased sediment movement. The residence is located downslope of the Highway on an elevated site above Vevey Creek to the north (160 m distance) and Aylwin Creek to the south (165 m distance). The Aylwin Creek crossing at Field Observation Site K8 is discussed individually below in Section 8.3. Aylwin Creek has been rated as having a LOW incremental post wildfire hazard with a LOW likelihood of spatial impact; the overall partial risk is rated as VERY LOW.

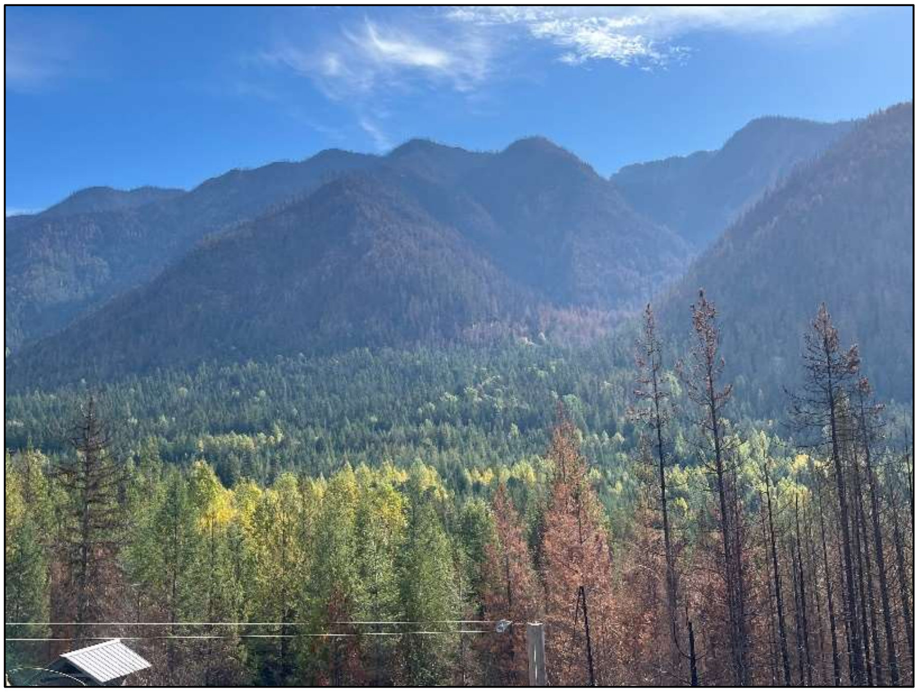

Photo 7: View of the lower reaches of the Aylwin Creek watershed. The upper slopes are burned at moderate and high VBS, but the large alluvial fan formed where the creek leaves the confined valley is completely unburned.

8.3. Aylwin Upper Creek

Aylwin Upper Creek is a small drainage (6.44 km^2) with a Melton ratio of 0.62 and a length of 4.510 km. This tributary watershed has two distinct sections: an upper bowl and a lower steeply graded section. The upper section has steep bedrock ridges surrounding a moderately graded bowl with a lake in the centre. The lower section starts at the outlet of the lake and has several small steep tributaries funneling down into a steep and confined channel which outlets onto a broad alluvial fan (Photo 8). Significant moderate and high burn severity occurred in the lower, steeper half of the watershed; this increases the incremental post wildfire risk. The creek is considered to be able to initiate and transport post wildfire debris floods or debris flows on the steep slopes above the Highway.

The fire burned 66% of the watershed with 27% moderate and 24% high burn severity; the calculated EBSI is 37.9 which is considered to be moderate. Due to the significant concentration of the moderate and high burn severity in the lower watershed the EBSI has been adjusted to high. The incremental post wildfire hazard will be significantly elevated.

There is an industrial use (MoTT) water licence point of diversion on Aylwin Creek at the Highway (PD192940).

A small sediment-laden flow was observed at Field Observation Sites K21 and K22. The landslide initiated upslope in a steep bedrock gully which was identified to be high VBS. Flow was relatively fluid and followed a shallow swale across the colluvial talus apron below the confined gully and eventually ran out and deposited on a road across the base of the slope. Our field visit occurred on September 27, 2024, and due to the freshness of the deposit appearance it is believed the landslide occurred on September 25, 2024. The Environment Canada weather station at Nakusp, approximately 50 km north, recorded 8.4 mm on the evening of September 25 with 5.5 mm occurring between 8 and 9 pm. Weather radar from Silver Star shows a weather system moving north-northeast across the fire between 1700 and 2100 hours. The heaviest rainfall recorded by the radar during the event indicates an amount up to 4 mm fell between 1900 and 2000 hours. The occurrence of a small landslide indicates the sensitivity of this slope (and likely adjacent slopes with high VBS polygons) to short duration intense rainfall events.

The element at risk on Aylwin Upper Creek is the highway crossing and a 2000 mm diameter steel pipe culvert. Should a debris flow initiate within this drainage it is likely that it would reach the alluvial fan as the upslope channel is confined and has an average slope between 20% and 30%. However, the debris flow is unlikely to reach the Highway or RMR because the alluvial fan has a less confined channel and an average gradient of 16%, which generally results in debris deposition. Approximately 500 m separates the apex of the fan from the Highway suggesting that the debris flow would deposit upslope of the Highway and sediment-laden floodwaters would continue down to and beyond the Highway. These types of floods generally are less destructive than a debris flow because they have a lower debris content, but they often travel further and can easily shift channels on the alluvial fan.

The flow path modelling of Aylwin Upper Creek (shown in Figure 2) suggests that water and debris can reach the Highway crossing.

Above the Highway, the channel of Aylwin Creek is already aggraded with coarse cobble and boulder sediments and large woody debris (Photo 9). Stream flow is currently diverted around elevated depositional bars and there is relatively low freeboard across the lower fan. In the 50 m reach upstream from the Highway crossing, there is significant potential for the creek to avulse on the north side of the channel and overtop the Highway north of the culvert (Photo 10). In addition, movement of aggraded sediment and large wood into the culvert opening is a distinct possibility; a significant spring freshet flood event may be enough to initiate this and cause the culvert to be blocked. Fortunately, the alluvial fan is almost completely unburned and the presence of the forest on the fan surface will help to slow and disperse any debris flows or floods.

Aylwin Upper Creek has been rated as having a HIGH incremental post wildfire hazard with a HIGH likelihood of spatial impact to the Highway and RMR; the overall partial risk is rated as VERY HIGH to the Highway and RMR.

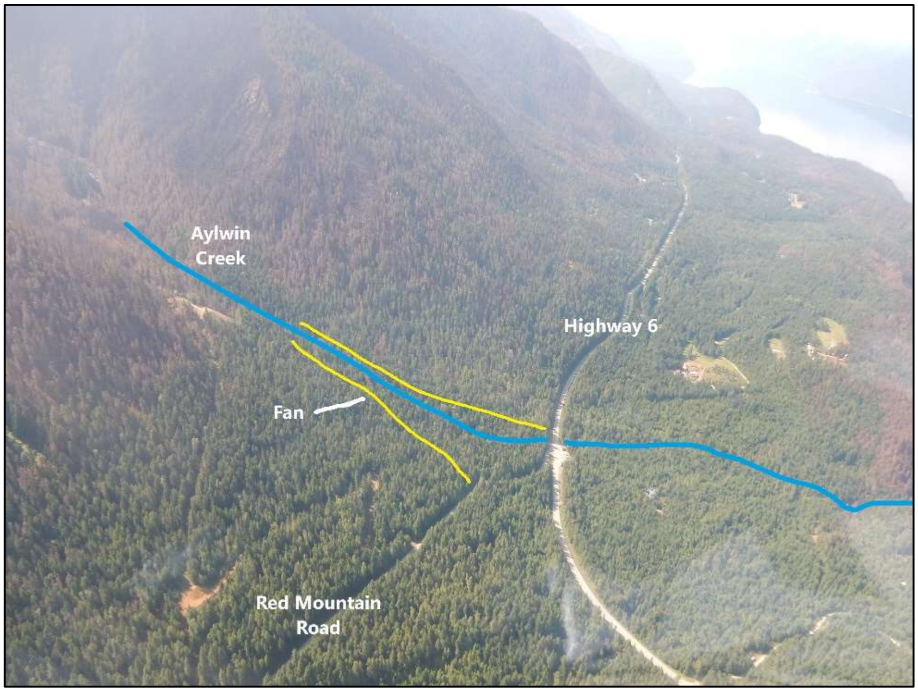

Photo 8: Oblique view of the alluvial fan at the outlet of Aylwin Upper Creek watershed. The Highway runs along the base of the slope and RMR leaves the Highway on the south side of the crossing and rises upslope to the northeast. Much of the upper watershed is severely burned but the alluvial fan is completely unburned.

Photo 9: View upstream along Aylwin Creek immediately upstream from the Highway crossing (a 2000 mm steel plate culvert). The creek is filled with coarse cobble and boulder gravels and large wood pieces. Streamflow is diverting around the elevated sediment accumulations (aggradation).

Photo 10: Looking upstream along Aylwin Creek from the Highway crossing (Field Observation Site K8). Note the low freeboard on the left side of the image where avulsion of the creek could easily occur and flow could be diverted onto the Highway.

8.4. Brahms Creek

Brahms Creek is a moderately sized watershed with numerous steep slope tributaries leading down to a broad gently sloped bench. The watershed is 5.29 km^2 in size, has a Melton ratio of 0.52 and a length of 3.77 km. The steep tributary watersheds (Highland View, Harte, Cabin and Kegel are discussed individually below) are considered to be able to initiate and transport post wildfire debris flows and debris floods, but the main watershed below the Highway is considered to be a flood prone watershed.

The fire burned 69% of the watershed with 18% moderate and 2% high burn severity; the calculated EBSI is 10.7 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

The elements at risk in the steep tributary watersheds on the upper slopes of Brahms Creek are discussed individually. Residences below the Highway are on lower slopes more distant from the hazards and are not considered to be at risk. Brahms Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to the Highway; the overall partial risk to the Highway is rated as VERY LOW.

8.5. Cabin Creek

Cabin Creek is a small tributary drainage on the upper slope above the Highway within the Brahms Creek watershed. The watershed is 0.49 km^2 in size, has a Melton ratio of 1.39 and a length of 1.58 km. The steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. A broad gently sloped fluvial fan has formed along the lower slope and there are no debris flow levees or sediment lobes indicative of debris flow activity. The creek observed within this watershed is small and flows through a moderately confined swale on the moderately to gently graded lower slopes (Photo 11).

The fire burned 91% of the watershed with 39% moderate and no high burn severity; the calculated EBSI is 19.8 which is considered to be low, and the incremental post wildfire hazard is likely to be only slightly elevated.

Two domestic use water licence points of diversion are located on Cabin Creek above the Highway (PD27911 and PD27913).

The elements at risk are two residences (8876 and 8906 Highway 6) along the lower slope and the Highway. Both residences are located on gentle slopes relatively close to the Highway and are sufficiently far enough away from the drainage channels on the steeper slopes to have a low likelihood of impact. Cabin Creek has been rated as having a LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to residences and the Highway; the overall partial risk is rated as VERY LOW.

Photo 11: Cabin Creek is a small creek in a shallow swale on the lower slope above the Highway (Field Observation Site K20).

8.6. Congo Creek

Congo Creek is a small tributary watershed within the Aylwin Creek watershed. The watershed is 1.11 km^2 in size, has a Melton ratio of 1.02 and a length of 1.730 km. The steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed is small and flows through a broadly confined draw on the moderately graded lower slopes (Photo 12).

The fire burned 94% of the watershed with 28% moderate and 25% high burn severity; the calculated EBSI is 39.4 which is considered to be moderate, and the incremental post wildfire hazard is likely to be moderately elevated.

One domestic use water licence point of diversion was located close to Congo Creek; the source was noted to be named Butt Spring (PD27923).

The elements at risk are RMR and a residence (8596 RMR) along the lower slope above the road. Congo Creek has a very long alluvial fan which starts around 1060 m elevation, has a gradient around 30% and is up to 50 m wide. The gradient of fan decreases gradually downslope to RMR at 900 m elevation where it averages 15% and is up to 100 m wide. There are several small channels on the fan surface through which the creek could flow with at least two (at Field Observation Sites K34 and K36) that have signs of recent streamflow. Low on the fan, a narrow creek channel was observed on the property which the owner indicated typically had limited flow during spring freshet. Increased flow is expected to be generated within the highly burned watershed and watery slurries and flooding across the fan are expected; these have a low potential to impact RMR. No culvert was observed below the 8596 RMR property; the nearest culvert was located at Field Observation Site K7, approximately 100 m south of the observed creek location on the property. The residence is located on the lower slope at least 50 m from the small channel of Congo Creek and is considered to have a low likelihood of impact.

Congo Creek has been rated as having a MODERATE incremental post wildfire hazard with a LOW likelihood of spatial impact to the residence at 8596 RMR and to RMR; the overall partial risk to the residence at 8596 RMR and to RMR is rated as LOW.

Photo 12: View upstream along Congo Creek on the upper alluvial fan (Field Observation Site K34). Congo Creek was a small creek with very limited flow at the time of observation, but there is a narrow channel armoured with coarse cobbles and boulders.

8.7. Cory Main Creek

Cory Main Creek is a small drainage with numerous steep slope tributaries leading down to a broad gently sloped bench. The watershed is 2.95 km^2 in size, has a Melton ratio of 0.80 and a length of 3.390

km. The steep tributary watersheds of Cory Middle, Cory North and Cory South are discussed individually below. The main watershed below the Highway is considered to be a flood watershed.

Timber harvesting was completed across the upper watershed starting in 1976 with the majority of the logging completed by 1980. This has left a legacy of old roads and skid trails on the plateau surface which may cause diversion and concentration of flow into watercourses unconditioned to flow. After the 2007 Springer Creek Fire burned across the upper watershed many of the roads and trails were deactivated.

The fire burned 13% of the watershed with 7% moderate and 4% high burn severity; the calculated EBSI is 7.4 which is considered to be very low. This watershed is still recovering from the 2007 Springer Creek Fire, thus the EBSI is adjusted to low; the incremental post wildfire hazard is likely to be only slightly elevated.

The elements at risk in the steep tributary watersheds on the upper slopes of Cory Creek are discussed individually. Residences below the Highway are on lower slopes more distant from the hazards and are not considered to be at risk. Cory Main Creek has been rated as having a LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to the Highway; the overall partial risk to the Highway is rated as VERY LOW.

8.8. Cory Middle Creek

Cory Middle Creek is a small tributary drainage within the Cory Main Creek watershed. The watershed is 0.40 km^2 in size, has a Melton ratio of 1.73 and a length of 2.190 km. This steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed has steady flow and is in a confined draw on the moderately graded alluvial fan (Photo 13).

Timber harvesting was completed across the upper watershed starting in 1976 with the majority of the logging completed by 1980. This has left a legacy of old roads and skid trails on the plateau surface which may cause diversion and concentration of flow into watercourses unconditioned to flow. After the 2007 Springer Creek Fire burned across the upper watershed many of the roads and trails were deactivated.

The fire burned 18% of the watershed with 6% moderate and 9% high burn severity; the calculated EBSI is 11.9 which is considered to be very low. This watershed is still recovering from the 2007 Springer Creek Fire, thus the EBSI is adjusted to low; the incremental post wildfire hazard is likely to be only slightly elevated.

There is one point of diversion on Cory Middle Creek but there is no attribution on iMap.

The elements at risk are the Highway and two residences (both on 9530 Highway 6) on the alluvial fan above the Highway. The creek follows a moderately confined channel across the fan and the channel gradient averages 18%. The fireguard approached the edge of the creek from both sides, but the creek was not altered during firefighting. Near the apex of the alluvial fan, the creek channel showed signs of passage of a recent debris flow. A trim line on the sidewalls of the incised draw suggested a small debris flow passed through the channel but downstream from this no debris flow levees or sediment lobes were observed, suggesting the event was relatively fluid. At the Highway, the creek flows through a 500 mm culvert which is considered to be undersized.

The northern residence is located on the mid-slope of the alluvial fan and approximately 25 m to the south of the fan channel; it is considered to have a high likelihood of spatial impact from debris flows, debris floods and floods. The southern residence is located slightly higher on the mid-slopes of the alluvial fan and approximately 75 m to the south of the fan channel; it is considered to have a low likelihood of spatial impact from debris flows, debris floods and floods. The Highway runs across the distal fan and is considered to have a moderate likelihood of spatial impact from debris floods and floods.

Modelling of the flows on the Cory Middle Creek watershed shows channel on the steep upper slopes losing confinement at the top of the gentler alluvial fan and water and sediment spreading out across the fan surface.

Photo 13: Cory Middle Creek along the fire guard (Field Observation Site K54). Note the trim line along the bank to the right, this is evidence of passage of a recent debris flow.

Cory Middle Creek has been rated as having a LOW incremental post wildfire hazard with a HIGH likelihood of spatial impact to the northern residence (this is supported by modelling of a debris flow runout through the Cory Middle Creek watershed); the overall partial risk to the northern residence is rated as MODERATE.

Cory Middle Creek has been rated as having a LOW incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the southern residence (this is supported by modelling of a debris flow runout through the Cory Middle Creek watershed); the overall partial risk to the southern residence is rated as LOW.

Cory Middle Creek has been rated as having a LOW incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the Highway (this is supported by modelling of a debris flow runout through the Cory Middle watershed); the overall partial risk to the Highway is rated as LOW.

8.9. Cory North Creek

Cory North Creek is a small tributary watershed within the Cory Main Creek watershed. The watershed is 1.10 km^2 in size, has a Melton ratio of 1.13 and a length of 2.600 km. This steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed has steady flow and is in a confined draw on the moderately graded lower slopes (Photo 14). The recently constructed fireguard reached this creek but did not cross it and the creek was not altered during the firefighting.

Timber harvesting was completed across the upper watershed starting in 1976 with the majority of the logging completed by 1980. This has left a legacy of old roads and skid trails on the plateau surface which may cause diversion and concentration of flow into watercourses unconditioned to flow. Cory North Creek is believed to have experienced a debris flow in the 1990's and again soon after the 2007 Springer Creek Fire. The 1990's debris flow reached the Highway and floodwater and sediment carried on downslope over 100 m and impacted a residence. After the 2007 Springer Creek Fire burned across the upper watershed many of the roads and trails were deactivated.

The fire burned 26% of the watershed with 16% moderate and 8% high burn severity; the calculated EBSI is 15.5 which is considered to be low. This watershed is still recovering from the 2007 Springer Creek Fire, thus the EBSI is adjusted to moderate, and the incremental post wildfire hazard is likely to be moderately elevated.

Two water licences are located on Cory North Creek below the Highway; one is joint use domestic and irrigation and the other is for residential power (PD27897).

Photo 14: Cory North Creek along the fireguard (Field Observation Site K55).

The elements at risk are the Highway and two outbuildings on the north side of the creek on the alluvial fan above the Highway (9510 Highway 6). The creek follows a moderately confined channel across the fan and the channel gradient averages 21%. The outbuildings are located on the lower portion of the alluvial fan with the northern (upslope) structure being 60 m from the creek channel; this northern structure is considered to have a low likelihood of spatial impact. The second structure is located further south and lower on the fan and approximately 35 m from the creek channel; this southern structure is considered to have a moderate likelihood of spatial impact. At the Highway, the creek flows through a 900 mm culvert. The Highway is considered to have a moderate likelihood of spatial impact from debris flows, debris floods and floods.

Modelling of the flows on the Cory North Creek watershed shows the channel on the steep upper slopes losing confinement at the top of the gentler alluvial fan and water and sediment spreading out across the fan surface. Debris reaches and crosses the Highway.

Cory North Creek has been rated as having a MODERATE incremental post wildfire hazard with a LOW likelihood of spatial impact to the northern outbuilding (this is supported by modelling of a debris flow runout through the Cory Middle watershed); the overall partial risk to the northern outbuilding is rated as LOW.

Cory North Creek has been rated as having a MODERATE incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the southern outbuilding (this is supported by modelling of a debris flow runout through the Cory Middle watershed); the overall partial risk to the southern outbuilding is rated as MODERATE.

Cory North Creek has been rated as having a MODERATE incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the Highway (this is supported by modelling of a debris flow runout through the Cory North Creek watershed); the overall partial risk to the Highway is rated as MODERATE. This is supported by modelling of a debris flow runout through the Cory North Creek watershed.

8.10. Cory South Creek

Cory South Creek is a small tributary drainage within the Cory Main Creek watershed. The watershed is 0.57 km^2 in size, has a Melton ratio of 1.58 and a length of 2.605 km. This steep tributary is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed has steady flow and is in a moderately confined swale on the moderately graded lower slopes (Photo 15). The creek has two small tributaries which join below the recently constructed fireguard on a large alluvial fan above the Highway.

Timber harvesting was completed across the upper watershed starting in 1976 with the majority of the logging completed by 1980. This has left a legacy of old roads and skid trails on the plateau surface which may cause diversion and concentration of flow into watercourses unconditioned to flow. A large debris flow ran out through the southern branch of South Cory Creek between 1976 and 1978 and was likely associated with the extensive logging during these years. The debris flow track is visible about 200 m below a landing with numerous roads leading down to it and the likely cause of the debris flow is water diversion by roads and trails being concentrated into this one watercourse. The track ends on the Cory

South alluvial fan with some more fluid deposits appearing to reach the Highway. After the 2007 Springer Creek Fire burned across the upper watershed many of the roads and trails were deactivated.

The fire is shown to cover a small area of the Cory South watershed, but this is identified as unburned on the BARC map. The calculated EBSI is 0.0 which is considered to be very low; however, the watershed is still recovering from the 2007 Springer Creek Fire, thus the EBSI is adjusted to low; the incremental post wildfire hazard is likely to be only slightly elevated. This watershed correlates to the South South Cory watershed referred to in the 2007 Springer Creek Fire report. The 2007 fire burned 96% of this watershed, 25% at moderate burn severity and 13% at high burn severity, the upper half of the drainage was more burned than the lower half.

A debris slide with minor sedimentation is reported[31] to have occurred on the open slope between Cory South and Cory Middle Creek in May 2008; these creeks correlate to the South South Cory and South Cory Creeks from the 2007 and 2009 Springer Creek Fire reports.

The elements at risk are the Highway and a trailer/residence located high on the north side of the alluvial fan above the Highway (Lot 13, Plan NEP12280 DL6531 Kootenay Land District). The trailer/residence is located on an elevated terrace and is over 30 m distant from the north branch of the creek. The trailer/residence is considered to have a low likelihood of impact from a debris flow or debris flood in the creek. At the Highway, the creek flows through a 500 mm culvert which appears to be correctly sized. The Highway crosses the distal portion of the alluvial fan and is considered to have a low potential for impact.

Cory South Creek has been rated as having a LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to the residence and the Highway; the overall partial risk is rated as VERY LOW.

Photo 15: The south branch of Cory South Creek crossing the fireguard constructed across the upper portion of the alluvial fan (Field Observation Site K53).

[31] D.R.Nicol Geotech Engineering Ltd. 2009. *Springer Creek Fire Number 2007-N50372, 2009 update to Short-term and Long-term Risk Analyses from post-wildfire related natural hazards.* Prepared for the Ministry of Forests and Range, dated May 2009.

8.11. Enterprise Main Creek

Enterprise Creek is a large watershed with numerous steeply sloped tributaries leading down to the mainstem channel (Photo 16). The watershed is 73.00 km^2 in size, has a Melton ratio of 0.24 and a length of 19.500 km. The main watershed is considered to be a flood watershed. Several steep tributary watersheds within the watershed burned, but these are upstream of the Highway crossing. Enterprise Gully is a very steep watershed located immediately upslope of the Highway on the south side of the crossing and is discussed individually below.

The fire burned 21% of the watershed with 8% moderate and 2% high burn severity; the calculated EBSI is 6.0 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

The element at risk is the Highway crossing over Enterprise Creek. The creek passes under the Highway through a very large arch culvert (Photo 17) which was constructed after the 2007 Springer Creek Fire and is believed to be appropriately sized to pass the design flood event which might be generated within the watershed. Enterprise Main Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to the Highway; the overall partial risk to the Highway is rated as VERY LOW.

Photo 16: View looking upstream along Enterprise Creek from the Highway crossing (Field Observation Site K43).

Photo 17: View of the inlet of the large arch culvert on Enterprise Creek at the Highway crossing (Field Observation Site K43).

8.12. Enterprise Gully

Enterprise Gully Creek is a small tributary drainage within the Enterprise Main Creek watershed. The watershed is 0.55 km^2 in size, has a Melton ratio of 1.30 and a length of 1.695 km. This steep tributary is considered to be able to initiate and transport post wildfire debris flows (Photo 18). The creek observed within this watershed had low flow in a steep confined draw leading to a moderately graded alluvial fan immediately above the Highway (Photo 19).

The fire burned 95% of the watershed with 40% moderate and 44% high burn severity; the calculated EBSI is 64.0 which is considered to be high, and the incremental post wildfire hazard will be significantly elevated. The resulting adjusted EBSI, while higher, does not result in the hazard shifting to Very High. The upper two-thirds of the drainage burned at moderate to high burn severity in the 2007 Springer Creek Fire.

The element at risk is the Highway. Debris accumulation behind mature trees on the fan indicates that there has been some sediment movement in the past 20 years which deposited at the apex of the alluvial fan. Above the fringe of mature trees at the base of the slope and on the fan, the slope was burned in the 2007 Springer Creek Fire and is regenerating with a mix of immature coniferous and deciduous trees. The creek channel upslope is 3-4 m wide and deeply incised in a well-confined steep draw; the channel is infilled with large and small woody debris and boulders which are moss-covered. Downslope of the apex across the fan, the channel has a coarse bouldery base which is clear, well-defined, and leads to a 600 mm culvert in a deep ditch under the Highway about 100 m west of the Enterprise Creek crossing.

Enterprise Gully has been rated as having a HIGH incremental post wildfire hazard with a HIGH likelihood of spatial impact to the Highway; the overall partial risk is rated as VERY HIGH.

Photo 18: View south up Enterprise Gully.

Photo 19: View upslope along Enterprise Gully (Field Observation Site K44) on the lower slope above the Highway. The channel has a steep gradient (35-45%), is deeply incised (3-5 m deep) and infilled with large woody debris.

8.13. Fingland Creek

Fingland Creek is a small tributary watershed within the Aylwin Creek watershed. The watershed is 2.12 km^2 in size, has a Melton ratio of 0.81 and a length of 3.490 km. This long narrow drainage has a steeply graded and confined upper watershed and a gently graded lower watershed which crosses the broad bench above RMR. The upper reaches of the creek are considered to be able to initiate and transport post wildfire debris floods or debris flows. Any debris flows or debris floods will runout and deposit on the lower gradient portion of the watershed above RMR. Any floods that initiate within the upper watershed are likely to reach and impact RMR (Photo 20).

Five domestic and irrigation use water licence points of diversion with numerous licenced water users are located on Fingland Creek above RMR (PD27937, PD27938, PD27941, PD27940 and PD74812).

The fire burned 56% of the watershed with 21% moderate and 5% high burn severity; the calculated EBSI is 15.7 which is considered to be low, and the incremental post wildfire hazard is likely to be only slightly elevated.

The elements at risk are a residence at 8473 RMR and RMR. The residence at 8473 RMR is located below RMR on the southwest side of Fingland Creek (Photo 21). As there is potential for increased flows within Fingland Creek, there is a possibility of floodwaters overtopping the low banks of the creek and the creek will likely avulse to the west towards the residence.

Fingland Creek has been rated as having a LOW incremental post wildfire hazard with a MODERATE likelihood of spatial impact on the residence at 8473 RMR; the overall partial risk to the residence at 8473 RMR is rated as LOW.

Fingland Creek passes under RMR through a 1200 mm culvert which has the potential to be blocked by elevated sediment and debris carried by floodwaters in the creek. Fingland Creek has been rated as having a LOW incremental post wildfire hazard with a MODERATE likelihood of spatial impact to RMR; the overall partial risk to RMR is rated as LOW.

Photo 20: View upstream along Fingland Creek. The creek is contained in a deep, low gradient draw as it reaches RMR at Field Observation Site K3.

Photo 21: View downstream along Fingland Creek from the access road to 8473 RMR (Field Observation Site K4). The creek has a low gradient and is contained in a shallow swale. The residence, visible at upper left, is located 50 m from the creek on a flat bench and is potentially vulnerable to flooding or creek avulsion.

8.14. Harte Creek

Harte Creek is a small tributary drainage on the upper slope above the Highway within the Brahms Creek watershed. The watershed is 0.31 km^2 in size, has a Melton ratio of 1.49 and a length of 1.380 km. The steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. A broad gently sloped fluvial fan has formed along the lower slope and there are no debris flow levees or sediment lobes indicative of debris flow activity. The creek observed within this watershed is small and flows through a moderately confined swale on the moderately to gently graded lower slopes (Photo 22).

There are no water licence points of diversion above the Highway on Harte Creek.

The fire burned 91% of the watershed with 18% moderate and no high burn severity; the calculated EBSI is 9.2 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

The element at risk is the Highway which crosses well below the gently sloped fluvial fan and has low potential of impact from any event occurring in the Harte Creek watershed. Harte Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to the Highway; the overall partial risk is rated as VERY LOW.

Photo 22: Harte Creek is a small creek in a shallow swale on the lower slope above the Highway (Field Observation Site K19).

8.15. Hasty Creek

Hasty Creek is a mid-sized watershed on the north end of the fire. The watershed is 8.27 km^2 in size, has a Melton ratio of 0.51 and a length of 5.570 km. The upper watershed is steep, but the majority of the watershed is on a broad mid-slope bench and is considered to be a flood watershed. The creek flows through a large marsh on the gently sloped bench which will reduce flow volume and velocity from the upper watersheds.

Numerous domestic and irrigation use water licence points of diversion are located along the creek below the marsh on Hasty Creek.

The fire burned 1% of the watershed with 0% moderate and 0% high burn severity; the calculated EBSI is 0.0 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

Hasty Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to RMR; the overall partial risk is rated as VERY LOW.

8.16. Hemlock Creek

Hemlock Creek is a small tributary watershed within the Aylwin Creek watershed. The watershed is 0.31 km^2 in size, has a Melton ratio of 1.44 and a length of 1.590 km. The steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed is small and flows through a moderately confined swale on the moderately graded lower slopes. On the 1:20,000 topographic map, the creek is shown as ephemeral on the slope below 1040 m elevation.

The fire burned 47% of the watershed with 2% moderate and 1% high burn severity; the calculated EBSI is 1.9 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

Two domestic and irrigation use water licence points of diversion with numerous licensed water users are located on Hemlock Creek above RMR (PD27930 and PD76732).

The elements at risk are RMR and two residences (8526 and 8530 RMR) along the lower slope above RMR. On the LiDAR imagery, upslope 500 m distance from RMR (around 1025 m elevation), Hemlock Creek flows in a confined draw. As it flows downslope the confinement is lost and the creek flows across a broad gentle open slope with no discernable surface trace. Above the uppermost residence (8530 RMR), the creek was observed to be a 1 m wide creek flowing in a wide swale and the residence is considered to have a low potential for impact from any event in Hemlock Creek. The lower residence (8526 RMR) is on the north side and 75 m distant from the creek; this residence has a very low potential for impact from an event in Hemlock Creek.

Hemlock Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to residences and RMR; the overall partial risk is rated as VERY LOW.

8.17. Highland View Creek

Highland View Creek is a small tributary drainage on the upper slope above the Highway within the Brahms Creek watershed. The watershed is 0.62 km^2 in size, has a Melton ratio of 1.19 and a length of 1.550 km. The steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed is small and flows through a well confined draw on the moderately graded lower slopes (Photo 23).

The fire burned 92% of the watershed with 37% moderate and no high burn severity; the calculated EBSI is 18.5 which is considered to be low. Due to almost the entire watershed being burned to some degree, the EBSI is adjusted to moderate, and the incremental post wildfire hazard is likely to be moderately elevated.

Two domestic use water licence points of diversion with two licenced water users are located above the Highway on Highland View Creek (PD80675 and PD67179).

The elements at risk are the Highway and a residence and outbuildings (8942 Highway 6) above the Highway. The Highland View Creek alluvial fan is over 200 m long and has been extensively modified by timber harvesting, road construction and buildings. Review of the alluvial fan indicated that there were no debris flow levees, sediment lobes or other signs of previous debris flows. The creek follows a shallow channel across the alluvial fan and there is potential for channel avulsion. The residence is located on the lower fan surface about 40 m north of the creek channel and is considered to have a moderate likelihood of impact by an event occurring in Highland View Creek.

Highland View Creek has been rated as having a MODERATE incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the residence and Highway; the overall partial risk to the residence and the Highway is rated as MODERATE.

Photo 23: View upslope along Highland View Creek at Field Observation Site K17. A small water intake is located in the base of the draw. The upslope channel is small and contained within a well defined draw. Downslope the creek crosses across a broad mid-slope alluvial fan above the Highway.

8.18. Kegel Brook

Kegel Brook is a small tributary watershed on the upper slope above the Highway within the Brahms Creek watershed (Photo 24). The watershed is 0.28 km^2 in size, has a Melton ratio of 1.63 and a length of 1.345 km. This steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. The creek observed within this watershed is small and flows through a moderately confined draw on the moderately steep lower slopes (Photo 25). At the base of the slope the creek crosses an alluvial fan located immediately above the Highway.

The fire burned across most of this watershed with a large high burn severity patch which spans the creek channel in the upper reaches of the watershed. The fire burned 96% of the watershed with 25% moderate and 35% high burn severity; the calculated EBSI is 47.2 which is considered to be moderate and the incremental post wildfire hazard will be significantly elevated. Due to almost the entire watershed being burned to some degree, the EBSI is adjusted to high.

Two domestic use water licence points of diversion with numerous licenced water users are located on Kegel Brook (PD27920 and PD72785).

The elements at risk are the Highway and a residence (8878 Highway 6) above the Highway. Review of the alluvial fan indicated that there were no debris flow levees, sediment lobes or other signs of previous debris flows. The creek followed a shallow channel which curved slightly southwards as it approached the Highway and there is potential for channel avulsion. The residence is located approximately 35 m north of the creek as it flows across the alluvial fan and is considered to have a moderate potential for impact. The Highway runs across the base of the alluvial fan and more fluid events occurring within the creek are expected to reach and impact the Highway.

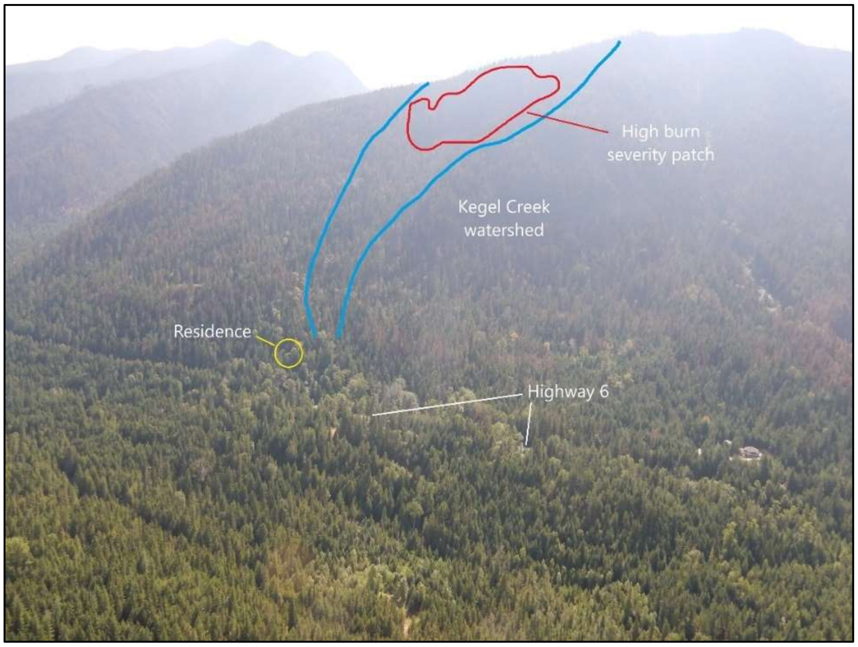

Photo 24: View of Kegel Brook watershed above the Highway corridor with the high burn severity patch across the upper watershed including the riparian zone. (Photo courtesy of Sarah Crookshanks, MOF).

Photo 25: View upslope along Kegel Brook at Field Observation Site K24. This creek is small and flows within a well defined draw which leads on to a short steep alluvial fan above the Highway.

Modelling of the flows on the Kegel Brook watershed shows the channel is confined on the steep upper slopes. Above the fan apex, at around 1000 m elevation, the channel appears to cross a moderately sloped bench and might develop a small mid-slope fan. Downslope from this the channel appears to be confined again until it reaches the apex of the alluvial fan (around 850 m elevation) where water and debris spread out across the fan following topographic lows. The model indicates that water and debris are likely to reach and impact the Highway.

Kegel Brook has been rated as having a HIGH incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the residence; the overall partial risk to the residence is rated as HIGH.

Kegel Brook has been rated as having a HIGH incremental post wildfire hazard with a MODERATE likelihood of spatial impact to the Highway; the overall partial risk to the Highway is rated as HIGH.

8.19. Maurier Creek

Maurier Creek is a large watershed on the northeast edge of the fire. The watershed is 24.53 km^2 in size, has a Melton ratio of 0.33 and a length of 8.925 km. The headwaters of the watershed are steep, but most of the watershed is moderately graded and is considered to be a flood or debris flood watershed.

The fire burned the upper west ridgeline of the watershed; the majority of this large watershed is unburned. The fire burned 1% of the watershed with 0% moderate and 0% high burn severity; the calculated EBSI is 0.0 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

There are no elements at risk. Maurier Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact; the overall partial risk is rated as VERY LOW.

8.20. Twigg Creek

Twigg Creek is a small watershed on the north end of the fire. The watershed is 1.94 km^2 in size, has a Melton ratio of 0.81 and a length of 3.010 km. The headwaters of the watershed are steep, but most of the watershed is moderately graded and is considered to be a debris flood watershed.

The fire burned in the upper headwaters of the watershed and the majority of the watershed is unburned. The fire burned 5% of the watershed with 2% moderate and 0% high burn severity; the calculated EBSI is 1.4 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

There are no elements at risk. Twigg Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact; the overall partial risk is rated as VERY LOW.

8.21. Vevey Creek

Vevey Creek is a tributary watershed to Aylwin Creek watershed; the watershed is 7.47 km^2 in size, has a Melton ratio of 0.45 and a length of 4.410 km. This drainage has steep headwaters leading down to a gently graded lower watershed which crosses the broad bench above RMR. The upper reaches of the creek are considered to be able to initiate and transport post wildfire debris floods or debris flows. Any debris flows or debris floods will runout and deposit on the lower gradient portion of the watershed above RMR. Any floods that initiate within the upper watershed may reach and impact RMR.

The fire burned in the headwaters of Vevey Creek and was quite patchy with some small areas of moderate and high burn severity. The lower half of the watershed was unburned. The fire burned 35% of the watershed with 12% moderate and 3% high burn severity; the calculated EBSI is 8.6 which is considered to be very low, and the incremental post wildfire hazard is unlikely to be elevated.

Three domestic use water licence points of diversion with numerous licenced water users are located on Vevey Creek above RMR (PD70732, PD79404, and PD183398).

The element at risk is RMR. Vevey Creek has been rated as having a VERY LOW incremental post wildfire hazard with a LOW likelihood of spatial impact to RMR; the overall partial risk is rated as VERY LOW.

9. Summary of Watershed Partial Risk

Based on burn severity observed in each watershed which incrementally increases the likelihood of landslides and flooding hazards, in addition to the watershed characteristics and conditions, the likelihood of a hazardous event occurring has been assigned to all of the watersheds. In Table 10, the Melton Ratio, Base EBSI Value and Expected Hazard is provided, as is the Adjusted EBSI Rating (from Table 9; shown as Hazard Likelihood) and Spatial Likelihood. The Hazard Likelihood and Spatial Likelihood are combined to provide a Partial Risk Rating; the partial risk is determined prior to any mitigation works. The Element at Risk is also identified.

Table 10: Compilation of watershed characteristics and hazards to estimate the likelihood of a hazardous event occurring, the spatial likelihood that the hazardous event will reach the element at risk and the partial risk.

Watershed	Melton Ratio	Base EBSI Value	Expected Hazard	Hazard Likelihood	Spatial Likelihood	Partial Risk	Element at Risk[32]
Allen	0.67	16.6	Open Slope Landslide	Moderate	Low	Low	Residences, Highway 6
Allen	0.67	16.6	Debris Flow or Debris Flood	Moderate	Low	Low	Residences, Highway 6
Aylwin Main	0.40	16.6	Flood or Debris Flood	Low	Low	Very Low	Residence, Highway 6
Aylwin Upper	0.62	37.9	Debris Flood or Debris Flow	High	High	Very High	Highway 6, RMR
Brahms	0.52	10.7	Flood or Debris Flood	Very Low	Low	Very Low	Highway 6
Cabin	1.39	19.8	Debris Flow	Low	Low	Very Low	Residences, Highway 6
Congo	1.02	39.4	Debris Flow or Debris Flood	Moderate	Low	Low	Residence, RMR
Cory Main	0.80	7.4	Debris Flood	Low	Low	Very Low	Highway 6
Cory Middle	1.73	11.9	Debris Flow	Low	High	Moderate	Northern Residence
Cory Middle	1.73	11.9	Debris Flow	Low	Moderate	Low	Southern Residence
Cory Middle	1.73	11.9	Debris Flow	Low	Moderate	Low	Highway 6

[32] Many of these drainages also have domestic and irrigation water licenses. Individual water license infrastructure was not reviewed.

Watershed	Melton Ratio	Base EBSI Value	Expected Hazard	Hazard Likelihood	Spatial Likelihood	Partial Risk	Element at Risk[32]
Cory North	1.13	15.5	Debris Flow	Moderate	Low	Low	Northern structure
Cory North	1.13	15.5	Debris Flow	Moderate	Moderate	Moderate	Southern structure
Cory North	1.13	15.5	Debris Flow	Moderate	Moderate	Moderate	Highway 6
Cory South	1.58	0.0	Debris Flow	Low	Low	Very Low	Residence, Highway 6
Enterprise Gully	1.30	64.0	Debris Flow	High	High	Very High	Highway 6
Enterprise Main	0.24	6.0	Flood	Very Low	Low	Very Low	Highway 6
Fingland	0.97	15.7	Flood	Low	Moderate	Low	Residence
Fingland	0.97	15.7	Debris Flood or Flood	Low	Moderate	Low	RMR
Harte	1.49	9.2	Debris Flow	Very Low	Low	Very Low	Highway 6
Hasty	0.51	0.0	Debris Flood or Flood	Very Low	Low	Very Low	RMR
Hemlock	1.44	1.9	Debris Flow	Very Low	Low	Very Low	Residences, RMR
Highland View	1.19	18.5	Debris Flow	Moderate	Moderate	Moderate	Residence, Highway 6
Kegel	1.63	47.2	Debris Flow	High	Moderate	High	Residence, Highway 6
Maurier	0.33	0.1	Flood or Debris Flood	Very Low	Low	Very Low	
Twigg	0.83	1.4	Debris Flow or Debris Flood	Very Low	Low	Very Low	
Vevey	0.52	8.6	Debris Flood or Flood	Very Low	Low	Very Low	RMR

10. Watershed Management Considerations

Salvage harvesting of burned areas has the potential to increase the associated hazards and risks associated with flooding and landslides. It is recommended that if salvage harvesting is proposed within watersheds with a likelihood of post wildfire landslide or flooding hazards exceeding low that site specific Terrain Stability Assessments (TSAs) be completed. It is the responsibility of the proponents of such development to review the risk assessments contained in the TSA and to determine whether the risk is tolerable or not, and whether to proceed with the development on this basis.

11. Summary of Recommendations

The recommendations are not intended as an evaluation of the acceptability of either the present risk or residual risk given the implementation of a risk reduction strategy. In addition, some risk reduction strategies may result in increased risks for other downslope values so any measures implemented must consider the potential for both positive and negative consequences.

All watersheds with a moderate (or higher) rating for Hazard Likelihood or Spatial Likelihood are further evaluated below.

11.1. General Recommendations for Residents: all affected drainages

Residents located adjacent to the creeks and watersheds discussed should be provided an electronic copy of this report. During periods of elevated risk:

- high flows during spring runoff (precipitation or snowmelt driven),
- summer rainstorm events (thunderstorms or convective cells), and
- fall storms with significant precipitation (generally with rain on snow events),

residents should be diligent with regards to work/travel adjacent to the local creeks and be aware of any sudden changes to creek flows (rapid increase or decrease in flows, or flow pulses), colour, or debris (logs, boulders, sediment) transport.

Residents should familiarize themselves with the creeks, their location relative to the creeks, and where damages would be sustained if flooding/debris flows were to occur. If changes are observed, they should be reported promptly to the Ministry of Emergency Management and Climate Readiness (EMCR) at 1 (800) 663-3456.

Residents should be vigilant by monitoring the creeks for turbidity and monitoring weather forecasts and local weather conditions; spatial variability of precipitation rates can be significant in mountainous terrain and should be prepared to evacuate on short notice during times of elevated risk.

Residents should familiarize themselves with the *Landslide and Flooding Risks due to Wildfires* and the *Debris Flow Hazard Awareness in the Kootenay Region* brochures published by the MOF, both of which are attached in Appendix C.

11.2. Water Points of Diversion

There are numerous points of diversion for licensed water use for domestic, irrigation or power usage throughout the Fire; these are shown on Maps 1 and 2 in Appendix A. Consideration should be given to either building protective structures around the licensed water intakes or developing contingency plans to provide an alternate source of water in case of damage to the intake or elevated levels of turbidity which render the water undrinkable.

If flow to residences is cut off for any reason, care should be exercised in resolving the issue. Loss of flow in a creek could be an indication that water is being ponded upslope; when this is released, the resulting flood could be highly charged with sediment and woody debris which might be very destructive. Review of the water intake is recommended to occur initially from a distance outside of the creek channel and after a suitable period of time to avoid being caught in floodwaters or by a debris flow.

Note that research has shown that heavy metal concentrations and biological contamination may increase in streams effected by wildfire. As such, residents obtaining water from wildfire effected creeks should consider testing their drinking water for heavy metal contamination and biological contamination.

11.3. Allen Creek

Allen Creek has an upper watershed (above the Highway) that lacks creeks despite having well defined steep draws. The upper regions of the watershed were moderately burned with occasional small patches of high burn severity (EBSI = 16.6; low adjusted to moderate incremental post wildfire hazard). This watershed is considered to most likely produce open slope landslides, but could also generate a debris flow or debris flood on the steep upper slopes.

Any open slope landslides are expected to come to rest at the base of the steep slopes and are unlikely to runout onto the moderate and low gradient lower slopes where residences at 9460, 9470, 9480 Highway 6 and private land (DL 1023 Lots 1 and 2) are located above the Highway. If a channelized debris flow or debris flood is generated on the upper slopes they will follow the existing topography downslope onto moderately graded slopes where they will become unconfined due to the lack of distinct channels. They are expected to disperse and come to rest on the upper mid-slope above residences, private land and the Highway. There is a low partial risk to the residences, private land and the Highway from open slope landslides. There is a low partial risk to the residences, private land and the Highway from debris flows or debris floods. Given the low partial risk, **no specific recommendations are provided**.

11.4. Aylwin Upper Creek

Aylwin Upper Creek has a broad alluvial fan at the outlet of a steep watershed which was extensively burned (EBSI = 37.9; moderate adjusted to high incremental post-wildfire hazard). This creek is assessed as being debris flow prone, capable of producing and transporting debris flows to the apex of the alluvial fan which is about 500 m upslope of the Highway. Once onto the fan, the channel becomes less confined and the gradient of the creek decreases; debris flows will lose momentum and start to slow and deposit debris across the upper fan and likely transition into a debris flood or a flood with a high sediment load. As the creek approaches the Highway, there is a broad alluvial fan surface with several relict and seasonally active channels into which high flows can readily migrate. Flow dispersion across this lower fan surface could divert the flow onto RMR or the Highway to the west of the present culvert crossing. **There is a very high partial risk to RMR and the Highway**.

It is recommended that the MoTT review the lower alluvial fan and determine where there is potential for channel avulsion. Construction of a berm on the east side of RMR and the Highway to control the flow and incorporated sediment and woody debris might be required to maintain the direction of flow into the existing culvert and prevent channel migration onto RMR or the Highway.

The culvert carrying Aylwin Creek under the Highway appears to be well sized for elevated clearwater flows, but the potential for increased sedimentary and woody debris movement could reduce the capacity of the culvert by plugging the culvert inlet. Development of a wide channel through a broad armoured catch basin with a trash rack (example shown in Photo 26) above the Highway may be a suitable solution to reduce the channel gradient at the culvert inlet and provide space for debris aggradation.

Photo 26: Construction of a wide channel through an armoured catch basin with a trash rack at the culvert inlet, such as shown in this image, may be a suitable solution at the highway crossing of Aylwin Creek.

Note that the above recommendations are conceptual in nature and implementation of a berm structure, culvert catch basin, and trash rack will require detailed study and design by an appropriately qualified registered professional (QRP) and may require authorization under the Water Sustainability Act.

11.5. Congo Creek

Congo Creek has an elongate alluvial fan at the outlet of a small steep watershed which was extensively burned (EBSI = 39.4; moderate incremental post-wildfire hazard). This creek is assessed to be a debris flow prone creek, capable of producing and transporting debris flows to the apex of the alluvial fan which is about 700 m upslope of RMR. Once onto the fan, the channel becomes less confined and the gradient of the creek decreases; debris flows will lose momentum and start to slow and deposit debris across the upper fan and likely transition into a flood with a high sediment load. There is a low partial risk to the residence at 8596 RMR and RMR.

As the creek approaches RMR, there is a broad alluvial fan surface with several small, shallow relict or seasonally active channels. Elevated clearwater flows are expected to reach and impact RMR; these flows might include a gravelly bedload, but are not expected to cause significant damage to the RMR. No culvert is present on RMR downstream of the clearest identified channel indicating that freshet flows or summer rainstorm flows have not previously been an issue at the RMR crossing. The residence is not considered to be in a location which is likely to be impacted by creek flow.

It is recommended that the MoTT determine the most likely creek channel location and install an adequately sized culvert on RMR.

11.6. Cory Middle Creek

Cory Middle Creek has a short steep watershed which was slightly burned by the Fire (EBSI = 11.9; very low adjusted to low incremental post wildfire hazard) but was still recovering from the 2007 Springer Creek Fire (Photo 6). The watershed was largely unburned during the Fire, and the burning that did occur is located on moderately graded slopes in the mid watershed. **There is a moderate partial risk to the northern residence at 9530 Highway 6.** There is a low partial risk to the southern residence at 9530 Highway 6. There is a low partial risk to the Highway.

The channel on the upper fan shows signs of a recent debris flow, believed to have occurred soon after the 2007 Springer Creek Fire. This creek is assessed to be a debris flow prone creek, capable of producing and transporting debris flows to the apex of the alluvial fan which is about 200 m upslope of the northern residence and 300 m above the Highway.

The northern residence is located 25 m distance from the mid-slope channel which flows in a small, moderately confined channel; the southern residence is over 75 m distant from the creek. **It is recommended that the property owner reviews the upper fan and consider construction of a berm on the south side of the creek to control potential debris and flow avulsion towards the northern residence.**

At the Highway, the creek flows in a shallow low-gradient swale into a 500mm diameter culvert; **it is recommended that the MoTT upgrade the culvert to convey the expected elevated streamflow and associated sediment load.**

Note that the above recommendations are conceptual in nature and implementation of a berm structure and upgraded culvert will require detailed study and design by an appropriate QRP and may require authorization under the Water Sustainability Act.

11.7. Cory North Creek

Cory North Creek has a short steep watershed which was moderately burned by the Fire (EBSI = 15.5; low adjusted to moderate incremental post wildfire hazard) but was still recovering from the 2007 Springer Creek Fire (Photo 6). The upper and lower watershed were largely unburned during the Fire, but the burning that did occur is located on moderate to steeply graded slopes in the mid watershed. There is a low partial risk to the northern outbuilding at 9510 Highway 6. **There is a moderate partial risk to the southern outbuilding at 9510 Highway 6. There is a moderate partial risk to the Highway.**

This creek is assessed to be a debris flow prone creek, capable of producing and transporting debris flows to the apex of the alluvial fan which is about 150 m upslope of two outbuildings and 200 m above the Highway.

The northern outbuilding on the lower fan is considered to be a sufficient distance from the creek to not require protection. The southern outbuilding is located close to the creek and appears to be a moveable structure; **it is recommended that the property owner consider moving the structure away from the creek channel to a safer location.** Further study is required to determine a safe location for where to move the structure.

At the Highway, the creek flows in a shallow low-gradient swale into a 900 mm culvert which is sufficiently sized to handle the expected increase in flow and sediment load from a flood, but a debris flow is expected to inundate and plug the culvert. Downslope of the Highway, debris flows are expected to settle and disperse sediment on the gentler forested slopes, but associated stream flow is expected to continue downslope along creek channels and roads.

11.8. Enterprise Gully

Enterprise Gully was extensively burned in the Fire (EBSI = 64.0; high incremental post wildfire hazard) and was still recovering from extensive burning in the 2007 Spencer Fire. This short, steep drainage is considered to be able to initiate and transport post wildfire debris flows directly to the Highway as the road is approximately 35 m below the apex of the steep alluvial fan. **There is a very high partial risk to the Highway.**

There does not appear to be sufficient space upslope of the Highway to construct a catch basin but there may be potential for development of a bermed diversion channel which directs flow to the east. Such a channel would likely have limited flow capacity and debris storage capability and be unlikely to control or contain a debris flow, but may alleviate the potential for floods and watery slurries to impact the Highway. **It is recommended that the MoTT investigate the potential to construct a diversion ditch.**

Note that the above recommendation is conceptual in nature and implementation of a berm structure will require detailed study and design by an appropriate QRP.

In addition, it is recommended that the MoTT should implement no stopping signage where the Enterprise Gully meets the Highway and monitor the gully for debris movement during, and immediately following significant precipitation events.

11.9. Fingland Creek

Fingland Creek crosses a broad bench above RMR and only flooding is expected to reach and impact the RMR. Downstream from the RMR, the residence at 8473 RMR is exposed to flooding due a combination of a shallow creek channel and the proximity of the residence to the creek. As there is potential for increased flows within Fingland Creek, there is a possibility of floodwaters overtopping the low banks of the creek and the creek will likely avulse to the west towards the residence. There is a low partial risk to the residence and RMR. **It is recommended that the property owner consider a further, more detailed review of the property to determine if mitigation works are required.**

11.10. Highland View Creek

Highland View Creek has moderately steep alluvial fan at the outlet of a small steep watershed which was moderately burned (EBSI = 18.5; low adjusted to moderate incremental post-wildfire hazard). This creek is assessed to be a debris flow prone creek, capable of producing and transporting debris flows to the apex of the alluvial fan which is about 200 m upslope of the Highway. **There is a moderate partial risk to the residence at 8942 Highway 6 and a moderate partial risk to the Highway.**

A residence is located 40 m north of the creek channel on the moderately steep alluvial fan. There is potential for avulsion of the fan channel to the north as the creek becomes less confined on the alluvial fan. **It is recommended that the property owner consider enlargement and armouring of the creek channel and construction of a berm along the north side of the channel to prevent debris and flow avulsion towards the residence.**

Note that the above recommendations are conceptual in nature and implementation of a berm structure and enlarged and armoured channel will require detailed study and design by an appropriate QRP and may require authorization under the Water Sustainability Act.

11.11. Kegel Brook

Kegel Brook has a short steep watershed which was heavily burned by the Fire (EBSI = 47.2; moderate adjusted to high incremental post wildfire hazard). This creek is assessed to be a debris flow prone creek, capable of producing and transporting debris flows to the apex of the alluvial fan which is about 70 m distance above the Highway. This steep tributary watershed is considered to be able to initiate and transport post wildfire debris flows. **There is a high partial risk to the residence at 8788 Highway 6 and the Highway.**

The residence is located 35 m north of the creek channel on the steep alluvial fan. There is potential for avulsion of the fan channel to the north as the creek becomes less confined on the alluvial fan. **It is recommended that the property owner consider enlargement and armouring of the creek channel and construction of a berm along the north side of the channel to prevent debris and flow avulsion towards the residence.**

A marshy area exists to the south of the fan above the Highway and this may serve as a small catch basin for streamflow and debris. A culvert under the Highway is located below the marshy area. **It is recommended that the MoTT review the lower fan and marsh to determine whether a catch basin and trash rack might be a possible solution to control potential elevated streamflow and debris.**

Note that the above recommendations are conceptual in nature and implementation of a berm structure, enlarged and armoured channel, catch basin, and trash rack will require detailed study and design by an appropriate QRP and may require authorization under the Water Sustainability Act.

11.12. Rockfall on Highway 6 near the Slocan Lake View Point

Rockfall was noted to have occurred during firefighting on a 1 km section of the Highway near the Slocan Lake View Point. On the east side of the Highway, there is a combination of a steep rock face (Photo 27) with steep colluvial talus cones (Photo 28). The vegetation burn severity is mapped as a mix of low, moderate and unburned. Field reviews indicated that the soil burn severity was similarly mixed with no high burn severity noted.

Where bedrock exposures are impacted by a wildfire, the potential for rockfall can be increased, due to:

- The loss of stabilizing vegetation, i.e., tree roots, shrub roots or soil and organic cover.
- Thermal expansion of fractured rock on the exposure.
- Freeze/thaw processes when moisture is entrained within a fractured rock.

The first two conditions can be present immediately after a wildfire, while freeze-thaw cycles require sub-zero temperatures and, as such, are generally only present in the late fall, winter and spring months.

On the talus cones, intense or long duration rainfall may dislodge additional rock fragments or perhaps initiate small debris avalanches or sediment-laden flows. These effects are expected to last through the first year and the **MoTT should be aware of this hazard and should inspect the slopes regularly and maintain as required.**

Photo 27: View of exposed rock above the Highway near the Slocan Lake View Point (Field Observation Site K28). The upper slope has a few burned patches from which vegetation cover has been removed and is the likely source of the rock that fell during the summer.

Photo 28: View of a moderately steep rubbly talus cone exposed above the Highway near the Slocan Lake View Point (Field Observation Site K29). Removal of the surface vegetation has decreased the stability of the slope and rock fragments are moving downslope into the ditch.

11.13. Culverts and Drainage Infrastructure

Culverts and drainage infrastructure on all roads within and below the Fire should be inspected and maintained regularly by the appropriate permit holder or owner. Increased flows are expected in many of the creeks, especially those that were burned more severely (i.e., have a higher EBSI). In addition to increases in water, sediment load and calibre of sediment may increase and should be accounted for when reviewing the efficacy of ditches and culverts to convey the post wildfire flows.

12. Closure – Report Use and Limitations

This report was prepared for the exclusive use of MOF, EMCR, MoTT and RDCK. Copies can be distributed to other stakeholders and local residents. The material in it reflects SNT Geotechnical Ltd.'s best judgment and professional opinion in light of the information available to it at the time of preparation. Any use which a third party makes of this report or any reliance on or decision to be made based on it are the responsibility of such third parties. SNT Geotechnical Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or action based, or lack thereof, on this report. No other warranty is made, either expressed or implied.

The report and assessment have been carried out in accordance with generally accepted professional practices in B.C. The discussion and recommendations presented are based on available information and limited field investigation and inferences from surficial features. No subsurface investigation was carried out as part of this assessment or development of conclusions or recommendations. Inherent variability in local precipitation, run-off conditions, soil and vegetation burn severity, surface and subsurface conditions may create unforeseen situations. Property boundaries (private, municipal, reserve, crown) referred to on maps and in the text were obtained via publicly available cadastral layers overlain onto orthoimagery and are approximate and may not be accurate for the purposes of locating risk mitigation strategies. Boundaries should be confirmed prior to design and implementation of risk mitigation strategies.

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SNTG Permit Number 1001083

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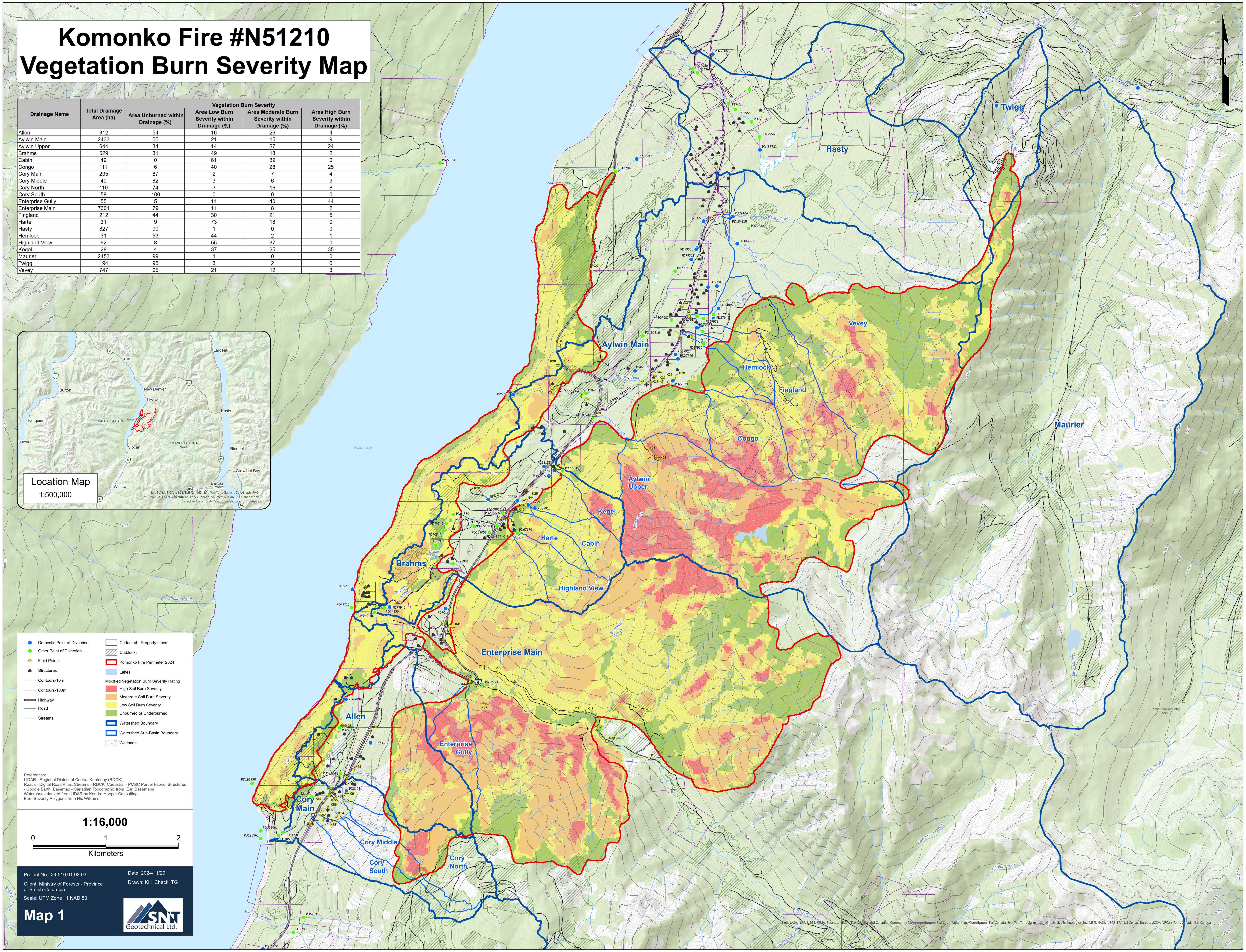
APPENDIX A
Maps

A1

Komonko Fire #N51210
Vegetation Burn Severity Map

Drainage Name	Total Drainage Area (ha)	Vegetation Burn Severity: Area Unburned within Drainage (%)	Vegetation Burn Severity: Area Low Burn Severity within Drainage (%)	Vegetation Burn Severity: Area Moderate Burn Severity within Drainage (%)	Vegetation Burn Severity: Area High Burn Severity within Drainage (%)
Allen	312	54	16	26	4
Aylwin Main	2433	55	21	15	9
Aylwin Upper	644	34	14	27	24
Brahms	529	31	49	18	2
Cabin	49	0	61	39	0
Congo	111	6	40	28	25
Cory Main	295	87	2	7	4
Cory Middle	40	82	3	6	9
Cory North	110	74	3	16	8
Cory South	58	100	0	0	0
Enterprise Gully	55	5	11	40	44
Enterprise Main	7301	79	11	8	2
Fingland	212	44	30	21	5
Harte	31	9	73	18	0
Hasty	827	99	1	0	0
Hemlock	31	53	44	2	1
Highland View	62	8	55	37	0
Kegel	28	4	37	25	35
Maurier	2453	99	1	0	0
Twigg	194	95	3	2	0
Vevey	747	65	21	12	3



Domestic Point of Diversion
Other Point of Diversion
Field Points
Structures
Contours-10m
Contours-100m
Highway
Road
Streams
Cadastral - Property Lines
Cutblocks
Komonko Fire Perimeter 2024
Lakes

Modified Vegetation Burn Severity Rating
High Soil Burn Severity
Moderate Soil Burn Severity
Low Soil Burn Severity
Unburned or Underburned
Watershed Boundary
Watershed Sub-Basin Boundary
Wetlands

References:
LIDAR - Regional District of Central Kootenay (RDCK)
Roads - Digital Road Atlas, Streams - RDCK, Cadastral - PMBC Parcel Fabric, Structures - Google Earth. Basemap - Canadian Topographic from Esri Basemaps
Watersheds derived from LiDAR by Kendra Hopper Consulting.
Burn Severity Polygons from Nic Williams.

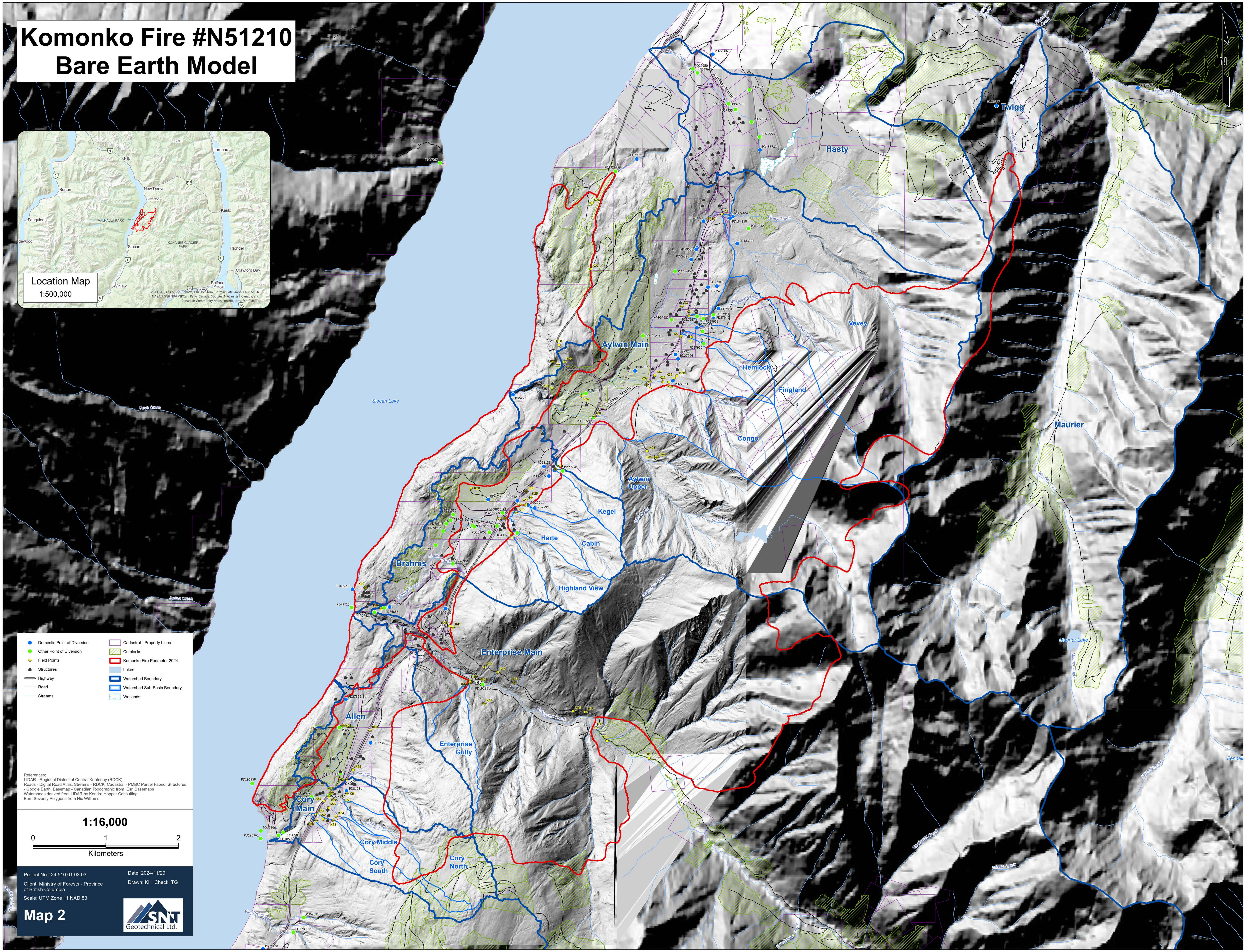
1:16,000

0 1 2
Kilometers

Project No.: 24.510.01.03.03
Client: Ministry of Forests - Province of British Columbia
Scale: UTM Zone 11 NAD 83
Date: 2024/11/29
Drawn: KH Check: TG

Map 1

SNT Geotechnical Ltd.



Komonko Fire #N51210
Bare Earth Model
Location Map
1:500,000
Hills
Lardeau
Burton
New Denver
Silverton
Kaslo
Fauquier
VALHALLA PARK
Slocan
KOKANEE GLACIER PARK
Riondel
Crawford Bay
Winlaw
Balfour
Procter
Siocan Lake
Cove Creek
Indian Creek
Hasty
Twigg
Vevey
Hemlock
Fingland
Congo
Maurier
Maurier Lake
Aylwin Main
Aylwin Upper
Kegel
Harte
Cabin
Brahms
Highland View
Enterprise Main
Allen
Enterprise Gully
Cory Main
Cory Middle
Cory South
Cory North
Beatrice Creek
Domestic Point of Diversion
Other Point of Diversion
Field Points
Structures
Highway
Road
Streams
Cadastral - Property Lines
Cutblocks
Komonko Fire Perimeter 2024
Lakes
Watershed Boundary
Watershed Sub-Basin Boundary
Wetlands
References:
LIDAR - Regional District of Central Kootenay (RDCK)
Roads - Digital Road Atlas, Streams - RDCK, Cadastral - PMBC Parcel Fabric, Structures - Google Earth. Basemap - Canadian Topographic from Esri Basemaps
Watersheds derived from LiDAR by Kendra Hopper Consulting.
Burn Severity Polygons from Nic Williams.
1:16,000
0
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2
Kilometers
Project No.: 24.510.01.03.03
Date: 2024/11/29
Client: Ministry of Forests - Province of British Columbia
Drawn: KH Check: TG
Scale: UTM Zone 11 NAD 83
Map 2
SNT Geotechnical Ltd.

APPENDIX B
Komonko Creek – Post-Wildfire Level 2 Reconnaissance Report

B1

MINISTRY OF FORESTS: POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS

KOMONKO CREEK - LEVEL 2 RECONNAISSANCE REPORT

NOTE: The results given on this form are reconnaissance in nature and are intended to be a warning of potential hazards and risks. ***A more detailed report will follow*** *and may alter the conclusions. Please read the appendix of this report for important limitations. Contact the author for more information.*

FIRE NUMBER: N51210 Komonko Creek	**FIRE YEAR: 2024**	**DATE OF REPORT:** September 11, 2024

AUTHOR: *Sarah Crookshanks, P.Geo., Ministry of Forests*

REPORT PREPARED FOR: Southeast Fire Centre, District Manager

FIRE SIZE, LOCATION, AND LAND OWNERSHIP: 4080 ha of provincially managed public land and private land south of Silverton

VALUES AT RISK:

1. Private residences and/or potentially occupied buildings along Highway 6 and Red Mountain Road
2. Domestic surface water quality on creeks originating from within the fire
3. Highway 6 and Red Mountain Road

WATERSHEDS AFFECTED	TOTAL AREA	AREA BURNED	BURN SEVERITY (% of watershed area)
Enterprise Creek	10541 ha	1169 ha (11%)	1% H, 5% M
Aylwin Creek	652 ha	431 ha (66%)	24% H, 27% M
Congo Creek	111 ha	104 ha (93%)	25% H, 29% M
Fingland Creek	237 ha	131 ha (55%)	5% H, 20% M
Baby Ruth Creek	221 ha	90 ha (41%)	5% H, 10% M
Vevey Creek	532 ha	175 ha (33%)	2% H, 12% M

SUMMARY OF POST-FIRE HAZARD AND RISK

1. Hazard = P(H), the probability of occurrence of a hazardous event
2. Probability of spatial impact, P(S:H), the probability of a hazard reaching or affecting an element at risk
3. Partial Risk, the probability of a hazard occurring and affecting an element at risk = P(H) x P(S:H)
4: Location with the highest risk rating given; at other locations the risk may be lower

Debris flow or flood on Allen/Cory Creek face impacting private residences or highway

Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = moderate Partial Risk[3,4] = high

The face unit south of Enterprise Creek burned extensively in the 2007 Springer Creek fire. In the Allen and Cory Creek drainages, the 2007 fire resulted in mostly low burn severity, with some patches of moderate burn severity. No debris flows occurred in these two creeks after the 2007 fire, but several post-wildfire events occurred on similar drainages with higher watershed burn severities to the south.

The 2024 Komonko Creek fire also burned the upper reaches of Allen and Cory Creeks at moderate to high severity. The rest of the face to the north of Allen Creek also burned at moderate to high severity, though this area had previously burned at high severity in 2007. No field verification of soil burn severity was undertaken in this area, and the reburn of the area complicates the assessment of hydrological impacts. This face is steep, and all drainages appear to be susceptible to debris flows.

There are six Regional District of Central Kootenay (RDCK) address points east of the highway potentially at risk. The spatial likelihood of a debris flow impacting any of these residences is estimated to be moderate but requires additional fieldwork to confirm their specific locations relative to the channels of Allen and

Cory Creeks. The closer a residence is to a channel, the higher the spatial likelihood of impact. The highway is also potentially at risk. The address points to the west of the highway are less likely to be at risk, as the slope flattens considerably here.

Debris flow or flood on south tributary to Enterprise Creek impacting Highway 6
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = high Partial Risk[3,4] = very high

At the Enterprise Creek hairpin on Highway 6, a small tributary to Enterprise Creek enters from the south. A debris flow in this channel is anticipated to impact the highway, though further field work is needed to confirm the probability of spatial impact. This drainage burned in the 2007 Springer Creek fire at high severity in the headwaters area. No debris flows are known to have occurred in this drainage after this fire. The burn severity mapping from the 2024 fire also shows high burn severity in this watershed. Given that the 2007 fire burned at high severity, there was likely limited fuel available to burn in 2024, though the cumulative impact of two fires on the soils is not well understood at this time. Additional work should be undertaken to confirm the crossing infrastructure. Regular inspection and maintenance at this site are recommended.

Rockfall impacting Highway 6 north of Slocan Lake View Point
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = high Partial Risk[3,4] = very high

Rockfall onto the highway occurred at this location during the fire. The rocks were mostly small, and likely came from surficial rocks being dislodged as the organic matter burned. It is likely that some additional rocks may be dislodged, particularly during periods of intense rainfall. MOTI is aware of this hazard and will be regularly inspecting and maintaining this section of road in the coming months.

Debris flow or flood on Johnson Creek, Highland View Creek, or Harte Creek impacting private residences or highway
Hazard P(H)[1] = low Probability of spatial impact P(S:H)[2] = moderate Partial Risk[3,4] = low

Debris flow or flood on Kegel Brook impacting private residences or highway
Hazard P(H)[1] = moderate Probability of spatial impact P(S:H)[2] = moderate Partial Risk[3,4] = moderate

The face between Enterprise and Aylwin Creeks was burned mostly at low severity, with a few small patches of moderate severity and high burn severity. Lidar hillshade imagery shows indistinct, parallel draws draining this face (from south to north: Johnson Creek, Highland View Creek, Harte Creek and Kegel Brook). Due to the low burn severity, the drainages to the south are rated as low hazard, whereas Kegel Brook at the north end has a patch of high burn severity in its headwaters and thus is rated as a moderate hazard.

There are seven RDCK address points east of the highway at the base of this slope that are potentially at risk. The spatial likelihood of a debris flow impacting these residences is estimated to be moderate based on a desktop assessment using satellite imagery and base mapping, but this rating requires additional fieldwork to confirm. The address points to the west of the highway are less likely to be impacted, as the slope flattens considerably here.

Debris flow or flood on Aylwin Creek impacting private structure
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = moderate

The Aylwin Creek watershed is composed of two parts: the lower portion is susceptible to debris flows, whereas the upper basin is a cirque-like feature with a small lake near the outlet that drains into the lower portion. The upper basin is only partially burned; therefore, the burned area of the entire watershed is only

66%. However, the burned area of the lower watershed area is almost 100%, most of which is moderate and high burn severity. Given the high burn severity over steep terrain, the likelihood of a post-wildfire debris flow is rated as high.

There is one structure on private property on the Aylwin Creek fan, but it has not been verified if it is a occupied residence. The structure is located away from the main channel, and on the lower third of the fan; therefore, the likelihood of spatial impact is rated as low. Field verification as part of a more detailed (level 3) assessment is recommended to confirm the location of the structure relative to potential avulsion paths.

Debris flow or flood on Aylwin Creek impacting Highway 6 or Red Mountain Road
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = high Partial Risk[3,4] = very high

Red Mountain Road and Highway 6 cross the Aylwin Creek fan mid-way down the fan. The creek flows under the highway in a large culvert (~ 1.5 m diameter), which is likely to be plugged in a debris flow or flood event. Furthermore, there is little to no channel confinement along the right bank immediately upstream of the culvert. The combination of these factors results in a very high potential for a diversion along the highway ditch line to the north.

Debris flow or flood on Congo Creek impacting private residences or Red Mountain Road
Hazard P(H)[1] = high Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = moderate

Congo Creek is a short, steep drainage with a high Melton ratio, which would indicate a susceptibility to debris flows. The southern fork in the upper watershed is mostly composed of high and moderate burn severity, whereas the northern fork in the upper watershed is composed of a mixture of high, moderate and low burn severity. Fan hazard mapping indicates there is one RDCK address point near the base of the fan, with several houses located just beyond the fan area. Red Mountain Road bounds the lower portion of the fan. Field investigation as part of a more detailed (level 3) assessment is recommended to confirm the hazard and probability of spatial impact.

Debris flow or flood on Fingland Creek impacting private residences or Red Mountain Road
Hazard P(H)[1] = moderate Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = low

The upper Fingland Creek drains steep sub-alpine terrain and could be susceptible to debris floods, or possibly debris flows. However, the channel's gradient moderates substantially upslope of private property, as it turns southwest to flow around a ridge. Given the patchy high, moderate and low burn severity in the upper watershed, the likelihood of a post wildfire debris flood or flow is rated as moderate. The likelihood of spatial impact to private property and Red Mountain Road is low given the channel configuration above the elements at risk.

Debris flow or flood on Baby Ruth Creek or Vevey Creek impacting private residences or Red Mountain Road
Hazard P(H)[1] = low Probability of spatial impact P(S:H)[2] = low Partial Risk[3,4] = very low

Like Fingland Creek, Baby Ruth and Vevey Creeks have steep upper watersheds with tributaries that are likely to be susceptible to small debris flows or floods, but the main channel gradients moderate substantially before reaching elements at risk downslope. Therefore, the likelihood of spatial impact is rated as low. Baby Ruth's watershed is 41% burned and Vevey Creek's watershed is 33% burned (both a mixture of patchy high, moderate and low burn severities), resulting in low hazard of a debris flow or flood.

FURTHER ACTIONS

A more detailed (level 3) assessment for the Komonko Creek fire is recommended to verify the hazard and risk to private residences, infrastructure, and drinking water quality.

COMMENTS

The Komonko Creek and Aylwin Creek fires were identified on July 19, 2024 and burned over 4000 ha. They were subsequently amalgamated into one fire and will be treated as such in this assessment. Only limited field assessment was conducted for this fire (focused around Aylwin Creek fan), given that a more detailed assessment is forthcoming. This analysis relies heavily on vegetation burn severity mapping which was corroborated with visual observations made during helicopter overflight of the fire on August 23.

The fire burned the western facing drainages from Vevey Creek in the north to Enterprise Creek in the south, as well as flatter terrain to the west of Highway 6 immediately above Highway 6. Many of the drainages burned are steep and debris-flow prone. The southern portion of the Komonko Creek fire re-burned a portion of the 2007 Springer Creek fire, including several Enterprise Creek tributaries and two drainages (Cory Creek and Allen Creek) on the face south of Enterprise Creek. The burned area slopes range from lake level (~550 m) up to the alpine above 2000 m.

Due to the high risks identified in this report, further analysis of post-wildfire natural hazards for the Komonko Creek fire is recommended. A more detailed report will be released at a later date that will expand on the hazards and risks outlined here and may alter conclusions.

All members of the public, and specifically water users, should avoid spending time in debris flow prone creek channels during or immediately after intense rainstorms, or during periods of rapid snowmelt. Episodic water quality impacts to surface domestic water users on sources originating from within the fire perimeter are anticipated. More detail on this risk will be included in the Level 3 report.

SIGNATURE, SEAL, FIRM PRACTICE #

SCrookshanks

September 12, 2024

PROFESSIONAL GEOSCIENTIST
PROVINCE OF BRITISH COLUMBIA
S. D. I. CROOKSHANKS
37362

Sarah Crookshanks, P.Geo.
Ministry of Forests
Permit to Practice #1003022

Reviewed by: Gareth Wells, P. Geo

ATTACHMENTS

See attached map, photos and Appendix

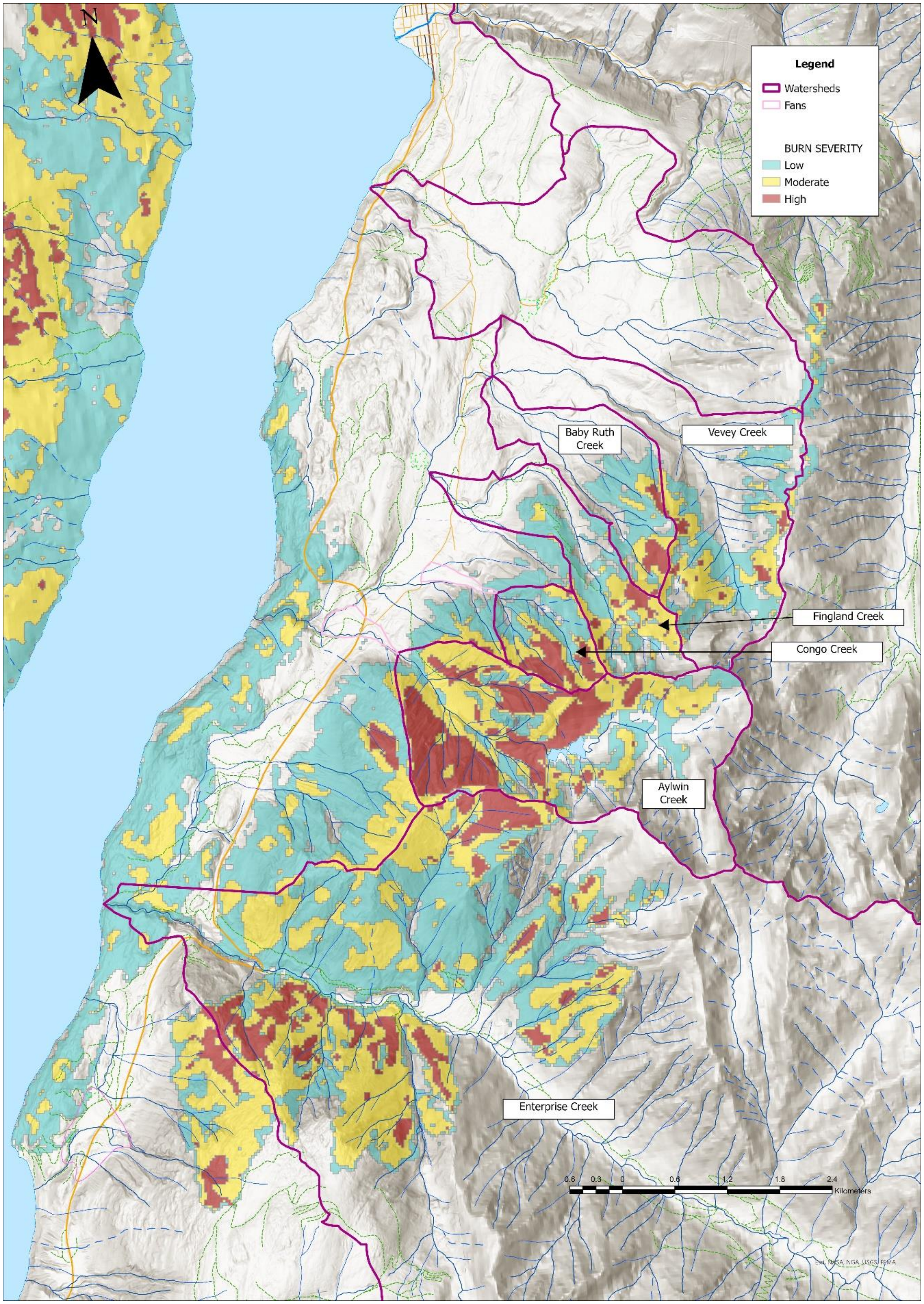


Figure 1. Burn severity map of the Komonko Creek fire showing estimated classes derived from Sentinel-2 imagery (prefire: July 11, 2024; post-fire: August 20, 2024). Further work may alter the estimated burn severity classes.

Figure 2. Enterprise Creek (Photo: T. Giles, SNT Geotechnical).

Figure 3. Headwaters of Cory Creek.

Figure 4. Photo of high burn severity in the Aylwin Creek watershed.

Appendix to PWNHRA Reconnaissance Reports

Scope of Reconnaissance (Level 2) Reports

Reconnaissance (Level 2) reports are primarily intended to identify whether post-wildfire hazards are likely to occur and need detailed investigation to protect identified elements at risk. Identified elements at risk are generally limited to public safety and infrastructure. Reconnaissance reports may also be used to assess safety conditions for wildfire fighters. In some cases, the MOF District Manager or other MOF personnel may request assessments for non-standard elements at risk or for other reasons.

Definitions of Hazard and Risk

Wildfire may produce conditions conducive to a suite of hazards. Debris flows, debris floods, and floods are often the most important hazards, but other types of landslide hazards including rockfall, debris slides and earthflows can also occur in response to wildfire. Wildfire can also cause snow avalanches and may affect water quality, cause erosion and result in sedimentation. Terrain, watershed, and channel conditions that produce post-wildfire hazards may also produce similar hazards in unburned conditions; these hazards may be mentioned but are not evaluated in this report.

P(H), P(S:H) and partial risk are presented for each identified elements at risk. Multiple types of channel hazards (debris flows, debris floods, floods) may affect an element at risk. These hazards are ranked by severity, with debris flow as the most damaging and destructive and flood as the least damaging and dangerous, and ratings are given for the highest rating hazard that may affect an element at risk. For example, where a channel has the potential for a debris flow and an element at risk may be affected, the lower ranking debris flood and flood hazards are not rated, since discharge and velocity are likely to be less than for a debris flow. These processes may cause erosion or sedimentation that affects the element at risk. Hazards that are unlikely to affect an identified element at risk are not discussed.

Table A1 shows the annual probability ranges for qualitative definitions of P(H). The probability of the hazard occurrence is for the post-wildfire period of elevated hazard, which in many cases may be less than five years, but in some cases may extend for several more years.

Table A1. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities.

Post-wildfire hazard rating	Description	Annual Probability Range
Very High	An event is expected to occur. Most of the catchment or face unit has burned with a significant proportion burned at moderate and/or high severity	>0.2
High	An event is probable under adverse conditions. Most of the catchment or face unit has burned with a significant proportion (i.e., >50 %) of terrain conducive to post-wildfire natural hazard initiation burned at moderate or high severity. Existing indicators of pre-fire terrain instability within stream channels, on fans or face units.	0.01 - 0.2
Moderate	An event could occur under adverse conditions. It is not probable but possible over a several year period. More than 20% of the terrain conducive to post-wildfire natural hazards in the catchment or on the face-unit has burned with moderate and/or high severity. Historic geomorphic indicators of instability are present.	0.002 – 0.01
Low	An event could occur under very adverse conditions. It is considered unlikely over a several year period. Only a limited proportion of the catchment or face unit has burned. Few or no signs of pre-fire instability present along stream channels, fans or face units.	0.0004 – 0.002
Very Low	An event will not occur or is conceivable though considered exceptionally unlikely. A limited proportion/none of the catchment was burned. No terrain instability indicators are present	<0.0004

Table A2 defines spatial impact to an element of risk. Post-wildfire event magnitude is considered when rating spatial impact.

Table A2. Post-wildfire spatial impact.

Likelihood of spatial impact	Description	Probability range
H	It is probable that the event will impact the element at risk.	>0.5
M	It is possible that the event will impact the element at risk.	0.5 - 0.1
L	It is unlikely that the event will impact the element at risk.	< 0.1.

Table A3 is a matrix which combines the hazard likelihood (Table A1) with the spatial impact likelihood (Table A2) to determine partial risk.

Table A3. Post-wildfire risk matrix partial risk matrix.

Hazard Likelihood P(HA) (Table 1)	Spatial Impact Likelihood (P(S:H)) (Table 2)		
	High	**Moderate**	**Low**
Very High	Very High	Very High	High
High	Very High	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Very Low
Very Low	Low	Very Low	Very Low

Report Standards

FLNRORD Land Management Handbook 69 is the primary standard followed in this report. LMH 69 describes the process to complete a detailed report. This reconnaissance report uses the framework of LMH 69 but does not follow it where detailed assessment procedures are described.

Land Management Handbook 69 Post Wildfire Natural Hazards Risk Analysis in British Columbia 2015
https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh69.htm

Additional guidance is provided in the MOF SOG for PWNHRA and the 2014 FLNRO Landslide Risk Management Procedure.

Other professional guidance standards that may be used for the preparation of reconnaissance reports are listed below. These guidelines have similar report content to this reconnaissance assessment, but are for different purposes, have different levels of appropriate effort, and do not recognize the potential emergency nature of this reconnaissance assessment. These guidelines include:

EGBC Guidelines for TSA in the Forest Sector 2010
https://www.egbc.ca/getmedia/684901d7-779e-41dc-8225-05b024beae4f/APEGBC-Guidelines-for-Terrain-Stability-Assessments.pdf.aspx

EGBC Guidelines for Legislated Landslide Assessments 2010
https://www.egbc.ca/getmedia/5d8f3362-7ba7-4cf4-a5b6-e8252b2ed76c/APEGBC-Guidelines-for-Legislated-Landslide-Assessments.pdf.aspx

Legislated Flood Assessments in a Changing Climate in BC 2018
https://www.egbc.ca/getmedia/f5c2d7e9-26ad-4cb3-b528-940b3aaa9069/Legislated-Flood-Assessments-in-BC.pdf

Watershed Assessment and management of hydrologic and geomorphic risk in the Forest Sector
https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMW2ATQA5BSODHJAKBAGZDYTRL6FJ/Watershed%20Assessment%20a

nd%20Management%20of%20Hydrologic%20and%20Geomorphic%20Risk%20in%20the%20Forest%20Sect

Other standards may also apply, depending on the professional qualifications of the writer.

Statement of Limitations

Reconnaissance PWNH Level 2 assessments are typically done in constrained timelines where personnel, resources, data collection, and analysis methods are limited. Post-wildfire hydrogeomorphic hazards in BC are not well understood and therefore hazard and risk assessments are estimates only. While probabilities ranges are given in Tables A1 and A2, the state of the science in BC does not allow for precise assessments, particularly near the borders of classes. Numeric probabilities ranges do not imply precision.

Identification of elements at risk relies on BC government data layers, satellite imagery, and perhaps an overview flight. BCWS and the MOF district office may provide additional information. No further confirmation of elements at risk was conducted.

Comments, conclusions, and suggestions contained in this reconnaissance assessment reflect my experience and judgement considering the information available to me at the time that this report was prepared and are considered appropriate for the reconnaissance nature of the review. The review has been carried out in accordance with generally accepted professional practices. This assessment and its contents are intended for the sole use of post-wildfire hazard management by provincial agencies, First Nation governments and local governments. I do not accept any responsibility for the accuracy of any of the data, the interpretation, or the conclusions contained or referenced in the report when the report is used or relied on for any other purpose than specified. Any such unauthorized use of this report is at the sole risk of the user.

APPENDIX C
Landslide and Flooding Risk Awareness Brochures

C1

Shorts Creek drainage, burned by 2009 Terrace Mountain fire.

Introduction

This pamphlet describes (1) how wildfire may increase the risk of natural landslides and flooding hazards, (2) what to watch for, (3) how this knowledge will help you avoid putting yourself and your family in danger, and (4) what to do in case of an emergency.

1 How does wildfire potentially increase the risk of landslide and flooding hazards?

Periodically, British Columbia experiences severe wildfires near urban or other populated areas, such as those that occurred in the summers of 1998, 2003, and 2009.

Severe wildfires damage the forest canopy, the plants below, as well as the soil. This can result in increased runoff after intense rainfall or rapid snowmelt, which can put homes and other structures below a burned area at risk of localized floods and landslides.

2 What are the specific hazards to watch for after a wildfire?

- Flooding, especially after intense downpours.
- Many types of landslides, however, the most common after wildfire are:
  - Debris flows, a specific type of fast-moving and powerful landslide resulting from heavy runoff carrying large amounts of soil, rocks, wood debris, and trees.
  - Rockfalls, resulting from fire-induced cracking of rocks, as well as the loss of stumps, logs, and roots, which normally hold loose rock in place.

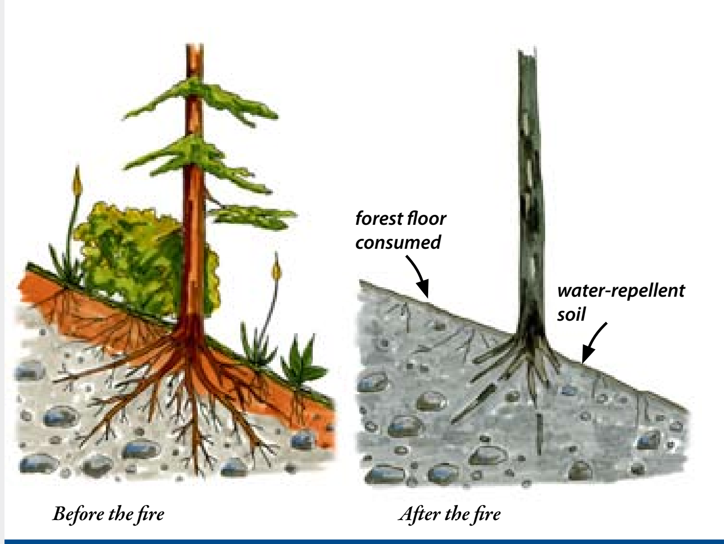
What are at risk?

- Residential, farm and industrial buildings that are downslope or downstream of a severe wildfire are at some risk of post-wildfire hazards. But the hazard may not be restricted to areas below large fires. Severe fires of only one or two hectares can in some cases trigger hazards. Structures that are below a recent wildfire, and near creeks, gullies or alluvial fans, are most at risk. Areas that have experienced flooding or landslides in the past are likely to have an increased chance of recurrences.
- Roadways, railway lines, pipelines and other infrastructure, including bridges downslope or downstream of fires, may also be obstructed, inundated, or washed out.
- Domestic or irrigation waterlines/intakes and other structures in gullies, streams, and creeks can be damaged or destroyed by a post-wildfire flood or landslide. These areas can be at risk during and even after an event due to channel blockages.

What are the weather conditions that trigger post-wildfire floods and debris flows?

The most common trigger is intense rainfall (e.g., 10 mm of rain in 20 to 30 minutes). The risk increases if this rainfall follows a prolonged dry period because dry weather can increase the water repellency of fire-altered soils. On the Coast, fall rainstorms are the most likely to cause post-wildfire floods or debris flows. Another trigger is rapid spring snowmelt in a drainage that has experienced a severe burn.

Evidence of concentration of overland flow on water-repellent soils. Kuskonook Creek drainage, August 2004.



Wildfires remove the protective ability of vegetation increasing runoff, erosion, debris flow, and the potential for landslides.

3 What are some things you can do to deal with post-wildfire hazards?

1. Be informed and be ready. Become familiar with the land and the normal drainage channels around you. Know where your home and property lies with respect to natural drainage channels. Find out if floods or landslides have occurred in your area in the past.
2. Contact your local authorities to learn about emergency response and evacuation plans for your area. Attend any meetings that are held to inform the public of local risks. Develop your own emergency plans for your family and business. Post-wildfire hazard events can occur with little advance warning.
3. If a fire has occurred on Crown land, a post-wildfire risk analysis may have been conducted to determine the safety risks to adjacent residential areas. Contact the local government office or Emergency Management BC (EMBC) to see if a risk analysis has been done for your area. Such analyses help determine the safety risks to residential areas adjacent to wildfires.

4 What should you do during a storm or heavy runoff event?

1. Be aware of forecasts that may include thunderstorms, or those with heavy rainfall warnings. Check the current forecast or use a VHF weather radio (www.msc.ec.gc.ca/msb/weatheradio/index_e.cfm).
2. Be alert when driving in an area that has had a recent wildfire. Washed-out bridges or culverts are especially dangerous, and roads below steep banks are susceptible to landslides. Watch the road for collapsed pavement, mud, fallen rocks, and other indications of possible debris flows. Never drive across a flooded road.
3. If your home is in a location at risk, and severe weather is occurring or forecast, stay alert. Listen for unusual sounds—trees cracking or boulders knocking together—and watch for changes to water flows in local stream channels. Sleep in an upper floor of the house, not in the basement.
4. Do not enter channels or hike upstream to inspect waterlines or buildings. Consider leaving the area if it is safe to do so.
5. On forest land where a wildfire has recently occurred, avoid camping on floodplains, beside small streams, on alluvial fans or at the base of burned slopes. Also, be aware that forest roads may wash out if a flood occurs, cutting off access.

Kuskonook landslide near Creston, BC. This large debris flow occurred during a localized rainstorm on the night of August 6–7, 2004. The heavy rain caused rapid runoff in the headwaters of Kuskonook Creek, in an area burned by a severe wildfire the previous summer.

Mudflow from the 2009 Kelly Creek Fire after a severe rainstorm, August 2010.

How long does the post-wildfire risk last?

Post-wildfire risks begin as soon as an area is severely burned and last for another two or more years. However, increased floods and debris flow risks in some severely burned areas may last much longer. After two to three years, revegetation and breakdown of soil water repellency means the risk is considerably lower.

Do you need more specific information regarding your property?

Consulting geotechnical specialists can provide specific information about your property and post-wildfire hazards, risks, and potential mitigation techniques.

This bulletin provides general information only; it does not cover all hazards. Additional information resources are available:

- For current wildfires: www.bcwildfire.ca
- For current flooding information and Provincial Emergency Plan information and contacts: www.pep.bc.ca/Emerg_Mgmt_BC/Emerg_Mgmt_BC.html
- For Ministry of Forests and Range district offices and contacts: www.gov.bc.ca/for
- For more background information on natural hazards, and why they occur after wildfire please visit: www.for.gov.bc.ca/hre/ecoearth/wildfire

Citation
B.C. Ministry of Forests and Range. 2011. Landslide and flooding risks after wildfires in British Columbia. Wildfire Manag. Br., and For. Sci. Prog., Victoria, B.C. www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro91.htm

Landslide and Flooding Risks after Wildfires in British Columbia

What you can do to recognize and deal with the hazards

British Columbia
The Best Place on Earth
Ministry of Forests and Range

Debris Flow Hazard Awareness in the Kootenay Region

Debris flows are fast-moving mixtures of water, sediment, boulders and logs that flow down steep mountain creeks. In recent years, debris flows have caused fatalities, near misses and significant property damage in the Kootenays.

This document is intended to help you understand this hazard in the Kootenay Region, identify some indicators that could be cause for concern and learn how to report a potential emergency.

Figure 1. Debris flow material that was deposited on the Kuskanook Creek fan after a rainfall event in August 2004.

Figure 2. Debris flood on Memphis Creek. Note the large volume of floating debris in the lake and the uncharacteristically turbid water.

Get to know your watershed:

- Learn the history of debris flow hazards on or near your property and the areas you visit often, especially near the mouths of creek channels and alluvial fans. Flood hazard mapping is available through your local government and is a good initial reference. For example, the Non-Standard Flooding and Erosion Areas (NSFEA) hazard map can be accessed through the Regional District of Central Kootenay's Property Information Mapping System (mapinfo.rdck.bc.ca/Pims/).
- Be aware of dikes or flood control structures that may be protecting your property from flooding and/or debris flows. Structures that were built many years ago and are not being maintained may no longer be providing the protection it was designed for. A dam upstream of your property may also pose a hazard, depending on its condition and maintenance history. Refer to www.env.gov.bc.ca/wsd/public_safety/index.html to identify the locations of any such structures.
- If you live near or visit areas prone to debris flows, you should become familiar with the terrain between your property and the creek channel and fan apex. During a major flood event, creeks may suddenly change course and flow along a new or abandoned flood channel, and debris flow material may run out onto the fan area. Terrain features to be aware of include: abandoned creek channels; levees; scarred trees; and lobal deposit features.
- If you have concerns about debris flows impacting your property, you may wish to hire a qualified professional to provide additional assistance.

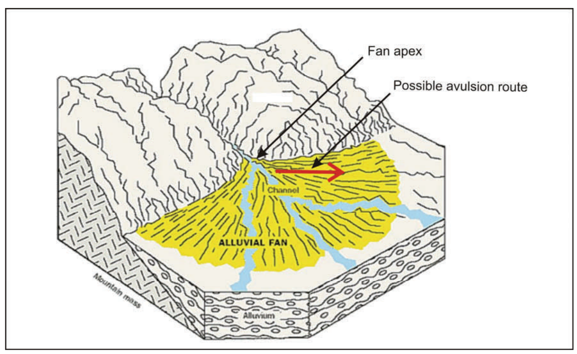


Figure 3. Schematic diagram of an alluvial fan, showing a possible flow route and geological features.

What you should do in an emergency:

- **To report a debris flow emergency that is occurring call 911.**
- **To report observations of these debris indicators, call the 24-hour provincial toll-free number: 1 800 663-3456**
- Local governments are responsible for responding to emergencies in their jurisdiction.
- The provincial government will provide technical expertise and assistance to local governments during emergencies. For more information, visit: www.embc.gov.bc.ca/index.htm

Debris flow hazard indicators:

- By monitoring the creeks near your property or the areas you visit frequently, you can become familiar with typical flow patterns and recognize any unusual events that may indicate a potential debris flow event.

- There are large natural variations in the water levels of creeks in the Kootenays associated with either snow-melt and heavy rainfall. Each creek responds differently, depending on the size and characteristics of its watershed.

  However, an unusually rapid increase or decrease in flow may indicate that the creek has been blocked by a landslide upstream or that a debris flow is about to occur. Call the provincial emergency number below to report your observations.

- Creeks in the Kootenays often flow dirty during spring runoff and after a major rainstorm. Dirty or turbid water does not necessarily indicate that a debris flow hazard exists.

  However, abnormally dirty water may signal that a landslide or bank failure has occurred up-stream. Pulses of sediment in a creek channel may also indicate that something unusual has occurred upstream. Call the provincial emergency number below to report your observations.

- A large volume of debris (logs, sediment, etc.) that accumulates in a creek channel or has recently been transported down the creek and is now floating near the mouth of the creek may indicate that a natural hazard event has occurred in the watershed.

  If you observe an unusually large and recent change in the accumulation of debris in a creek channel, call the provincial emergency number at 1 800 663-3456 to report your observations.

Figure 4. Turbid water in Gar Creek the day before the Johnson's Landing landslide on July 12, 2012.

Public Safety Advisory:

Use caution while spending time in a confined creek channel or gully that is prone to debris flows. Fatalities and close calls have occurred when people have been caught up in debris flows while working on their water intake systems.

To summarize, the following factors may indicate an upstream hazard:

- Abnormally dirty water
- Accumulation of large logs or debris in the creek
- Sudden changes in flow
- Pulses in flow (i.e. rapid changes in flow) or pulses of sediment
- Rapid accumulation of sediment or bedload along a flat section of a creek channel

Not all debris flows are preceded by these indicators.
Following the advice in this document does not ensure your safety.

To report the potential emergency, call the 24-hour toll-free number: 1 800 663-3456

BRITISH COLUMBIA