

POST-WILDFIRE NATURAL HAZARDS RISK ANALYSIS ARGENTA CREEK WILDFIRE (N71058)



Prepared for:



B.C. Ministry of Forests

Attn: Sarah Crookshanks, M.Sc. P.Geo.

Prepared by:



Sitkum Project No. 24-1990

March 31, 2025

Table of Contents

1. INTRODUCTION	3
2. METHODOLOGY	5
2.1 Office Assessment	5
2.2 Field Assessment	6
2.3 Burn Severity Plot Sites	7
2.4 Soil Burn Severity Mapping	7
2.5 Watershed and Fan Delineation	7
2.6 Post-Wildfire Partial Risk Analysis	7
2.7 Limitations	8
3. EFFECTS OF WILDFIRE ON TERRAIN STABILITY AND HYDROLOGY	9
3.1 Soil Properties	9
3.2 Runoff	9
3.3 Terrain Stability	10
3.4 Snow Avalanches	10
3.5 Water Quality	10
3.6 Timing of Wildfire Effects	11
4. ARGENTA CREEK WILDFIRE AND STUDY AREA CHARACTERISTICS	12
4.1 Site Location & General Physiography	13
4.2 Climate	13
4.3 Geology	15
4.4 Surficial Geology	17
4.5 Past Wildfire, Hydrogeomorphic, and Development History	18
4.6 2024 Argenta Creek Wildfire Burn Severity	18
5. SPECIFIC WATERSHED CHARACTERISTICS, HAZARDS, AND RISKS	20
5.1 Bulmer Creek	21
5.1.1 Watershed Characteristics	21
5.1.2 Burn Severity	21
5.1.3 Post-wildfire Hydrogeomorphic Hazards	22
5.2 Argenta Creek	22
5.2.1 Watershed Characteristics	22
5.2.2 Burn Severity	24
5.2.3 Post-wildfire Hydrogeomorphic Hazards	24
5.2.4 Downslope Elements and Likelihood of Spatial Impact	25
5.2.5 Partial Risk Summary	27
5.3 Argenta – Carter Face and Argenta Creek North	28
5.3.1 Watershed Characteristics	28
5.3.2 Burn Severity	29
5.3.3 Post-wildfire Hydrogeomorphic Hazards	29
5.3.4 Downslope Elements and Likelihood of Spatial Impact	30
5.3.5 Partial Risk Summary	30
5.4 Carter Creek	31
5.4.1 Watershed Characteristics	31
5.4.2 Burn Severity	32
5.4.3 Post-wildfire Hydrogeomorphic Hazards	33
5.4.4 Downslope Elements and Likelihood of Spatial Impact	33
5.4.5 Partial Risk Summary	34
5.5 Hamill Creek and Clint Creek	35
5.5.1 Watershed Characteristics	35
5.5.2 Burn Severity	36
5.5.3 Post-wildfire Hydrogeomorphic Hazards	36
5.5.4 Downslope Elements and Likelihood of Spatial Impact	38
5.5.5 Partial Risk Summary	39
5.6 Hamill Creek to Glacier Creek	40
5.6.1 Watershed Characteristics	40

5.6.2	Burn Severity	41
5.6.3	Post-wildfire Hydrogeomorphic Hazards	42
5.6.4	Downslope Elements and Likelihood of Spatial Impact	43
5.6.5	Partial Risk Summary	43
5.7	Glacier Creek	44
5.7.1	Watershed Characteristics	44
5.7.2	Burn Severity	45
5.7.3	Post-wildfire Hydrogeomorphic Hazards	46
5.7.4	Downslope Elements and Likelihood of Spatial Impact	48
5.7.5	Partial Risk Summary	50
5.8	Duncan Ridge North of Glacier Creek	51
5.8.1	Watershed Characteristics	51
5.8.2	Burn Severity	51
5.8.3	Post-wildfire Hydrogeomorphic Hazards	52
5.8.4	Downslope Elements and Likelihood of Spatial Impact	52
5.8.5	Partial Risk Summary	53
6.	PARTIAL RISK SUMMARY TABLE – ALL AREAS	54
7.	RECOMMENDATIONS AND MITIGATION OPTIONS	57
8.	CLOSURE	61
	REFERENCES	62

LIST OF APPENDICES

Appendix A – Photographs

Appendix B – Post Wildfire Natural Hazards Risk Analysis Definitions and Ratings

Appendix C – Post Wildfire Hydrogeomorphic Hazard Definitions

Appendix D – Point of Diversion Tables

Appendix E – Debris Flow and Flooding Risk Awareness Pamphlets

Appendix F – Figures

LIST OF FIGURES

Report Figures

Figure 1– Argenta Creek Wildfire Location Map

Figure 2 – Argenta Creek Wildfire Perimeter

Figure 3 – Sentinel-2 L2A Satellite Imagery of the Argenta Creek Wildfire Area, July 7, 2024

Figure 4 – Sentinel-2 L2A Satellite Image of the Argenta Creek Wildfire Area, September 5, 2024

Figure 5 – Biogeoclimatic Zone/Subzone within the Argenta Creek Wildfire Area

Figure 6 – Argenta Creek Wildfire Bedrock Geology Map

Figure 7 – Modified Soil Burn Severity Map of the Argenta Creek Wildfire

Appendix F Figures

Figure F1 – Argenta Area Post Wildfire Natural Hazards Risk Analysis Map (1:15,000 scale)

Figure F2 – Hamill Creek Area Post Wildfire Natural Hazards Risk Analysis Map (1:20,000 scale)

Figure F3 – Glacier Creek Area Post Wildfire Natural Hazards Risk Analysis Map (1:20,000 scale)

Figure F4 – Hamill Creek Fan Post Wildfire Natural Hazards Risk Analysis Map (1:2,500 scale)

Figure F5 – Argenta Creek Stream Profiles

Figure F6 – Argenta Creek South Fork Stream Profiles

1. INTRODUCTION

At the request of Sarah Crookshanks, P.Geo., on behalf of the B.C. Ministry of Forests (MoF) BC Wildfire Service branch, Sitkum Consulting Ltd. (SCL) has carried out a Level 3 (detailed) Post-Wildfire Natural Hazards Risk Analysis (PWNHRA) for areas affected by the 2024 Argenta Creek wildfire (N71058). The burn is located within the Argenta Creek, Hamill Creek, Glacier Creek and Duncan Lake drainage in southeastern B.C., directly east and northeast of the community of Argenta within the Regional District of Central Kootenay (Figure 1 on page 5).

The scope of the project is defined in Schedule A – Services as part of the contract agreement. In general, the intent of the assessment is:

- to identify potential post-wildfire natural hazards;
- to evaluate the potential impact of these hazards on downslope elements at risk;
- to present a risk analysis relating to selected downslope elements at risk; and
- to identify the potential for risk mitigation and provide conceptual risk management options.

A Level 2 (reconnaissance) report was published by Sarah Crookshanks, M.Sc. P.Geo., Research Geomorphologist for MoF, on October 10, 2024. This detailed report is intended to provide supplemental information and additional details to assist the MoF in increasing the public, local government, and stakeholder awareness of the specific post-wildfire natural hazard risks, so that they can undertake specific measures or assessments to mitigate the risk if deemed unacceptable to them.

The area affected by the 2024 Argenta Creek Wildfire is located on the traditional territories of the Ktunaxa, Stoney, Syilx, and Confederated Tribes of the Colville Reservation (locally Sinixt) peoples¹. We acknowledge that these groups have been stewards and protectors of this land since time immemorial.

¹ <https://native-land.ca/>

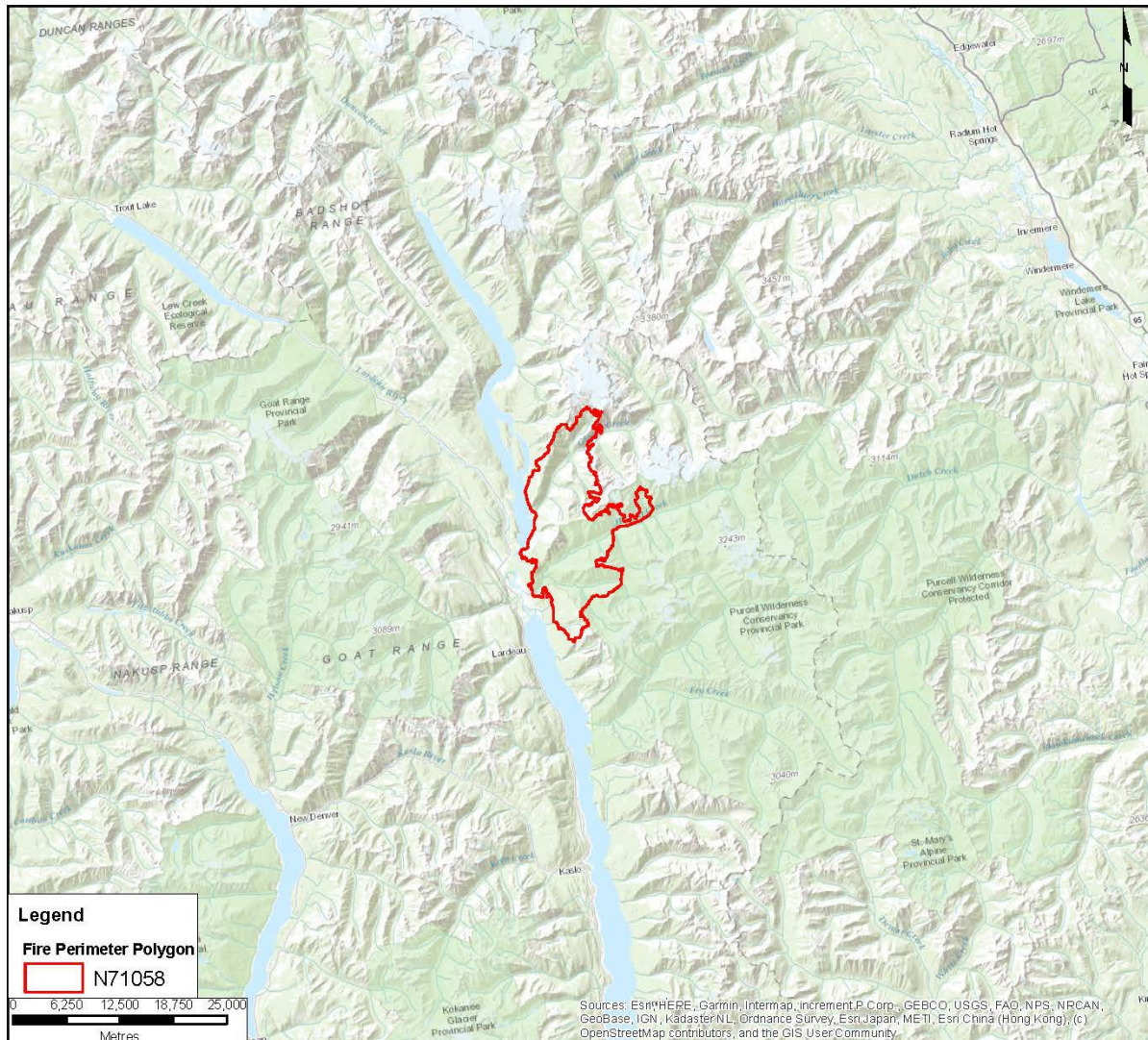


Figure 1: Argenta Creek Wildfire Location Map

The Argenta Creek wildfire is situated upslope of numerous elements potentially at risk from post-wildfire natural hazards including:

- private property, residences, and other structures;
- public roads and resource roads;
- lineal infrastructure including power and communications;
- domestic water quality and supply; and
- recreation trails.

More detail regarding specific elements at risk is presented within the report sections for each watershed or face unit.

2. METHODOLOGY

This assessment has been carried out using methods consistent with Land Management Handbook 69: Post-wildfire Natural Hazards Risk Analysis in British Columbia (Hope et al. 2015).

2.1 Office Assessment

As part of the office assessment, the following information was reviewed by SCL:

- LiDAR and TRIM based topographic maps (scales ranging from 1:2000 to 1:20,000, 1 m to 20 m contour intervals);
- LiDAR based slope themed mapping and hillshade mapping;
- burn severity mapping from BCTS and MoF sources;
- high resolution post-wildfire satellite imagery provided by MoF;
- available background reports relating to terrain stability and hydrology (as referenced);
- Google Earth (GE), iMapBC, and UBC Centre for Forest Conservation Genetics Climate BC Map web mapping applications;
- RDCK Public Web Map applications²; and
- historical air photos

Date/Colour	Scale	Photo numbers
1945/ BW	Approximately 1:20,000	A9524: 89-90, 93-94, 97-98, 108, 111-112, 115-116 A7660: 99-100, 103-104, 107-108
1951/ BW	Approximately 1:32,000	BC1338: 43-47 BC1320: 87-92
1968/ BW	1:16,000	BC7101: 193-196, 221-227 BC7115: 202-205 BC7117: 50, 53-56 BC7113: 355-256, 259-261
1980/BW	1:40,000	BC80119: 104-107, 157-159
1988/BW	1:15,000	BC88053: 50-52, 89-93, 131-135, 171-176
1991/BW	1:15,000	30BCB91130: 90-93 30BCB91122: 82-88, 318-324 30BCB91121: 31-37 30BCB91125: 176-183
1997/BW	1:15,000	30BCB97100: 233-237 30BCB97105: 15-20, 117-123, 154-158
2005/ Colour	Approximately 1:26,000	30BCC05037: 14-16
2006/ Colour	1:20,000	30BCC06066: 219-224, 231-236

² <https://gis.rdck.bc.ca>

2.2 Field Assessment

A helicopter overview flight was completed by Tedd Robertson, P.Geo. P.L.Eng. and Florence Lanouette, EIT, of SCL, along with hydrologist Ashley Jollymore, P.Geo. from Machydro (who was retained by BCTS) on August 14, 2024. Photographs were captured during this flight to calibrate the preliminary burn severity mapping. At the time of the flight the fire was mostly extinguished but still burning in some isolated areas.

Two additional field days were conducted within and around the Argenta Creek and Carter Creek watersheds by Tedd Robertson and Florence Lanouette, joined by Marc Deschênes, B.Sc. Eng., also from SCL, on September 16 and 18, 2024. These field days included a geomorphic assessment of the Argenta Creek and Argenta Creek North watersheds and fans, the Argenta-Carter Face, and the Carter Creek watershed. Limited observations were also made near the southwest boundary of the Clint Creek watershed. The weather at the time of the field assessment was sunny and clear, with a temperature high of 20°C. Approximately 8 mm of rain had fallen in the area over the previous weekend, according to the Powder Creek weather station³. On the September 16 field day Marc Deschenes and Tedd Robertson met with Dave Putt and Rik Valentine of Argenta, who were able to provide valuable information regarding the local terrain, water systems, and hydrogeomorphic history.

Tedd Robertson and Florence Lanouette also conducted a field assessment on August 28, August 29, and September 4, 2024. Part of the fieldwork completed on these days also concerned BC Timber Sales (BCTS) road corridors, which extend along Duncan Lake, Duncan Ridge, and Glacier Creek Valley. The field days of August 28 and 29 covered the area of Glacier Creek watershed comprised within the wildfire perimeter, which includes seven sub-basins and ten faces. On August 28, the weather was cloudy, with light rain in the morning and an average temperature of 12°C. Heavy rain over the previous 24 hours had induced turbidity in Lavina Creek and Hamill Creek, but Glacier Creek presented a normal level of sediment transport. Snow accumulation from the same rain event was still visible in the alpine. On August 29, the weather was sunny, with an average temperature of 20°C. The field day of September 4 covered the SE face of Duncan Ridge, the watersheds of Duncan Lake Tributaries 3, 2, 1 and their associated faces, and the Hamill-Lavina Face. The weather at the time was sunny with few clouds and temperatures ranging from 17°C to 27°C. The cumulative precipitation over the 10 previous days was 16 mm, mainly between August 25 and 28³.

Hamill Creek and Clint Creek watersheds were observed during the helicopter

3 BC Wildfire Active Weather Stations and Data - Datasets - Data Catalogue (gov.bc.ca)

reconnaissance flight but limited safe access to these watersheds restricted further ground assessments. Two drone flights were conducted on October 1 and December 2, 2024, to further monitor the log jam located in the lower canyon of Hamill Creek.

Additional field days were conducted in the area for BCTS on October 1 and December 2, 2024, to assess a post-wildfire debris flow that impacted Duncan FSR at 7.8 km on September 25 and a post-wildfire debris slide that impacted Glacier Creek FSR at 12.3 km on November 27.

2.3 Burn Severity Plot Sites

In addition to numerous visual observations from foot traverses, truck access along roads, and the helicopter and drone overview flights, the field assessment included 36 burn severity plot sites where the burn severity of the vegetation and the soil were assessed in accordance with the methods outlined in LMH 69 (short forms). Plots were concentrated on slopes above elements at risk. Burn severity ratings are presented in Appendix B.

2.4 Soil Burn Severity Mapping

A soil burn severity map was produced by adjusting the MoF provided vegetation burn severity mapping based on a combination of field observations and office interpretations. Relevant field observations include the burn severity plots as noted in Section 2.3, as well as visual observation sites and information gathered during field traverses and the helicopter overview flight relating to the accuracy of the vegetation burn severity mapping and the relationship between vegetation burn severity and soil burn severity. Observations include adjacent unburned areas to assist with understanding the changes to soil, vegetation, and fuel characteristics resulting from the fire. The high-resolution post-wildfire satellite imagery provided by MoF was also used to adjust the soil burn severity polygons by extrapolating vegetation and soil burn severity correlations based on field observations. Geospatial data of the final soil burn severity mapping has been provided to MoF.

2.5 Watershed and Fan Delineation

Relevant watersheds, face units, and fan areas were separated within the fire perimeter for the purpose of identification and description as well as hazard and risk analysis. These areas were delineated using a combination of 5 m contours based on LiDAR and 20 m contours based on TRIM. LiDAR-based 1 m contours and hillshade mapping were also used to help with the delineation of the Hamill Creek fan and Carter Creek watershed.

2.6 Post-Wildfire Partial Risk Analysis

Post-wildfire hazards may include landslide, debris avalanche, rockfall, debris flow, debris flood, clearwater flooding or water quality effects, as well as snow avalanches; refer to

Appendix C for definitions used in this report.

To assess the post-wildfire likelihood of hazards, the background (pre-wildfire) conditions and likelihood of hazards must be understood, in addition to the expected incremental increase in the likelihood of a hazard occurring in the post-wildfire environment. The post-wildfire ratings presented in this report include the combination of background hazard likelihood and the incremental increase in hazard likelihood due to the wildfire. Specific definitions and an overview of the partial risk analysis methods and burn severity ratings are presented in Appendix B.

The likelihood of hazards has been estimated in a qualitative manner based on generally accepted geotechnical interpretations and assumptions, the experience of SCL, comparative observations of pre-and post-wildfire hazard events throughout the southern interior of B.C., and results from landslide attribute studies in the southern interior of B.C. (Jordan 2003). Generalized criteria for the hazard likelihood and likelihood of spatial impact are described in Table B1 and Table B2 in Appendix B. Additional analysis was carried out with respect to likely hazard processes and landslide run-out distances, including watershed morphometrics and angle of reach measurements, respectively, to augment field observations and interpretations.

Private parcel polygons from the provincial cadastral dataset have been identified on the Appendix F figures in addition to private building (dwelling or major structure) locations within the affected areas using a combination of the provincial EBM_BLDGS_polygon dataset supplemented with interpretation of orthomosaic imagery obtained in 2022 (ESRI World Imagery source). **It is the responsibility of stakeholders to identify potentially affected infrastructure and property based on the information provided in this report to assist them with assessing the risks. Stakeholders should understand the scope of this assessment along with limitations of the risk analysis and retain further detailed professional assessment if they determine it is warranted.**

2.7 Limitations

Field assessments are a result of surface and near-surface investigations of the surficial geology, soil drainage, and evidence of dominant hydrogeomorphic processes. Shallow soil pits, existing road cuts, overturned root wads, stream channels, landslide headscarp and landslide deposits were examined; no deeper subsurface investigation was completed. Subsurface conditions are inferred from observations and interpretations of surface characteristics, and conditions encountered during excavation may vary.

Stereo air photo pairs were only reviewed for a select portion of the area affected by the fire, with a focus on the interface areas and downslope elements at risk. This is not considered a significant limitation for the remainder of the areas due to the quality of LiDAR products

and orthomosaic imagery reviewed, in addition to the extent of fieldwork and the authors' and reviewers' familiarity with the terrain in the area.

LiDAR was unavailable for a portion within the Argenta Creek Wildfire perimeter within the area of Duncan Lake Tributary 1 (Lavina Creek). Therefore, topographic and slope maps reviewed were based on TRIM data for this area.

Interpretations of surface flow patterns were made by careful observations of the forest floor, vegetative indicators, and surface configuration, as is typical for geotechnical assessments. These interpretations consider the experience of SCL observing conditions in similar terrain during periods of high runoff, including working in both pre- and post-wildfire environments during the past 25 years.

3. EFFECTS OF WILDFIRE ON TERRAIN STABILITY AND HYDROLOGY

Wildfire is a natural disturbance that has been an active part of the forested landscape in B.C. for thousands of years. Wildfires can vary widely in burn severity, which is generally a result of differences in antecedent conditions, fuel availability, fire behaviour, and fire duration (Hope et al. 2015; Parsons et al. 2010). An increase in fuel availability due to effective fire suppression activities over several decades combined with climate related increases to the duration and intensity of fire seasons has resulted in enhanced fire activity in the western United States (Guilinger et al. 2020), with similar effects applicable to British Columbia.

Burn severity observations can be separated into vegetation burn severity and soil burn severity, with soil burn severity generally having greater effects on runoff and terrain stability. Refer to Appendix B for more details on burn severity ratings.

3.1 Soil Properties

In general, soil burn severity describes the effects of fire on ground surface characteristics and soil conditions. Areas of high vegetation burn severity often correlate with areas of high soil burn severity, but there can be differences depending on fire behaviour. High soil burn severity can result in alteration of soil and forest floor properties including the consumption of forest litter and ground cover, exposure of mineral soil, and alteration of mineral soil properties including the formation of water repellent (hydrophobic) layers within the near surface soil profile (Hope et al. 2015; Parsons et al. 2010). Areas of moderate or high soil burn severity also generally have a significant increase in the availability of erodible materials including ash and non-cohesive soil in comparison to unburned forest floors.

3.2 Runoff

The potential effect of wildfire on runoff volume and rate is dependent on numerous factors

including the area burned, the burn severity, drainage area characteristics, as well as the timing, and intensity of climatic events (Robichaud et al. 2000, Curran et al. 2006). In general, the greater the proportion of a given catchment area that has experienced high vegetation and soil burn severity, the greater the potential there is for increased volume and rates of peak flow runoff values (Robichaud et al. 2000). Tree mortality from wildfire can also result in increased runoff due to a loss of rain and snow interception, increasing both snow available for melt and snow melt rates (Winkler et al. 2010). Where high soil burn severity has resulted in water repellent soil conditions, there is the potential for extremely rapid runoff response after intense rainfall events following summer dry spells, with runoff amounts potentially increased by a factor of one to three orders of magnitude (Curran et al. 2006, Jordan, 2006, Winkler et al. 2010). These types of intense summer storm events are relatively common in southeastern B.C.

3.3 Terrain Stability

The incidence of landslides generally increases following major wildfires in southern B.C. (Hope et al. 2015). Post-wildfire landslides can include debris flows, debris slides, debris avalanches, and rockfall. Refer to Appendix C for post wildfire hydrogeomorphic hazard definitions. In southern B.C., debris flows are the most common type of hazardous post-wildfire landslide, and most of these debris flow events are triggered by high peak flows in stream channels (Jordan 2015). While post-wildfire landslides in southeastern B.C. can occur at any time, water repellent properties of soil which contribute to rapid runoff response and debris flow initiation are generally most pronounced during summer months when intense rainfall events can impact areas with low antecedent moisture conditions. As a result, the most significant hazard is often debris flow activity reaching alluvial fans where public or private development may be located. These fans may be subject to periodic debris flows even during non-wildfire conditions, but the likelihood of a debris flow can be substantially increased after a wildfire.

3.4 Snow Avalanches

Post wildfire conditions with consumed undergrowth and wood on the forest floor results in reduced surface roughness that functions to anchor a snowpack. This lack of surface roughness in combination with more layers within the snowpack due to the loss of tree canopy can result in an increase in snow avalanches.

3.5 Water Quality

Wildfire also has the potential to affect surface water quality in terms of both physical and chemical impacts. Where observed, the extent of these effects is often correlated with burn severity; however, there are many other factors which play a role in the level of impact

(Jordan 2012). As previously noted, runoff rates, landslide frequency, and rates of erosion can all increase following wildfires within a watershed. All of these factors can lead to an increase in sediment yield, but the level of increase experienced in any given stream will also depend on other factors such as the rainfall timing, intensity and amounts following the wildfire as well as the connectivity of the burned areas to stream channels (Jordan 2012). Elevated suspended sediment levels can also include ash and needles from partially burned trees where there is sufficient connectivity between the burned areas and stream channels. Where elevated suspended sediment does reach domestic water intakes, increased maintenance of intake structures may be required.

Post-wildfire water chemistry changes can occur because of water temperature changes due to the loss of riparian shading, the consumption of organic materials, and the conversion of insoluble chemicals within organic matter into more readily soluble chemicals in ash (Pike et al. 2010). While there is limited research within B.C. available documenting changes to water chemistry resulting from forest fires and the potential impact to water for human consumption, some studies do exist in the Kootenay region. Based on documented findings in Jordan (2012), the concentration of nitrogen and phosphorous in surface water will likely be elevated during the first few years during high runoff events, including the spring runoff. However, where changes were observed at study sites, post-wildfire nitrogen and phosphorus concentrations in streams did not exceed drinking water quality guidelines. Jordan (2012) also reports that, in general, post-wildfire changes in chemical water quality are typically not a concern for domestic water supply and that adverse water quality effects relating to turbidity and sediment yield are more common. Assessing the potential for changes in water chemistry, including the presence or absence of heavy metals, is outside the scope of this assessment.

3.6 Timing of Wildfire Effects

Post-wildfire effects on soils are generally greatest for the first two to three years following a wildfire, with most documented post-wildfire landslides or erosion events having occurred during this timeframe. After this period, the effects become less pronounced as needle mulch can play a role in reducing erosion rates, groundcover vegetation re-establishes, and the hydrophobic soils become less persistent. Water repellent properties of high burn severity areas can reoccur during the dry summer season for two to three years following fire but have been observed to exist for up to six years (Curran et al. 2006).

Post-wildfire effects on watershed hydrology relating to tree mortality are generally longer lasting and dependent on the hydrological recovery of forests. This process can take several decades as full recovery is not achieved until a mature forest stand re-establishes.

4. ARGENTA CREEK WILDFIRE and STUDY AREA CHARACTERISTICS

The Argenta Creek Wildfire (N71058) was initiated by lightning on July 17, 2024. On July 25, the Argenta Creek wildfire grew quickly from 50 ha to 13,000-14,000 ha due to dry and hot conditions overnight that triggered extreme fire behaviour and merged with the Lavina wildfire and some smaller wildfires burning on Glacier Ridge. The final total burned area of the merged fires is 19,153 ha based on BCWS data⁴; refer to Figures 2, 3, 4.

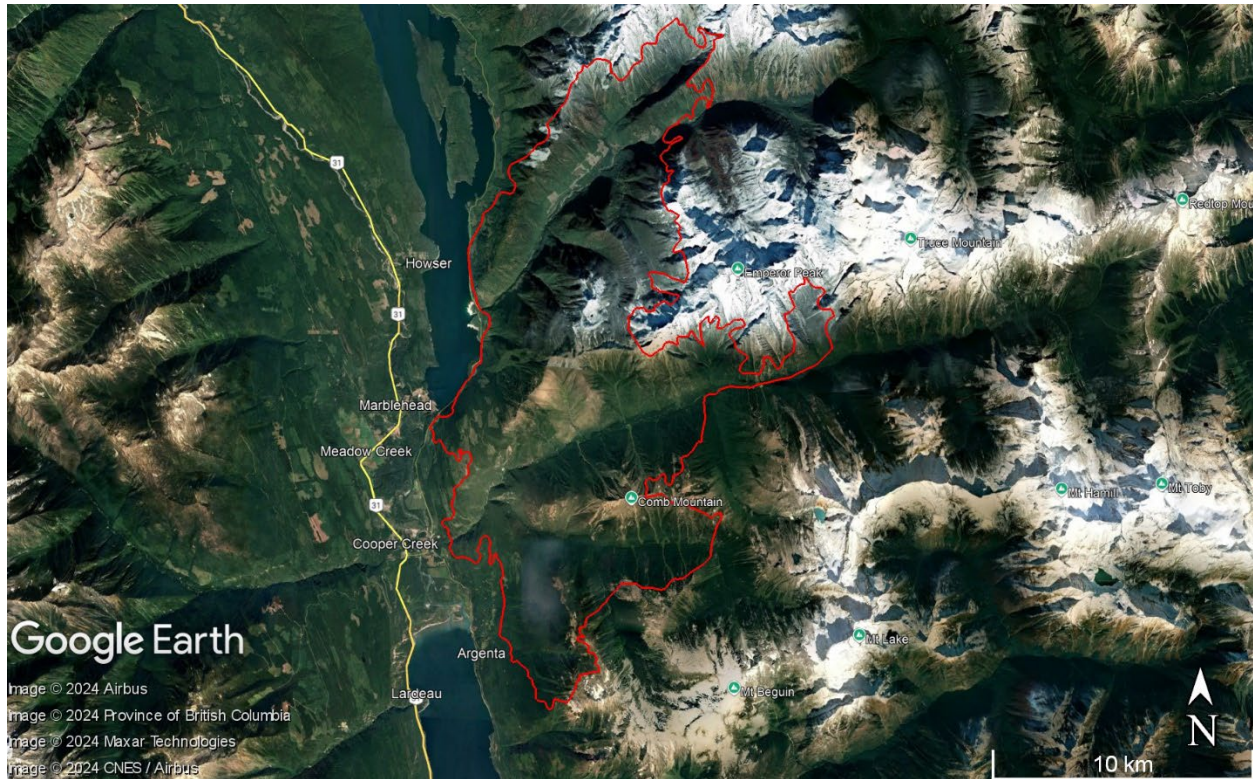


Figure 2: Fire Perimeter from BC Wildfire Service of the Argenta Creek Wildfire (N71058). Google Earth imagery is a mosaic ranging from July 2003 to September 202

4 <https://wildfiresituation.nrs.gov.bc.ca/incidents?fireYear=2024&incidentNumber=N71058&source=map>



Figure 3: July 7, 2024, Sentinel-2 L2A satellite image (pre-wildfire conditions).



Figure 4: September 5, 2024, Sentinel-2 L2A satellite image (post-wildfire conditions).

4.1 Site Location & General Physiography

The Argenta Creek Wildfire is situated in southeastern British Columbia, east of both the northern end of Kootenay Lake and the southern end of Duncan Lake in the Purcell Mountains of the Columbia Mountain System. The general physiography of the region consists of steep serrated ridges and peaks above approximately 2100 m elevation with somewhat more rounded ridge crests below. Valley sides range from moderate to steep, with some very steep areas. Summit levels lie between 2200 m and 3250 m. Local relief of approximately 1300 m to 2650 m is typical in the study area, with elevations of 580 m at Duncan Lake to approximately 3230 m at the peak of Archduke Mountain.

4.2 Climate

Based on precipitation modeling available from ClimateBC_Map⁵, the mean annual precipitation within the fire area varies from approximately 760 mm to 1600 mm, generally increasing with elevation. The majority of this precipitation falls as snow from mid-October through March or April, depending upon elevation, with rain in the summer months. Lower elevations along Kootenay Lake and Duncan Lake have a shorter winter season resulting from both the lower elevations as well as the moderating effects of the lakes.

⁵ <https://climatebc.ca/mapVersion> (Copyright (2022) University of British Columbia. All right reserved.)

Based on the referenced biogeoclimatic mapping, the Argenta Creek Wildfire falls into seven different biogeoclimatic zones, refer to Figure 5 below for a map representation of these geological units:

- Valley bottom around Kootenay Lake to 720 m - 955 m elevation: West Kootenay Dry Warm Interior Cedar Hemlock (ICHdw1). This zone contains ecosystems with frequent stand-initiating events (such as wildfire).
- Valley bottom around Duncan Lake to 1400 m - 1550 m elevation: Slocan Moist Warm Interior Cedar Hemlock (ICHmw2). This zone contains ecosystems with infrequent stand-initiating events.
- Approximately 1400 m - 1550 m elevation to approximately 1650 m elevation: St. Mary Wet Hot Engelmann Spruce – Subalpine Fir (ESSFwh2). This zone contains ecosystems infrequent stand-initiating events.
- Approximately 1650 m to 2000 m elevation: Purcell Wet Mild Engelmann Spruce – Subalpine Fir (ESSFwm2). This zone contains ecosystems with rare stand-initiating events.
- Approximately 2000 m to 2250 m elevation: Wet Mild Woodland Engelmann Spruce – Subalpine Fir (ESSFwmw). This zone contains ecosystems with rare stand-initiating events.
- Approximately 2250 m to 2400 m elevation: Wet Mild Parkland Engelmann Spruce – Subalpine Fir (ESSFwmp) / Alpine tundra and Subalpine Parkland ecosystems.
- Above approximately 2400 m elevation: Interior Mountain-heather Alpine undifferentiated (IMAun) / Alpine tundra and Subalpine Parkland ecosystems.

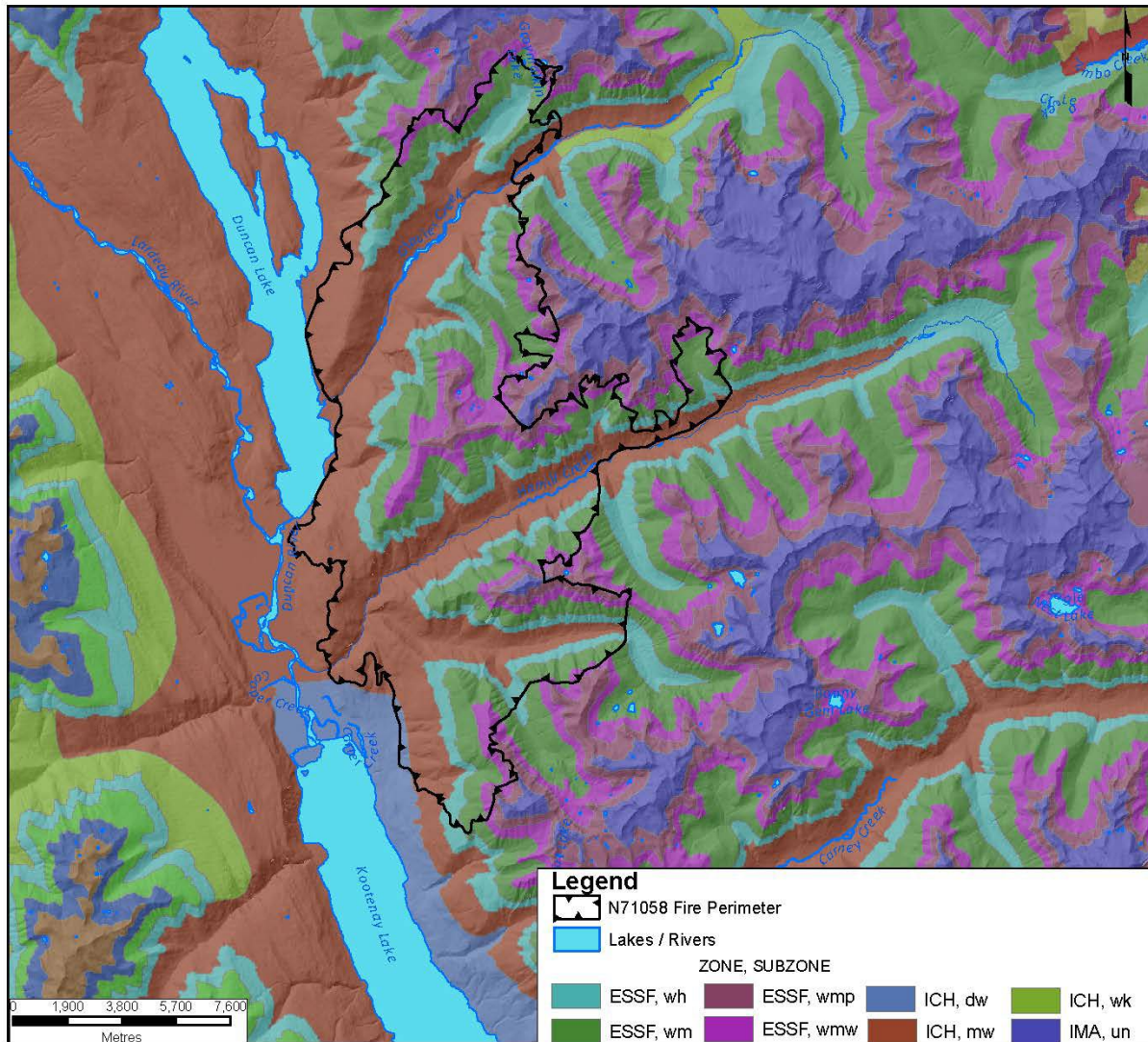


Figure 5: Biogeoclimatic Zones/Subzones within Argenta Creek Fire Perimeter

4.3 Geology

The regional geology mapping available from iMapBC indicates that the burn area is underlain by five geological units that are generally aligned in a north-south orientation (refer to Figure 6 below for a map representation of these geological units):

- Cambrian to Devonian age metamorphic rocks, composed primarily of schists from the Index Formation of the Lardeau Group;
- Cambrian age sedimentary rocks, which include limestone, dolomite, and calcareous sedimentary rocks of the Badshot Formation;
- Upper Proterozoic to Lower Cambria aged sedimentary and metamorphic rocks, which include quartzite, schist, and quartz arenite rocks of the Hamill Group;

- Jurassic age intrusive rocks, which include granodioritic rocks of the Selkirk Stocks Formation; and
- Upper Proterozoic age sedimentary rocks, which include coarse clastic sedimentary rocks of the Horsethief Creek Group.

The Badshot Formation within the study area has been classified as primary karst likelihood and high karst development intensity based on provincial reconnaissance karst potential mapping (Stokes 1999). This classification is based on regional geology mapping and the proportion of soluble bedrock. Within the fire perimeter north of Hamill Creek, the Badshot Formation consists primarily of dolomite with some interbedded crystalline limestone and phyllite. To the south of Hamill Creek, within the Badshot Formation, there is a greater presence of crystalline limestone (Fyles 1964). The high solubility of the limestone bedrock is responsible for the high karst potential within the Argenta Creek watershed, with evidence of tufa (a carbonate precipitate) observed in some seepage sites along the Argenta Creek gully indicating the emergence of groundwater from a calcium carbonate rich source.

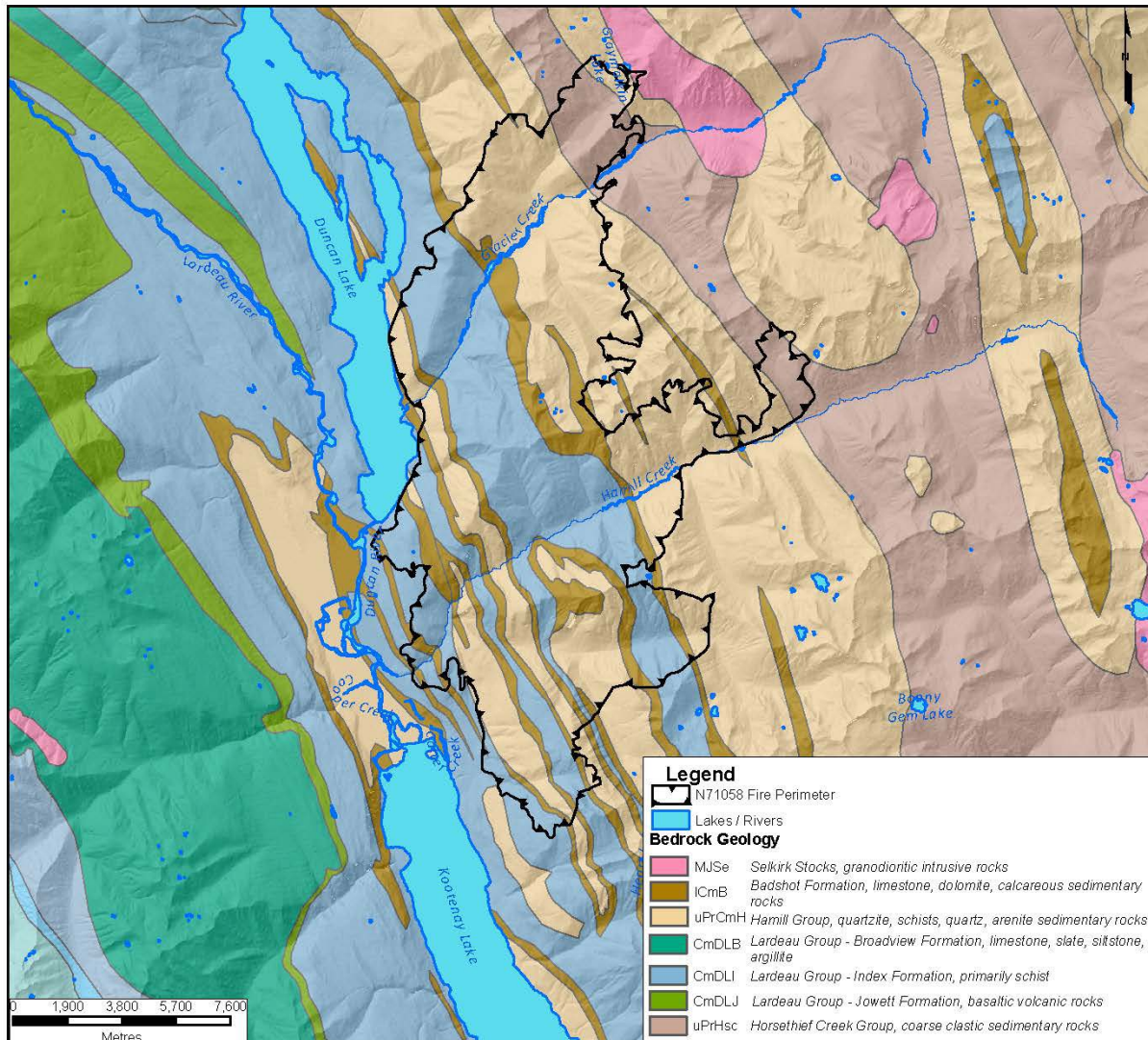


Figure 6: Argenta Creek Wildfire Bedrock Geology Map

4.4 Surficial Geology

Surficial materials within the study area mainly consist of glacial till, colluvium, and bedrock, with lesser deposits of glaciofluvial and fluvial materials. Glacial till is widely deposited on the low and moderate gradient valley sides as well as the low to moderate gradient uplands between Glacier Creek and Hamill Creek. Where slopes are steepest, exposed bedrock is at or near the surface with associated colluvial deposits. Weathered bedrock is likely to be found on some ridge crests and isolated gentle upland locations. With abundant meltwater present during deglaciation, glaciofluvial outwash deposits as well as kame or ice contact deposits and possibly isolated occurrences of glaciolacustrine deposits

were left behind in some valley bottom locations and along some valley bottom sides. More recent fluvial deposits are common along unconfined sections of the main valley bottoms.

4.5 Past Wildfire, Hydrogeomorphic, and Development History

Hydrogeomorphic activity, wildfire, and human development (forestry, mining, and residential) have altered the landscape over time in the Argenta Creek area and surroundings.

Indigenous peoples maintained seasonal camps in the area prior to the twentieth century (Utzig et al. 1983). Initially settlers arrived by boat and railway for mining and exploration, with the first mineral discoveries between 1890 and 1900 (Fyles 1964). A slow and steady increase in population along with small scale logging and farming began in the 1950's with the construction of a mining road.

Fires began to occur with increased frequency following the arrival of the settlers (Utzig et al. 1983). There is an extensive history of wildfire within the 2024 fire perimeter as seen by historical fire perimeters available in iMapBC and within the historical air photo review, particularly within Hamill Creek. Approximately 80% of the Hamill Creek watershed within the new fire perimeter has burned within the last century. Much of the lower elevation valley sides of both Glacier Creek and Clint Creek have also burned within the last century.

A history of hydrogeomorphic activity including landslides and floods was also noted within a historical air photo review of photos dated from 1945 to 2006. In general, landslide and geomorphic activity was observed to increase after a fire and lessened as the slopes affected by fire became revegetated. Further details on past hydrogeomorphic events specific to individual watersheds is presented in Section 5.

4.6 2024 Argenta Creek Wildfire Burn Severity

The Argenta Creek fire burned with significant intensity as the smaller fires in the area merged on July 25. This extreme fire behavior resulted in approximately 74% the area within the fire perimeter having a moderate or high burn severity, with 49% being high (refer to Figure 7 below and Figures F1, F2, F3 and F4 in Appendix F). The burn severity proportions are also outlined for individual watershed units throughout Section 5 of this report.

The preliminary burn severity mapping provided by MoF was created using a Differenced Normalized Burn Ratio (dNBR) calculation on pre- and post-fire imagery using a one year later classification which was classified into four Burned Area Reflectance Classification (BARC) categories (unburned, Low, Moderate, and High). Field verification was used to modify BARC burn severity mapping to produce a modified soil burn severity mapping layer. In general, the total burned area was increased by approximately 9%, with most of the

change relating to an increase in Moderate and High ratings; refer to Figure 7. Areas where changes were most significant include:

- Argenta Creek area: based on field work and extrapolated to adjacent areas using the high resolution post-wildfire satellite imagery there was an increase in Low to Moderate soil burn severity in areas mapped as unburned by BARC;
- Clint Creek and Hamill Creek areas: the BARC mapping was found to be less reliable in alpine and treeline elevations, and modifications in terms of increasing and decreasing burn severity were made based on a combination of the helicopter overview flight observations and the high resolution post-wildfire satellite imagery; and
- Glacier Creek and Birnam Creek: based on observations from the helicopter flight in combination with ground observations there was generally an increase in soil burn severity in comparison with BARC mapping.

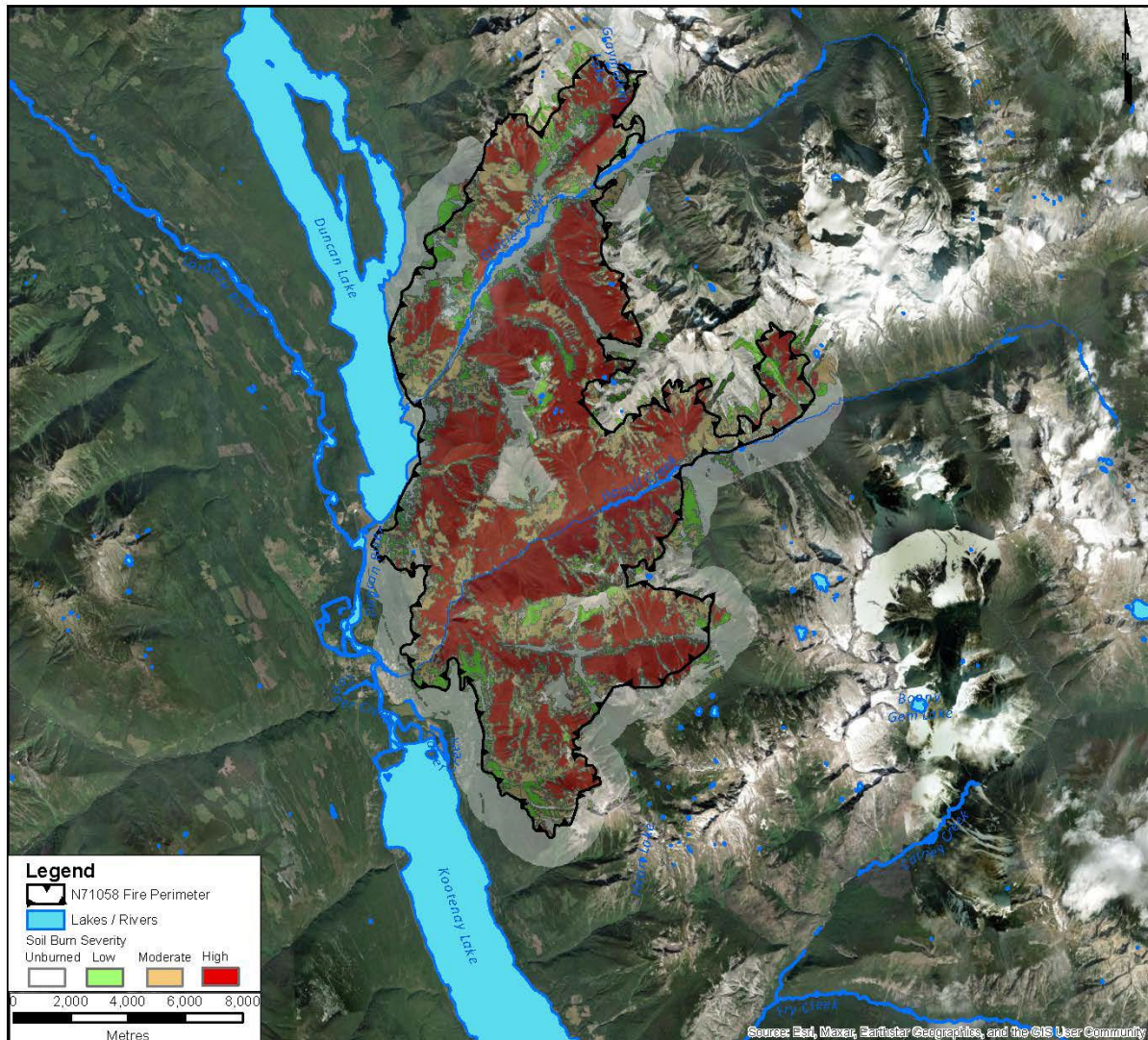


Figure 7: Modified Soil Burn Severity Map

5. SPECIFIC WATERSHED CHARACTERISTICS, HAZARDS, and RISKS

The fire area has been divided into individual watersheds or face units for the purpose of discussion and risk analysis. These areas have been delineated based on natural watershed boundaries as outlined in Section 2.5 and shown on Figures F1, F2, F3, F4 in Appendix F. Further discussion for each area or group of areas is presented below, from south to north.

5.1 Bulmer Creek

5.1.1 Watershed Characteristics

Bulmer Creek is located on the south and west side of Mt. Willet, south of Argenta Creek. The Bulmer-Argenta Face is situated between Bulmer Creek to the south and Argenta Creek to the north.

Terrain and Watershed Morphology

Bulmer Creek is a steep, mountainous watershed extending from 2760 m elevation at ridgetop to 700 m elevation near the apex of the fan at Kootenay Lake. Till and colluvium are the predominant surficial materials as well as bedrock outcrops. Debris flow and snow avalanche paths are common in the upper watershed elevations, with debris flows periodically reaching the valley bottom fan.

The Bulmer-Argenta Face unit ranges from 2640 m elevation at ridgetop to 540 m at lake shore. It has predominantly moderate gradient benched terrain with cross-slope ridges and benches controlled by the underlying bedrock. Short steep gradient slopes with occasional bedrock outcrops are separated by the lower gradient benches.

Fan Characteristics

Bulmer Creek has a well-defined fan where it meets Kootenay Lake. The fan has a relict erosional escarpment approaching the lake indicating primary formation during the early post-glacial period (paleo fan), but there are smaller present-day fans that extend past the escarpment to meet the lake. The upper half of the fan also shows a profile and roughness consistent with debris flow fans in the region, and vegetation trim lines in the gully and upper fan indicate relatively recent debris flood or debris flow activity. The fan is mostly on private land with residential development located along the lakeshore.

5.1.2 Burn Severity

A negligible area was burned within Bulmer Creek (<1%), and only a very small proportion of the Bulmer-Argenta Face was burned (4%). The burned area on the Bulmer-Argenta Face is distributed along the ridgetop position only. The fire burned along this ridge mostly at low to moderate burn severity. Refer to Table 1 below for a summary of the mapped soil burn severity as shown in Appendix F, Figure F1.

Table 1: Summary of watershed area and burn severity for Bulmer Creek.

Watershed Unit	Watershed Unit Area	Area Burned		% Burn Severity					
				Low		Mod		High	
	km ²	km ²	%	km ²	%	km ²	%	km ²	%
Bulmer Creek	9.6	0.011	0.1%	0.006	0.1%	0.0	0.0%	0.0	0.1%
Bulmer-Argenta Face	8.5	0.340	4.0%	0.12	1.4%	0.16	1.9%	0.06	0.7%

5.1.3 Post-wildfire Hydrogeomorphic Hazards

Considering the very small amount of burned areas within these watershed units, and the narrow linear distribution of burned area upslope of the face unit which limits the potential for concentrated effects of the fire on the downslope terrain, the incremental increase in the likelihood of natural hazards due to the wildfire in Bulmer Creek and on the Bulmer-Argenta Face is considered insignificant in comparison to the pre-fire conditions (Very Low incremental increase). No further hazard or risk analysis has been carried out.

5.2 Argenta Creek

5.2.1 Watershed Characteristics

Argenta Creek is located east of the community of Argenta, on the west slope of Mt. Willet. The watershed extends from 2760 m at the ridgetop to 580 m at the apex of fan.

The Argenta Creek South Fork is a significant tributary to the main channel. The drainage extends from 2680 m at the ridgetop to 1140 m at confluence with main channel of Argenta Creek (Appendix A, Photo 4).

The Argenta Creek North unit and the Argenta-Carter Face units do not contribute to Argenta Creek stream flow by means of surface runoff and are described separately in Section 6.3.

There is a degree of groundwater influence to Argenta Creek based on observed bedrock aquifer sourced seepage areas along the gully sidewalls, which likely helps moderate annual low flows. However, in general, the drainage is snowmelt dominated with late spring peak flows and midsummer through winter low flows.

Terrain and Watershed Morphology

Argenta Creek is a steep, mountainous watershed with till and colluvial surficial materials as well as bedrock outcrops (Appendix A, Photo 2). The watershed has snow avalanches, rock fall, and debris flows as the primary hydrogeomorphic processes. Snow avalanches and rockfall are generally limited to the upper elevations of the watershed, but debris flows

will periodically run to near valley bottom. Refer to Appendix F, Figure F5 and F6 for a stream profile of Argenta Creek and the South Fork.

The higher elevation reaches of Argenta Creek and the south fork generally have less gully confinement upstream of approximately 1400 m elevation. In these upper reaches there is less potential for in-channel debris flow initiation and also more potential for debris avalanche or debris flow deposition if initiated on a steeper valley side. The reach in Argenta Creek between approximately 1400 m and 1750 m elevation is steep enough to allow for debris flow transport but is not tightly confined to a single gully. Recent (possibly post-wildfire) small to medium sized debris flows originating on the southwest aspect slope in upper Argenta Creek near 2200 m elevation were observed in the helicopter overview flight; these debris flows terminated on a steep colluvial cone between 1800 m and 1850 m elevation prior to reaching Argenta Creek (Appendix A, Photo 3), and did not continue downstream as a debris flow in Argenta Creek. Evidence of other older debris flows on the steep gullied valley sides upslope of 1800 m elevation was also observed, but no evidence of these events continuing downstream as a debris flow was noted.

A debris flow initiating in the Argenta Creek South Fork channel near 1350 m elevation occurred in May 1997, impacting domestic water quality and supply in Argenta Creek and causing flooding on adjacent private lands. This debris flow mostly deposited at approximately 790 m elevation in an area of reduced channel gradient and confinement, but secondary debris transport did continue to approximately 720 m elevation.

At approximately 860 m elevation the creek channel exits the steeper bedrock-controlled basin and gully system where thinner surficial materials dominate and enters a broad benched area of primarily thick surficial material deposits. Argenta Creek remains well confined in a gully throughout this lower reach to the apex of the fan, although does have short reaches with a broad gully bottom and less channel confinement. Within this lower gradient reach there is an 800 m distance between approximately 700 m and 860 m elevation with intermittent less confined reaches and channel gradients between 10% and 20% where evidence of past (reforested) debris flow deposition has occurred.

Fan Characteristics

Argenta Creek has a small but well-defined fan at Kootenay Lake (Appendix A, Photo 5). The fan has an average slope gradient of 17% and is crossed by the Argenta Road near the apex (refer to Appendix F, Figure F5 for a creek profile). The fan surface has been modified by private land development, and there are residences on the fan. Argenta Creek has low confinement on the fan downslope of the lower Argenta Road crossing. Visual identification of the presence or absence debris flow history was not possible from Argenta Road crossing, but large boulders along the lakeshore at the edge of the fan indicate large bedload

movement has occurred in the past, but an estimated frequency of debris flows reaching the fan was not determined.

5.2.2 Burn Severity

The Argenta Creek watershed and adjacent units experienced a significant amount of High vegetation and soil burn severity (Appendix A, Photo1). Within the Argenta Creek South Fork there was a higher degree of soil burn severity observed than reflected in the original BARC mapping; this has been corrected in the modified soil burn severity mapping shown in the figures and in the burn area statistics.

Much of the high burn severity areas are in the upper elevations of the watershed above 1600 m elevation. Argenta Creek Main and South Fork channels and riparian areas remain mostly unburned downslope of 1800 m elevation. Where burned areas did encroach on the channel downslope of 1800 m elevation, they are generally not extensive and have Low to Moderate soil burn severity.

Refer to Table 2 for a summary of the mapped soil burn severity as shown in Appendix F Figure F1.

Table 2: Summary of watershed area and burn severity for Argenta Creek.

Watershed Unit	Watershed Unit Area	Area Burned		% Burn Severity					
				Low		Mod		High	
				km ²	%	km ²	%	km ²	%
Argenta Creek	6.6	4.8	73%	1.0	16%	1.9	29%	1.8	28%
Argenta Creek South Fork	1.7	1.2	69%	0.4	25%	0.6	32%	0.2	12%

5.2.3 Post-wildfire Hydrogeomorphic Hazards

Debris Flows

There is a very high likelihood of small to medium sized post-wildfire debris flows initiating in the steep gullied sidewalls of the upper Argenta Creek basin where there is high soil burn severity and evidence of recent debris flows. Most of these events would be very unlikely to continue downstream Argenta Creek in this upper basin area due to the low channel confinement.

There is a high likelihood of medium sized post-wildfire debris flows in Argenta Creek, considering the extent of moderate to high burn severity within the watershed and the past history of debris flows. Debris flows could initiate as in-channel mobilization during a very high runoff event associated with short duration intense summer or early fall rain on hydrophobic soils, or during period of high runoff in spring or fall. Debris flows could also

initiate from a destabilizing impact from a smaller debris flow in a tributary gully or a landslide off the steep valley sides in areas of moderate or high burn severity.

Debris flows in Argenta Creek would most likely terminate on gentle gradient reaches in the lower gully between 700 m and 825 m elevation based on evidence of past events depositing in this area (including the 1997 event). While less likely, there is the possibility of a larger event continuing downstream to reach the fan at Kootenay Lake.

Floods

Much of the upper watershed elevations above 1600 m elevation burned at moderate to high burn severity. Snowmelt in these elevations generally has the greatest influence on spring freshet flows. A significant portion of this area had lower crown closure than typical mid elevation forests due in part to the steep and rocky terrain with colluvial materials. This would moderate the incremental increase in snow accumulation and melt rates in comparison with a more closed canopy forest; however, it would not necessarily reduce the effects of changes to the forest floor.

Considering the extent of moderate to high burn severity within the upper watershed area of Argenta Creek there is a high likelihood of increased peak flows due to the fire. The high degree of tree mortality is expected to result in increased snow accumulation and melt rate, elevating the potential for peak flow flooding. This effect is likely to take decades to return to pre-fire conditions as forests regenerate.

5.2.4 Downslope Elements and Likelihood of Spatial Impact

1. **Domestic PODs** in Argenta Creek (refer to Appendix D for a list of water licenses and Appendix F Figure F1 and F5 for a map and stream profile with POD locations).
 - a. There are 12 PODs within Argenta Creek associated with numerous domestic water licenses, as well as many irrigation licenses and a commercial power license. In the event of a debris flow in Argenta Creek, it is likely to deposit most of the material within an area of low gradient and low confinement near 800 m elevation. In this case, the open diversion channel of PD24939 would likely be damaged, and sediment laden flow or high turbidity would likely reach and potentially damage all downstream POD infrastructure such as settling tanks, screens, and conduits. If a debris flow were to continue downstream to near 700 m elevation or beyond, then the extent of damage to lower PODs would be greater.
 - b. Elevated levels of turbidity can also be expected in Argenta Creek at the PODs during times of high runoff or intense precipitation due to increased sediment

delivery to the creek within the fire area associated with erosion of exposed ash, soils and landslides.

2. Private Land adjacent to Argenta Creek

- a. The Argenta Creek gully crosses through private land for most of the reach from near 800 m elevation to Kootenay Lake. Apart from POD infrastructure, there are no private structures within the gully. A POD access trail enters the gully from the south side near 720 m elevation. This trail was a source of sediment laden flow division out of the gully onto the adjacent open slope during the 1997 debris flow event. In the present condition of the trail, a similar flow diversion would be possible, with the resulting potential for sediment laden flow and flooding to spatially affect downslope properties on the south side of the gully.

3. Private Land and Dwellings on Argenta Creek Fan

- a. As documented in the MoF Level 2 PWNHRA report, there are three rural addresses on this fan with one occupied year round, one seasonally, and one abandoned. The occupied dwellings are located on the downstream side of Argenta Road.
- b. In the event of a post-wildfire debris flow in Argenta Creek, it would likely terminate upstream of the fan apex (~565 m elevation) considering the extent of low gradient reaches between 700 m and 825 m elevation. However, while unlikely it would be possible for a larger debris flow to reach the valley bottom fan having a spatial impact to the dwellings based on comparison with runout distances of other post-wildfire debris flows in the region.
- c. Post-wildfire flooding processes in Argenta Creek would likely have an impact on the private land on the fan due to the relatively low confinement of the creek channel on the fan. The dwelling closest to the creek downslope of the Argenta Road would be the one most likely to be affected.

4. Argenta Road (upper crossing)

- a. The upper Argenta Road crossing is in a confined gully reach with 10% gradient channel immediately upstream of the road for ~25 m with 15%-17% gradient continuing upstream. There is a 1200 mm culvert and approximately 3.5 m of fill at the crossing, and the road has a slight low point in the grade. There is no evidence of debris flows reaching the crossing location within the life of the forest. The culvert appears to be accommodating annual high flows without signs of overflow or ponding at the inlet.

- b. In the event of a debris flow in Argenta Creek, it is likely to terminate upstream of the road crossing based on evidence of past events as well as the extent of reaches <20% gradient where debris flow deposition is likely to occur, but sediment laden flow could be expected to reach the site.
- c. In the event of a debris flow reaching the crossing, it would most likely block the culvert and overflow the road into the gully below. There is a subtle low point at the crossing, but debris deposition on the road surface would alter this grade and water or sediment laden flow could continue down the road grade (-4%) to the south, potentially affecting adjacent private land outside of the gully.
- d. Post-wildfire flooding process in Argenta Creek would likely have a spatial impact on the road crossing. The culvert could potentially become partially blocked and overwhelmed with flow.

5. Argenta Road (lower crossing)

- a. The lower Argenta Road crossing is situated near the apex of the fan.
- b. In the event of a debris flow in Argenta Creek, it is likely to terminate upstream of the road crossing based on evidence of past events as well as the extent of reaches <20% gradient where debris flow deposition is likely to occur, but sediment laden flow could be expected to reach the site.
- c. In the event of a debris flow reaching the crossing, it would most likely block the culvert and overflow the road into the gully below. Sediment laden flow could continue down the road grade to the north due to the consistent grade, potentially affecting adjacent private land outside of the gully.
- d. Post-wildfire flooding process in Argenta Creek would likely have a spatial impact on the road crossing. The culvert could potentially become partially blocked and overwhelmed with flow.

5.2.5 Partial Risk Summary

Partial risk ratings are presented in Table 3. Rational for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 3: Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Argenta Creek.

Watershed Unit	Argenta Creek				
Elements at Risk	Domestic POD's	Private Land	Private Residence (fan)	Argenta Road (Upper crossing)	Argenta Road (Lower crossing)
Hazard Event	Hazard Rating - Likelihood of Event P(H)				
Flood/Debris Flood or Sediment Laden Flow	H	H	H	H	H
Debris Flow	H	H	H	H	H
Hazard Event	Likelihood of Spatial Effect P(S:H)				
Flood/Debris Flood or Sediment Laden Flow	H	H	M	H	H
Debris Flow	H	H	L	M	L
Hazard Event	Partial Risk P(HA) = P(H) x P(S:H)				
Flood/Debris Flood or Sediment Laden Flow	VH	VH	H	VH	VH
Debris Flow	VH	VH	M	H	M

5.3 Argenta – Carter Face and Argenta Creek North

5.3.1 Watershed Characteristics

Argenta Creek North unit and the Argenta-Carter face unit are located east of the community of Argenta and north of Argenta Creek. Elevations along the Argenta-Carter face unit ranges from approximately 540 m at the Lake to 2320 m at ridgetop. Argenta Creek North ranges from 2420 m to 800 m in elevation.

These watershed areas consist of a gullied terrain between approximately 900 m and 1400 m elevation, with more irregular and benched terrain continuing upslope to ridgetop. These two units do not contribute to Argenta Creek stream flow by means of surface runoff.

Terrain and Watershed Morphology

Within the Argenta Creek North and Argenta-Carter Face units there are no perennial stream channels, but some intermittent channels and seepage areas to exist (streams shown on Figure F1 in Appendix F are TRIM based on may not be accurate). Gullies generally have no

alluvial beds, but some do have evidence of post-wildfire surface flow. There are some reforested debris flow deposits extending out the bases of some gullies, including the Argenta Creek North unit, but no evidence of recent debris flows within the life of the forest. Debris flow deposits associated with these gullies appear to terminate upon reaching the unconfined gentle gradient terrain near 800 m elevation. These gully systems were primarily formed by early post-glacial landslide and erosion processes when terrain and climatic conditions were different than today. Present day gully processes such as gully sidewall failures, channel erosion, or debris flows do occur periodically, but are infrequent in comparison with the past.

5.3.2 Burn Severity

Approximately 93% of the Argenta Creek North watershed was impacted by the Argenta Creek fire, with 86% Moderate to High burn severity; refer to Table 4. Approximately 65% of the Argenta-Carter Face unit was impacted by the Argenta Creek fire, with 56% Moderate to High burn severity (Appendix A, Photo 6). Refer to Table 4 for a summary of the mapped soil burn severity as shown in Appendix F Figure F1.

Table 4. Summary of watershed area and burn severity for Argenta Creek North and Argenta-Carter Face.

Watershed Unit	Watershed Unit Area km ²	Area Burned km ² %		% Burn Severity					
				Low		Mod		High	
				km ²	%	km ²	%	km ²	%
Argenta Creek North	2.1	1.9	93%	0.2	7%	1.0	46%	0.8	40%
Argenta-Carter Face	6.8	4.4	65%	0.5	8%	1.5	21%	2.4	35%

5.3.3 Post-wildfire Hydrogeomorphic Hazards

Landslides

There is a high likelihood of post-wildfire debris flows in the Argenta Creek North and Argenta-Carter Face units considering the extent of moderate to high burn severity within the watersheds and the past history of debris flows. A debris flow event would most likely terminate on the gentle to moderate gradient slopes where the gullies lose confinement near the eastern boundaries of private land, but sediment laden flow could continue across the gentle gradient downslope terrain.

Flooding

The Argenta Creek North and Argenta-Carter Face units do not have stream channels extending beyond the gullies but will likely experience overland flow and sediment laden

flow in the post-fire environment due to the loss of forest floor coverage and fire effects on the soil. This has already happened in some locations.

5.3.4 Downslope Elements and Likelihood of Spatial Impact

Argenta Creek North and Argenta-Carter Face

1. Private land with residences

- a. In the event of a debris flow, private land would likely be affected due to the proximity of the base of the gullies. Existing residences on the private land parcels are not situated near the base of the gullies and are unlikely to be directly impacted.
- b. In the event of flooding or sediment laden flow extending from the base of the gully, private land would likely be affected due to the proximity of the base of the gully. Existing residences on the private land parcels are not situated near the base of the gully and are unlikely to be directly impacted.

2. Domestic water intakes

- a. There are no domestic water intakes downslope of Argenta Creek North. There are domestic water intakes associated with both springs and surface water (Seamark Brook and Mautner Brook) downslope of Argenta-Carter Face. The spring locations (PD24938, PD24962) are not associated with a significant upslope gully, and are unlikely to be effected by landslides or flooding. The surface water intakes (PD24934 and PD24936) are situated downslope of the southernmost of two main gully systems on the Argenta-Carter face. These two intakes may be impacted by debris flow or flooding events originating in the upslope gully system.

5.3.5 Partial Risk Summary

Partial risk ratings are presented in the Table 5 below. Rational for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 5. Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Argenta Creek North and Argenta-Carter Face.

Watershed Unit	Argenta Creek North		Argenta-Carter Face		
Elements at Risk	Private Land	Private Residences	Private Land	Private Residences	Domestic PODs
Hazard Event	Hazard Rating - Likelihood of Event P(H)				
Flood / Debris Flood or Sediment Laden Flow	H	H	H	H	H
Debris Flow	H	H	H	H	H
Hazard Event	Likelihood of Spatial Effect P(S:H)				
Flood / Debris Flood	H	L	M	L	M
Debris Flow	H	L	M	L	M
Hazard Event	Partial Risk P(HA) = P(H) x P(S:H)				
Flood / Debris Flood	VH	M	H	M	H
Debris Flow	VH	M	H	M	H

5.4 Carter Creek

5.4.1 Watershed Characteristics

Carter Creek is a southerly draining stream with a relatively low channel gradient (average ~11% upstream of 700 m elevation). Carter Creek ranges from 670 m elevation at the intersection with the Argenta-Carter Face to 2040 m elevation at ridgetop. Based on the stream flow and channel characteristics and consistent with information from past assessments in the area, Carter Creek appears to be a deep spring fed watercourse with very little seasonal variation. As a result of the bedrock aquifer source, the topographic based watershed unit delineated for Carter Creek that represent surface flow and shallow subsurface flow patterns is unlikely accurate for the spring source.

The Carter Creek Watershed Unit has also been delineated using a convergence area for tributary streamflow downslope of Argenta Road as the lower point of interest as opposed to where the stream enters Kootenay Lake. This effectively separates the Argenta-Carter Face from Carter Creek upslope of Argenta Road and is suitable for the intended purpose.

The Carter-Hamill Face is located to the northeast of Carter Creek and has no known streams or springs. Carter-Hamill Face ranges from 540 m to 1160 m elevation.

Terrain and Watershed Morphology

Carter Creek is situated within a broad low gradient basin with an irregular and benched face upslope to the east of Argenta Road. There are no continuous gullies on this face unit within the watershed and short steep gradient slopes are controlled by the local bedrock structure. The creek location has been modified from TRIM mapping based on a combination of field verification and LiDAR data review, and while considered suitable for this assessment it may not be accurately mapped in all sections. Flooding is not a common occurrence in Carter Creek due to the attenuation of flow from the bedrock aquifer and limited seasonal input from shallow subsurface runoff. Debris slides may occur periodically on the short steep slopes within the watershed unit, but in general mass wasting events are uncommon and not likely to continue downslope for significant distances due to the benched topography.

The Cater-Hamill Face unit has predominantly moderate gradient benched terrain with cross-slope ridges and benches controlled by the underlying bedrock. While there are short steep gradient slopes with occasional bedrock outcrops, they are separated by lower gradient benches. There are no significant gullies on this face unit, but localized rockfall and small debris slides may occur periodically.

Fan Characteristics

There is no present-day fan landform associated with Carter Creek due to the limited sediment transport capacity of the stream.

5.4.2 Burn Severity

The Carter Creek watershed unit delineated for the purpose of this assessment does have a notable amount of Moderate and High soil burn severity in the eastern half of the unit; however, there is no direct surface flow connectivity between these areas and the stream.

The Carter-Hamill Face experienced mostly Low with some Moderate burn severity, with the fire area concentrated in the upper ridge top area and dispersed patches lower on the face. Riparian areas are generally either unburned or experienced low burn severity.

Refer to Table 6 below for a summary of the mapped soil burn severity as shown in Appendix F, Figure F1.

Table 6. Summary of watershed area and burn severity for Carter Creek

Watershed Unit	Watershed Unit Area	Area Burned		% Burn Severity					
				Low		Mod		High	
	km ²	km ²	%	km ²	%	km ²	%	km ²	%
Carter Creek	5.2	3.4	64%	1.2	22%	1.1	21%	1.1	22%
Carter-Hamill Creek	2.2	0.6	25%	0.4	17%	0.2	8%	0.0	0%

5.4.3 Post-wildfire Hydrogeomorphic Hazards

Landslides and Rockfall

Small debris slides and raveling within the Carter Creek watershed unit are possible where High soil burn severity has affected short steep slopes, but these processes are unlikely to continue downslope past gentle gradient benches, considering the lack of converging drainages or gully confinement.

The irregular and benched terrain along the Carter-Hamil Creek face unit limits connectivity with most of the fire area and valley bottom elements, including private land, resulting in a Low incremental increase in the likelihood of hazardous landslides or rockfall in comparison with pre-fire conditions.

Flooding

Localized increases in surface runoff within the Carter Creek unit are possible due to the extent of moderate and high burn severity. However, flood events in Carter Creek because of the Argenta Creek fire are unlikely due to the apparent separation between upslope seasonal surface runoff and attenuated spring-derived streamflow.

5.4.4 Downslope Elements and Likelihood of Spatial Impact

Carter Creek

1. Private land and dwellings

- a. Private land and dwellings are unlikely to be impacted from debris slides due to the benched nature of the upslope terrain that would likely cause deposition of small landslides.
- b. Carter Creek flows through private property with low confinement. Therefore, if flooding were to occur the private property is likely to be impacted.

2. Argenta Road

- a. Argenta Road is unlikely to be impacted from debris slides due to the benched nature of the upslope terrain that would likely cause deposition of small landslides.
- b. Argenta Road would be impacted by flooding in Carter Creek if it were to occur as there are two creek channels that cross the road through culverts.

3. Domestic water intakes

- a. Domestic water intakes are unlikely to be impacted from debris slides due to the benched nature of the upslope terrain that would likely cause deposition of small landslides.

- b. Domestic Water intakes within the Carter Creek watershed unit, whether spring derived or in Carter Creek, could be impacted by flooding processes if they were to occur.
- c. Significant elevated levels of turbidity due to the fire are not expected in Carter Creek at the PODs because of the spring source and disconnect between the creek and areas of Moderate to High burn severity.

Carter-Hamill Face

1. Private land with residences and Argenta Road

- a. There is private land along and upslope of Argenta Road at the western edge of the Carter-Hamil Face. Some of the northernmost private land parcels experienced low to moderate burn severity along their eastern, upslope boundaries. The private land is mostly separated from the localized areas of moderate burn severity on this face unit, as is Argenta Road, and they are unlikely to be affected by fire related hydrogeomorphic hazards.

5.4.5 Partial Risk Summary

Partial risk ratings are presented in Table 7. Rational for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 7. Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Carter Creek.

Watershed Unit	Carter Creek			Carter-Hamill Face	
Elements at Risk	Domestic POD's	Private Property	Argenta Road	Private Residence	Argenta Road
Hazard Event	Hazard Rating - Likelihood of Event P(H)				
Flood	L	L	L	-	-
Debris Slide	M	M	M	L	L
Rockfall	-	-	-	L	L
Hazard Event	Likelihood of Spatial Effect P(S:H)				
Flood	H	H	H	-	-
Debris Slide	L	L	L	L	L
Rockfall	-	-	-	L	L
Hazard Event	Partial Risk P(HA) = P(H) x P(S:H)				
Flood	M	M	M		
Debris Slide	L	L	L	VL	VL
Rockfall	-	-	-	VL	VL

5.5 Hamill Creek and Clint Creek

5.5.1 Watershed Characteristics

Hamill Creek is a large watershed extending to the main divide of the Purcell Mountains near 3150 m elevation, with Clint Creek being a significant southern tributary that joins Hamill Creek ~2.7 km upstream of the Hamill Creek fan. The burned area of these two watersheds lies mostly within the Purcell Wilderness Conservancy Park. There is significant alpine terrain in these drainages and some permanent snow fields, as well as glaciated terrain. Recent past wildfires in Hamill Creek occurred in 2007 (1528 ha) as well as 2022 (246 ha) and 2023 (710 ha in Hamill Creek, 479 ha in Clint Creek).

Terrain and Watershed Morphology

The Hamill Creek and Clint Creek watersheds have steep valley sides with a combination of till and colluvial materials as well as frequent bedrock outcrops. Rockfall, debris flows, and debris slides likely occur at a frequency of less than five years, and large snow avalanches occur annually in the upper watershed. These processes commonly impact Hamill Creek introducing wood and sediment into the stream system. Debris slides, debris flows, rock fall and smaller snow avalanches are also common processes in the lower canyon reach of Hamill Creek, downstream of the confluence with Clint Creek. Based on the Melton Ratio (0.15) and due to the size of the watershed and relatively low channel gradient of the creek, flooding is likely to be the dominant hydrogeomorphic process in the channel. This is consistent with field observations of the fan morphology. Periodic debris floods may occur in Clint Creek due to the steeper gradient but are unlikely to continue downstream in Hamill Creek.

Fan Characteristics and Flood History

Hamill Creek has a large alluvial fan (Appendix A, Photo 12) where it joins the Duncan River valley near 670 m elevation. Based on documented events both in the 1920's and 2013 as well as the historic air photo review, Hamill Creek fan is an active fluvial fan subject to periodic avulsion. In the 1920's, it is reported that an avalanche/debris flow in Hamill Creek caused the creek to change its course from flowing into Kootenay Lake to its present discharge into Duncan River (Rodman, 1996). Historic air photos show fresh avulsion channels visible on the 1945 photographs and most recently, flood events resulting in channel changes and damage to bridge infrastructure in October 2003 and in June 2013. During this most recent event, a mobile trailer was taken downstream, a cabin was flooded and the approach to the bridge was washed out on both sides (Thiessen, 2013).

Following the 2013 flood event, the lower reach of Hamill Creek was flown by Peter Jordan, P.Geo., and Dwain Boyer, P.Eng. of MoF and it was reported that there was no evidence of

landslide dams or outburst floods, but that the flood event appeared to originate from very high rainfall in the upper watershed. At that time there was small log jams noted in the upper watershed, and several recent debris flows, debris slides, and snow avalanches observed which contributed wood to the channel, but no log jam was noted in the lower canyon reach approaching the fan.

5.5.2 Burn Severity

Approximately 27% of the Hamill Creek watershed was impacted by the Argenta Creek fire, with 24% moderate to high burn severity (Appendix A, Photo 10). Much of the areas previously burned in 2007 as well as in 2023 burned again during the 2024 fire. The reduced fuel load available for burning in these areas may have reduced fire intensity; however, it did not stop the fire due to the extreme fire behaviour at the time. Refer to Table 8 below for a summary of the mapped soil burn severity as shown in Appendix F Figure F2.

Much of the Hamill Creek riparian area within the fire perimeter experienced Moderate to High burn severity (Appendix A, Photo 9). Clint Creek experienced less severe burn along the riparian area, with green canopy remaining for most of the creek length in the fire perimeter.

Table 8. Summary of watershed area and burn severity for Hamill Creek and Clint Creek.

Watershed Unit	Watershed Unit Area km ²	Area Burned km ² %		% Burn Severity					
				Low		Mod		High	
				km ²	%	km ²	%	km ²	%
Hamill Creek	297.8	80.3	27%	10.2	3%	24.7	8%	45.3	15%
Clint Creek	71.0	24.0	34%	3.03	4%	7.75	11%	13.2	19%

5.5.3 Post-wildfire Hydrogeomorphic Hazards

Landslides

Post wildfire landslides including debris flows and debris avalanches occurred in Hamill Creek in August and September 2024 based on observations made during the overview helicopter flight (Appendix A, Photo 8) and reports of varied turbidity levels in Hamill Creek. These landslides occurred in steep terrain and had direct impacts with the creek, introducing both wood and sediment. No channel instability along Hamill Creek or Clint Creek was observed and no debris flow or debris flood events continued down the main channels.

Debris flows and debris avalanches can be expected to increase in frequency within Hamill Creek and Clint Creek due to the extent of moderate to high burn severity in areas already prone to landslides. These landslides are likely to terminate near or within the main creek

channels, introducing wood and sediment, but are not likely to continue downstream as larger debris flows.

Snow Avalanches

Large snow avalanches can be expected to increase in frequency and magnitude within the Hamill Creek and Clint Creek drainages due to the loss of forest canopy in areas of steep high elevation terrain with high burn severity. Smaller snow avalanches are also likely to increase in frequency in the lower elevation canyon reach of Hamill Creek where forest canopy has been consumed. These events will likely introduce additional wood to the main channel, increasing the potential for log jam formation.

Flooding

A significant increase to flood hazard due to increased runoff in the post-wildfire environment is unlikely due to most of the burn being in the lower elevation areas and only 15% of the watershed being burned at high burn severity and 8% at moderate burn severity. Peak flows in Hamill Creek are generated from high elevation snow melt which would occur when much of the lower elevation burned areas have already become snow free. However, a flood hazard relating to significant log jam formation and breach is possible due to the known presence of a jam as discussed below.

Log Jam

Presently, there is a substantial log jam located in the lower Hamill Creek Canyon, approximately 750 m upstream of the fan apex and 1.2 km upstream of the Duncan FSR crossing (Appendix A, Photo 11). The log jam is situated in a tight bedrock constriction that is inside the provincial park boundary. This log jam appears to have been existing before the fire based on the weathered wood condition of the frontal jam, but it has accumulated a significant amount of additional wood since the fire associated with post-wildfire landslides in the adjacent canyon reach. There appears to be some water pooling upstream of the log jam, with the potential for an increase in volume as more wood accumulates. Based on observations from the August helicopter overview flight as well as drone photograph observations on October 1 and December 2, 2024 there was no significant changes to wood accumulation or pooling volume during the fall of 2024. Further analysis would be required to accurately estimate the volume of pooled water or woody debris; however, safe access is limited due to the steep bedrock canyon.

There is uncertainty as to how this log jam will behave over time with an increase in wood, debris, and sediment loading associated with the fire. There is a high likelihood of additional wood buildup at this site, or at other sites in the lower canyon due to the extent of moderate to high burn severity along the Hamill Creek channel upstream of this lower canyon reach combined with the high likelihood of debris flows and snow avalanches introducing new

wood into the channel. The potential for an increase in damming followed by a sudden release and subsequent outburst flood should be recognized, with potential for flooding effects including channel avulsion on the Hamill Creek fan.

5.5.4 Downslope Elements and Likelihood of Spatial Impact

1. **The Earl Grey Pass Trail** ascends the valley with several Hamill Creek Crossings as well as a crossing of Clint Creek near the confluence with Hamill Creek.
 - a. The trail is likely to be impacted by debris flows and snow avalanches as it crosses colluvial fans.
 - b. The trail is also likely to be significantly impacted by windfall of burnt timber.
2. **Private land** with residences on the Hamill Creek fan.
 - a. In the event of flooding on the Hamill Creek fan, private property would be spatially affected as the fan is mostly private land. Figure F4 in Appendix F delineates the Hamill Creek fan based on 1m contours and bare earth modelling from LiDAR data. The fan has been delineated into three areas of relative activity based on this data; further field assessment on private land would be required to refine the flooding potential and vulnerability of dwellings. The delineated areas include three activity ratings:
 - High rating is associated with the most active portion of the fan and is most prone to flooding or channel avulsion. While the details of the 1920's flood event are unclear, the 1945 air photos show channel instability in this area, and it was also partially flooded and eroded during the 2003 and 2013 flood events. A mobile home was damaged in the 2013 flood. Dwellings in this area have little protection from flooding or channel avulsion in the event of a significant flood that overtops the channel.
 - Moderate rating is associated with a portion of the fan less likely to be affected based on the fan surface topography and increased relief between the surface and channel. Dwellings in this area are less likely to be impacted as the fan topography provides some protection from flooding.
 - Low rating is associated with the southeastern most portion of the fan surface which is very unlikely to be impacted by flooding or avulsion due to the relief between the fan surface and the channel as well as the straight channel section passing by this area. This portion of the fan may generally be considered a paleo fan, formed during the early

post glacial period and inactive during present day environment, but it may be possible that flooding or avulsion could occur in this area given the potential for a log jam formation near fan apex. Dwellings in this area are much less at risk than those on the Moderate and High activity areas but should be aware of potential flood risks.

3. **Domestic water** intakes in Hamill Creek near fan apex.

- a. Domestic water intakes located in Hamill Creek would be impacted in the event significant flooding or channel avulsion. Elevated levels of turbidity can also be expected in Hamill Creek at the PODs during times of high runoff or intense precipitation due to increased sediment delivery to the creek within the fire area associated with erosion of exposed ash, soils and landslides.

4. **Public roads** including Argenta Road and Duncan River FSR with FSR bridge over Hamill Creek.

- a. The Duncan River FSR bridge (Appendix A, Photo 13) is the most likely part of road infrastructure on the fan to be impacted by flooding. The bridge currently has good clearance, and channel training has reduced vulnerability of the bridge since repairs after the 2013 flood event.

5. **Trapper's cabin** in Clint Creek (Appendix A, Photo 7).

- a. The trapper's cabin is situated in a location where it is unlikely to be impacted by post-wildfire natural hazards. Elevated rates of rockfall can be expected on the steep slopes to the southwest of the cabin where there is high burn severity extending from valley bottom to ridge top, but the cabin location is separated from the talus slopes associated with this rock fall. Prominent rounded ridges are located on either side of Clint Creek at the cabin site, also reducing the likelihood of an impact from rockfall or debris slides on these slopes.

5.5.5 Partial Risk Summary

Partial risk ratings are presented in Table 9. Rationale for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 9. Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Hamill Creek and Carter Creek.

Watershed Unit	Hamill Creek					Clint Creek
Elements at Risk	Private Property	Private Residences	Domestic POD's	Earl Grey Pass Trail	Duncan River FSR bridge	Trapper's Cabin
Hazard Event	Hazard Rating - Likelihood of Event P(H)					
Flood / Debris Flood	H	H	H	H	H	H
Debris Flow	-	-	-	VH	-	H
Debris slide/ Rockfall	-	-	-	VH	-	H
Hazard Event	Likelihood of Spatial Effect P(S:H)					
Flood / Debris Flood	H	M	H	H	H	L
Debris Flow	-	-	-	H	-	L
Debris slide/ Rockfall	-	-	-	H	-	L
Hazard Event	Partial Risk P(HA) = P(H) x P(S:H)					
Flood / Debris Flood	VH	H	VH	VH	VH	M
Debris Flow	-	-	-	VH	-	M
Debris Slide/ Rockfall	-	-	-	VH	-	M

5.6 Hamill Creek to Glacier Creek

5.6.1 Watershed Characteristics

The section from Hamill Creek to Glacier Creek along the Duncan River and Duncan Lake includes the face units and gully systems along the east side of Mount Lavina and upslope of Duncan River and Duncan Lake. These units range in elevation from 1500 m to 2300 m elevation at ridgetop to ~600 m elevation at Duncan Lake and Duncan River. Lavina Creek is the largest stream drainage in this area, and the only stream in this area with perennial flow reaching its fan. Lavina Creek ranges from 720 m elevation at the apex of its fan to 2220 m elevation at ridgetop. Duncan Lake is a reservoir formed by the damming of Duncan River in 1967. The reservoir was created following the signing of the Columbia River Treaty agreement between the Canadian and United States governments which was implemented in 1964 for the purpose of downstream flood control and hydroelectric power generation in the Columbia River as it flows through British Columbia, Washington, and Oregon. The Duncan Dam is presently operated by BC Hydro to regulate flow but does not generate hydroelectric power. Duncan River FSR extends along the eastern side of these units, and the Duncan dam is located downslope of the Hamill-Lavina Face.

Terrain and Watershed Morphology

The terrain in this area is generally comprised of moderate to steep gradient slopes consisting of till and colluvial veneers to blankets overlying bedrock. The two main gully systems (Duncan Lake Tributary 1/Lavina Creek and Duncan Lake Tributary 2) extend to near the ridgetop on Mount Lavina, with Lavina Creek having numerous snow avalanche and debris flow paths and a perennial stream. Upslope of the Duncan FSR to the south of Duncan Dam the upslope terrain is generally more moderate gradient with numerous bedrock controlled benches. North of Duncan Dam and upslope of Duncan FSR the terrain is generally steeper, with bands of very steep bedrock outcrops.

Fan Characteristics

The Lavina Creek channel is a steep gradient, colluvial channel subject to periodic debris flows within a snow avalanche path that extends to the apex of the fan. Lavina Creek has a well-developed fan located at valley bottom and is crossed between ~7 km and ~8 km on Duncan River FSR (Appendix A, Photo 15). The fan has an average slope gradient of 24%. The stream channel has low confinement on the fan, which before the fire resulted in dispersed flow and infiltration with very little seasonal flow reaching Duncan FSR. Following the fire, there have been two debris flows in Lavina Creek, which deposited material in the upper half of the fan (Appendix A, Photo 16 and 17) and inundated Duncan River FSR with sediment-laden flow.

Duncan Lake Tributary 2 has a colluvial fan at valley bottom. This fan is likely constructed primarily from debris flows in the early post glacial period with no known recent debris flows, and no perennial creek channel extends across Duncan River FSR.

5.6.2 Burn Severity

The south half of the Hamill-Lavina Face did not have a significant amount of burn. The north half of this face unit and all other units to the north up to Glacier Creek experienced much more burn, with a significant amount of high burn severity. There is generally not much high burn severity directly adjacent to the Duncan FSR, with mostly low and moderate burn severity along the road.

The riparian area along the Lavina Creek stream channel was generally not burned or experienced Low burn severity.

Refer to Table 10 below for a summary of the mapped soil burn severity as shown in Appendix F, Figure F3.

Table 10: Summary of watershed area and burn severity for Hamill Creek to Glacier Creek areas.

Watershed Unit	Watershed Unit Area	Area Burned		% Burn Severity					
				Low		Mod		High	
	km ²	km ²	%	km ²	%	km ²	%	km ²	%
Hamill-Lavina Face	14.0	5.9	42%	1.03	7%	2.22	16%	2.62	19%
Duncan Lake Tributary 1 (Lavina Creek)	4.1	3.9	95%	0.1	3%	0.7	17%	3.1	75%
Lavina South Face	1.1	0.8	78%	0.07	6%	0.15	14%	0.62	57%
Duncan Lake Tributary 2	0.8	0.8	99%	0.01	1%	0.02	3%	0.73	95%
Lavina North Face	0.9	0.3	36%	0.08	9%	0.1	11%	0.14	16%

5.6.3 Post-wildfire Hydrogeomorphic Hazards

Landslides

At least two debris flows have already occurred in Lavina Creek following the 2024 fire (Appendix A, Photo 18), affecting Duncan River FSR by inundating the road surface with sediment-laden flow. Channel avulsion on the fan has also occurred after the debris flows, with streamflow reaching Duncan River FSR in fall 2024 at volumes not seen in the past due to the newly concentrated stream flow. Additional debris flows and channel avulsion on the fan is expected to occur in Lavina Creek.

Debris flows are also possible in Duncan Lake Tributary 2. This drainage is much smaller than Lavina Creek and less active but was extensively burned at high burn severity.

Rockfall/Ravelling

Elevated rates of rockfall and ravelling can be expected along and upslope of the Duncan River FSR at and north of the Duncan Dam, as well as along other forest roads within the burned area. Elevated risk of danger trees in these corridors also existed after the fire but have since been sanitized (cleared of danger trees) for maintaining industrial access where required.

Snow Avalanche

Duncan River FSR is subjected to snow avalanches from a series of low elevation steep bedrock-controlled gullies upslope of ~6 km (Appendix A, Photo 14). These gullies historically produce size 2 avalanches, which typically reach Duncan River FSR annually.

The magnitude and frequency of snow avalanches, along with the amount of wood in the debris, is likely to increase due to the areas of Moderate and High burn severity in the starting zones.

Snow avalanches up to size 3 are also an annual occurrence in the Lavina Creek drainage. These avalanches run out at the apex of the fan, and do not impact Duncan River FSR which is ~200 m downslope.

Snow avalanches up to size 2 may occur in the steep forested upper gully headwall area of Duncan Lake Tributary 2, but these events historically do not extend down the gully. Due to the extent of high burn severity in this drainage, the frequency and magnitude of snow avalanche may increase, with longer runouts than before the fire. It is unlikely that Duncan River FSR would be impacted by avalanches on the fan based on comparison the runout behaviour of adjacent Lavina Creek.

5.6.4 Downslope Elements and Likelihood of Spatial Impact

1. Duncan River FSR

- a. Duncan River FSR is located along the toe of these units with no separating terrain from the Duncan dam to Duncan Lake Tributary 2. In this ~3.5 km section the road from approximately 5.5 km to 9 km is in the zone of impact for rock fall (5.5 km to 7 km), snow avalanches (at 6 km), flooding and sediment laden flow from debris flows (7 km to 8 km), and rockfall (8 km to 9 km).

2. Duncan Dam

- a. There are no gullies or converging drainages upslope of the Duncan dam location, and it is separated from the toe of the slope above by over 100 m of moderate gradient terrain. This terrain configuration limits the potential for impact from upslope hazards.

5.6.5 Partial Risk Summary

Partial risk ratings are presented in Table 11. Rational for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 11: Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Hamill Creek to Glacier Creek areas.

Watershed Unit	Hamill-Lavina Face		Duncan Lake Tributary 1 (Lavina Creek)	Lavina South Face	Duncan Lk Trib. 2	Lavina North Face
Elements at Risk	Duncan River FSR	Duncan Dam	Duncan River FSR	Duncan River FSR	Duncan River FSR	Duncan River FSR
Hazard Event	Hazard Rating - Likelihood of Event P(H)					
Flood / Debris Flood	-	-	VH	-	-	-
Debris Flow	-	-	VH	-	H	-
Snow Avalanche	VH	-	-	-	H	-
Ravelling/Debris Slide/Rockfall	H	M		H	H	M
Hazard Event	Likelihood of Spatial Effect P(S:H)					
Flood / Debris Flood	-	-	H	-	-	-
Debris Flow	-	-	H	-	M	-
Snow Avalanche	H (6 km)	-	-	-	L	-
Ravelling/Debris Slide/Rockfall	M (5.5 km to 7 km)	L		M	L	L
Hazard Event	Partial Risk P(HA) = P(H) x P(S:H)					
Flood / Debris Flood	-	-	VH	-	-	-
Debris Flow	-	-	VH	-	H	-
Snow Avalanche	VH (6 km)	-	-	-	M	-
Ravelling/Debris Slide/Rockfall	H (5.5 km to 7 km)	L	-	H	M	L

5.7 Glacier Creek

5.7.1 Watershed Characteristics

Glacier Creek is a glacier-fed stream with a large watershed (279.8 km²) that flows from ~3,000 m elevation in the Northern Purcell Mountain Range into Duncan Lake at approximately 580 m of elevation. The wildfire affected seven tributaries sub-basins, which range in size from 0.6 km² to 31.2 km². The largest is the Birman Creek watershed, a glacier-

fed stream. Overall, Glacier Creek and its tributaries are snow-melt dominated watersheds and experience spring snow-melt driven peak flows.

Terrain and Watershed Morphology

A large portion of the Glacier Creek watershed is non-forested (alpine, glacier, permanent-snow, bedrock outcrops). The dominant hydrogeomorphic process for Glacier Creek is floods, due to its large size (280 km²) and relatively gentle channel gradients. Based on the estimated Melton Ratios for Blind Creek, Ervin Creek as well as Tributaries 1 and 2, the dominant hydrogeomorphic process in these catchments is likely debris flows. McLeod Creek, Birnam Creek and Deep Creek are larger sub-basins with gentler channel gradients making debris flood the dominant hydrogeomorphic process.

The steep gradient southwest face of Duncan Ridge has numerous snow avalanche paths and debris flow tributaries between Duncan Lake and Birnam Creek (Appendix A, Photos 22 & Photo 24). On December 2, 2024, a small debris slide impacted Glacier Creek FSR at 12.3 km and there is potential for a greater landslide to impact road and Glacier Creek (Appendix A, Photo 20). This site is also a narrow snow avalanche path expected to impact the FSR annually with size 1 to size 3 avalanches.

In addition, there is a relic deep-seated gravitational deformation on the south east side of Duncan Ridge upslope of the Glacier FSR across from Ervin Creek, with recently active movement in thick colluvial material approaching Glacier Creek FSR at approximately 13 km (Appendix A, Photo 21). Based on communication in 2019 with Doug Nicol, P.Eng. of SNT who had monitoring the site of active instability for approximately 12 years, there can be movement up to 50 cm a year. This slope movement tends to occur in the spring following a large freshet year.

A narrow snow avalanche and debris flow path also regularly affects Glacier FSR near ~21.5 km at approximately 1000 m elevation (Appendix A Photo 24).

Fan Characteristics

The Glacier Creek fan is located at the confluence with Duncan Lake and is a paleo fan formed primarily during the early post-glacial period. The fan has been incised by the present-day channel (approximately 5 m relief to the north and 10 m to 15 m relief to the south). As a result, the fan surface is not subject to regular flood events.

5.7.2 Burn Severity

Approximately 18% of the total Glacier Creek watershed area was burned by the 2024 Argenta Creek Wildfire at moderate to high burn severity; most of which is located in the western half of the watershed extending upstream ~12.5 km from the apex of the fan (Appendix A, Photo 19).

The largest effected subbasin is Birman Creek, of which 35% was burned at moderate to high burn severity (Appendix A, Photo 23). On the south side of Glacier Creek the main subbasins of Blind Creek, Mcleod Creek, and Deep Creek were all extensively burned while Ervin Creek has less total burned area but still a significant portion of high burn severity.

With the exception of Glacier East NW Face, significant areas of all the faces along Glacier Creek located within the fire perimeter are affected by moderate or high burn severity. Glacier Creek is mainly surrounded by a narrow band of unburned forest or low burn severity at the valley bottom

Refer to Table 12 below for a summary of the mapped soil burn severity as shown in Appendix F Figure F3.

Table 12: Summary of watershed area and burn severity for Glacier Creek.

Watershed Unit	Watershed Unit Area	Area Burned		% Burn Severity					
				Low		Mod		High	
		km ²	%	km ²	%	km ²	%	km ²	%
Glacier Creek	279.8	61.8	22%	10.2	4%	17.0	6%	34.5	12%
Lavina-Blind Face	1.6	1.3	85%	0.2	10%	0.5	31%	0.7	44%
Blind Creek	2.2	2.2	97%	0.2	9%	0.8	37%	1.2	52%
Blind-Ervin Face	0.9	0.8	94%	0.2	21%	0.6	68%	0.0	5%
Ervin Creek	4.9	3.0	61%	0.5	10%	0.6	12%	1.9	38%
Ervin-McLeod Face	1.7	1.3	78%	0.2	11%	0.3	18%	0.8	49%
McLeod Creek	11.3	10.2	90%	1.3	12%	2.0	17%	6.9	61%
McLeod-Deep SW Face	1.9	1.6	86%	0.4	19%	0.1	8%	1.1	59%
Glacier Creek Tributary 1	0.6	0.5	77%	0.0	5%	0.1	21%	0.3	52%
McLeod-Deep NE Face	1.2	0.7	57%	0.2	14%	0.1	10%	0.4	32%
Deep Creek	16.2	10.8	67%	1.0	6%	1.7	11%	8.1	50%
Deep NW Face	1.6	1.2	77%	0.2	10%	0.1	5%	1.0	62%
Deep N Face	0.5	0.5	96%	0.1	16%	0.2	30%	0.3	50%
Glacier Creek Tributary 2	1.9	1.0	53%	0.3	17%	0.3	17%	0.4	19%
Glacier East NW Face	1.2	0.9	71%	0.2	17%	0.7	54%	0.0	1%
Glacier East SE Face	6.3	3.4	54%	0.91	14%	1.07	17%	1.43	23%
Birnam Creek	31.2	13.9	44%	2.7	9%	4.77	15%	6.38	20%
Duncan Ridge SE Face	9.4	7.9	84%	1.2	13%	2.99	32%	3.66	39%

5.7.3 Post-wildfire Hydrogeomorphic Hazards

Flooding and Debris Floods

The Duncan Ridge Southeast Face unit does not have perennial streams located within the gullies but may experience overland flow and sediment laden flow in the post-fire environment due to the loss of forest floor coverage and fire effects on the soil.

Based on 22% of the Glacier Creek watershed being burned with a significant portion of this burn area at lower elevation that would already be snow free during peak flows, there is a Low likelihood of an increase in flood events in Glacier Creek following the 2024 wildfire. This is in agreement with the 2024 MacHydro report, which indicates there is a 1% increase in 20 year peak-flows following the 2024 wildfire, compared to pre-fire conditions.

Birnam Creek has 44% burned area, with 35% at Moderate or High burn severity. While the extent of alpine terrain and lower elevation burn areas reduce the potential impact of flooding in Birnam Creek, it is possible that a post-wildfire increase in flooding hazards could occur due to the extent of high burn severity in some of the gully systems with direct connectivity to the creek.

Flood hazards in the subbasins on the southeast side of Glacier Creek have not been individually addressed because of the disconnect with elements at risk. However, these areas have been considered in the overall assessment of the Glacier Creek drainage. One exception to note is the potential for increased peak flows or debris floods in McLeod Creek which has a small valley bottom fan located immediately upstream of the private land near 760 m elevation. The Glacier Creek FSR across from this fan is tightly confined between the steep valley side and the Glacier Creek channel and could be susceptible to channel changes if a debris flood were to impact Glacier Creek from McLeod Creek. There is a known area of bank instability at the edge of the FSR approximately 150 m downstream of where McLeod Creek enters Glacier Creek.

Debris Flows

There is a High likelihood of a post-wildfire debris flow occurring within areas of Glacier East SE Face and Duncan Ridge SE Face unit that experienced High burn severity on steep gradient slopes with gullied terrain. There is a Moderate likelihood of a post-wildfire debris flow occurring in areas with predominantly Low to Moderate burn severity including the area upslope of the private land. Debris flow hazards in the subbasins on the southeast side of Glacier Creek have not been assessed due to the disconnect with high value elements at risk.

Snow Avalanches

Large snow avalanches (size 2 and greater) can be expected in the Duncan Ridge SE Face and the Glacier East Southeast face units due to the loss of forest canopy in areas of steep high elevation terrain with high burn severity. However, there is a lower likelihood of a post-wildfire snow avalanche occurring along the Duncan Ridge Southeast Face upslope of private property. This is due to the generally unburned to Low soil burn severity located in this area.

Debris Slides, Ravelling and Rockfall

In general, post-wildfire debris slides, ravelling and rockfall are likely within the Glacier Creek areas and associated drainages due to the extent of Moderate and High burn severity on steep gradient slopes with common gullies and abundant bedrock outcrops.

5.7.4 Downslope Elements and Likelihood of Spatial Impact

1. Private land and residences

- a. There is a single private land parcel approximately 17 ha in size located within the Glacier Creek drainage at valley bottom near 760 m elevation. There are several buildings located on this private land at or near the toe of the slope, including dwellings.

A debris slide, snow avalanche, ravelling or rockfall that occurred upslope of the private land would most likely reach private property due to the lack of intervening gentle to moderate gradient terrain separating the private land from the steep slopes. Considering the spatial probability of a hydrogeomorphic hazard impacting a residence, and the lack of a preferential path for a hazard to be directed towards a residence, there is a Low likelihood of a hydrogeomorphic hazard impacting a residence along Glacier Creek.

2. Domestic water intake in Glacier Creek

- a. There is a licensed point of diversion (PD184123) for domestic consumptive and stock watering purposes located in Glacier Creek within the private property boundary. While this POD location may be impacted by elevated turbidity associated with increased rates of erosion and sediment delivery to Glacier Creek.

3. Glacier Creek FSR

- a. Glacier Creek FSR is located along valley bottom adjacent to Glacier Creek. Landslides and snow avalanches that occur upslope of Glacier Creek FSR without sufficient gentle or moderate gradient intervening terrain would likely impact the road. Landslides and snow avalanches are known to impact the road at ~12.3 km and at ~22 km, and a slow moving instability is crossed by the road at ~13 km. These three sites all have significant Moderate to High burn severity in their upslope catchments.

4. Glacier Creek and Birnam Creek bridge structures

- a. In the unlikely event of a significant increase in peak flow in Glacier Creek due to the fire, it is unlikely to impact the bridge structures crossing Glacier Creek

near 22 km on Glacier FSR and near 10 km on Duncan River FSR. These bridges currently have good clearance and are well located at confined reaches (Appendix A, Photo 25).

- b. In the event of a post-wildfire increase in peak flow in Birnam Creek, the Glacier Creek FSR bridge crossing is unlikely to be affected as it has suitable clearance, and the channel is stable at the crossing. A debris flood event in the creek is unlikely to reach the bridge crossing due to the 700 m low gradient reach prior to the crossing where Birnam Creek joins the Glacier Creek valley bottom.

5. Macbeth FSR (Recreation Trail Access)

- a. MacBeth FSR provides access to the MacBeth Icefields recreational trail. The road is generally separated from high burn severity areas, and is unlikely to be subject to significant ravelling. Some increase to runoff at the road should be expected, but there are no significant gullies or unstable areas upslope of the road.
- b. The MacBeth Icefields trail ascends through many areas of moderate to high burn severity. These areas will have substantial windthrow hazards along the trail. Erosion of the trail may also increase where surface flow occurs in high burn severity areas. Further identification of hazards affecting the trail location such as snow avalanches and debris flows has not been carried out.

6. Glacier Creek Regional Park campground and Glacier Creek Rec Site (REC2120)

- a. Glacier Creek Regional Park campground and Glacier Creek Rec Site are located on the south and north side of the paleo fan with > 5 m of vertical relief separating the sites from Glacier Creek. As a result, Glacier Creek Regional Park campground and Glacier Creek Rec Site are considered not at significant risk, and no further partial risk analysis has been carried out.

5.7.5 Partial Risk Summary

Partial risk ratings are presented in Table 13. Rational for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 13. Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Glacier Creek.

Watershed Unit	Duncan Ridge SE Face				Birnam Creek		Glacier East SE Face	Glacier Creek
Elements at Risk	Glacier Creek FSR	Private Land	Private Residences	Domestic POD	MacBeth FSR (Recreation Trail Access)	Birnam Creek bridge	Glacier Creek FSR	Bridges
Hazard Rating - Likelihood of Event P(H)								
Flood, Debris Flood or Sediment Laden Flow	L	-	-	L	-	M	-	L
Debris Flow	H	M	M	-	-	-	VH	-
Snow Avalanche	H	M	M	-	-	-	VH	-
Ravelling/Debris Slide/Rockfall	VH	M	M	-	L	-	H	-
Likelihood of Spatial Effect P(S:H)								
Flood, Debris Flood or Sediment Laden Flow	H	-	-	H	-	L	-	L
Debris Flow	H	H	L	-	-	-	H	-
Snow Avalanche	H	H	L	-	-	-	H	-
Ravelling/Debris Slide/Rockfall	H	H	L	-	M	-	H	-
Partial Risk P(HA) = P(H) x P(S:H)								
Flood, Debris Flood or Sediment Laden Flow	M	-	-	M	-	L	-	VL
Debris Flow	VH	H	L	-	-	VH		-
Snow Avalanche	VH	H	L	-	-	VH		-
Ravelling/Debris Slide/Rockfall	VH	H	L	-	L	VH		-

5.8 Duncan Ridge North of Glacier Creek

5.8.1 Watershed Characteristics

Duncan Ridge North of Glacier Creek encompasses Duncan Ridge Northwest face unit extending north from Glacier Creek to Duncan Lake Tributary 3 Creek, as well as Tributary 3 itself. Both of these units are located on west aspect slopes and are located upslope of Duncan Lake. Elevations in this area range from approximately 2100 m at ridgetop to 600 m at Duncan Lake.

Terrain and Watershed Morphology

Terrain within the Duncan Ridge Northwest face unit is comprised of moderate to moderately steep gradient slopes, with areas of steep to very steep gradient slopes generally associated with bedrock controlled terrain. Surficial material is comprised of till and colluvial veneers to blankets overlying bedrock. There is a well-defined gully system located in the northern portion of the face unit. There are areas of gentle to moderate gradient slopes approaching Duncan Lake. There are a few snow avalanche paths located at upper elevations in the northern portion of the Duncan Ridge Northwest face unit, which terminate prior to valley bottom.

Duncan Lake Tributary 3 is 2.8 km² in size with a well-defined gully complex. The main channel is a steep colluvial channel. There is evidence of debris flows, debris slides and snow avalanche paths along the upper elevations of Tributary 3.

Fan Characteristics

There are no fans associated with the face unit, and the Duncan Lake Tributary 3 fan has not been addressed due to the limited burn area within the drainage (3% with no High).

5.8.2 Burn Severity

The portion of the Duncan Ridge Northwest face unit located south of the Twin Bays Rec Site experienced generally Moderate to High burn severity. With the northern portion of the Duncan Ridge Northwest Face unit experiencing generally no to Low burn severity. Approximately 3% of the Duncan Lake Tributary Watershed burned during the 2024 wildfire.

Refer to Table 14 below for a summary of the mapped soil burn severity as shown in Appendix F Figure F3.

Table 14: Summary of watershed area and burn severity for Duncan Ridge north of Glacier Creek.

Watershed Unit	Watershed Unit Area	Area Burned		% Burn Severity					
				Low		Mod		High	
		km ²	%	km ²	%	km ²	%	km ²	%
Duncan Ridge NW Face	12.7	6.3	49%	2.3	18%	2.3	18%	1.7	13%
Duncan Lake Tributary 3	2.8	0.1	3%	0.04	1%	0.02	1%	0.01	0%

5.8.3 Post-wildfire Hydrogeomorphic Hazards

Landslides and Rock Fall

There is an elevated likelihood of debris slides, debris avalanches, and rock fall in the Duncan Ridge Northwest face unit occurring due to the fire, considering the extent of Moderate to High burn severity within the unit. Debris flows may also be possible in some of the gullied terrain with Moderate to High burn severity. The irregular and benched terrain and areas of gentle to moderate gradient terrain approaching Duncan Lake limits connectivity with most of the fire area and valley bottom elements; however, there are areas with consistent steep gradient sloped leading to valley bottom.

Considering the small (~3%) amount of burned areas within Duncan Lake Tributary 3 watershed, there is limited potential for concentrated effects of the fire to impact downslope terrain. The incremental increase in the likelihood of natural hazards due to the wildfire in Duncan Lake Tributary 3 watershed is considered insignificant in comparison to the pre-fire conditions (Very Low incremental increase). No further hazard or risk analysis has been carried out.

Snow Avalanches

While there are avalanche paths located along upper elevations in the northern portion of the Duncan Ridge Northwest Face Unit, they terminate significantly upslope of Duncan River FSR. There is generally unburned to Low burn severity along the majority of the avalanche paths, but some Moderate to High burn severity at the starting zone areas.

5.8.4 Downslope Elements and Likelihood of Spatial Impact

1. Duncan River FSR

- a. The irregular and benched terrain and areas of gentle to moderate gradient slopes limits connectivity with most of the fire area and valley bottom elements.

However, there are areas where there are consistently steep gradient slopes leading from the burned areas to Duncan River FSR in the southern third of the Duncan Ridge NW Face (starting ~1.5 km south of Twin Bays) where Duncan River FSR could be impacted by debris slides, debris avalanches, or rockfall.

2. Twin Bays Rec Site (REC 5838)

- a. Twin Bays Rec Site is a popular campsite operated by Recreation Sites and Trails BC and is located along the western edge of the central portion of the Duncan Ridge Northwest face unit. There is >350 m of gentle to moderate gradient slopes separating Twin Bays Rec Site from the steep slopes along the valley side. As a result, it is very unlikely that a post-wildfire landslide will impact Twin Bay Rec Site. Therefore, no further hazard or risk analysis has been carried out for Twin Bays Rec Site.

5.8.5 Partial Risk Summary

Partial risk ratings are presented in Table 15. Rational for ratings can be found in the preceding sections. Where applicable, risk mitigation options are presented in Section 6.

Table 15: Partial risk ratings for elements at risk from post-wildfire hydrogeomorphic hazards in Duncan Ridge north of Glacier Creek.

Watershed Unit	Duncan Ridge NW Face
Elements at Risk	Duncan River FSR
Hazard Event	Hazard Rating - Likelihood of Event P(H)
Debris Slide / Debris Avalanche / Debris Flow	M
Snow Avalanche	M
Ravelling/Rockfall	M
Hazard Event	Likelihood of Spatial Effect P(S:H)
Debris Slide / Debris Avalanche / Debris Flow	H (south of Twin Bays)
Snow Avalanche	L
Ravelling/Rockfall	H (south of Twin Bays)
Hazard Event	Partial Risk P(HA) = P(H) x P(S:H)
Debris Slide / Debris Avalanche / Debris Flow	H (south of Twin Bays)
Snow Avalanche	L
Ravelling/Rockfall	H (south of Twin Bays)

6. PARTIAL RISK SUMMARY TABLE – ALL AREAS

The following table (Table 16) presents a summary of partial risk ratings for the primary affected watershed units with considered elements at risk. Refer to the relevant watershed unit descriptions in Section 5 for additional information and rationale for the ratings.

Table 16: Argenta Creek Wildfire Partial Risk Summary Table

Watershed Unit	Hazard Event	Hazard Likelihood P(H)	Elements at Risk	Likelihood of Spatial Impact P(S:H)	Partial Risk P(HA)
Argenta Creek	Flood/Debris Flood/Sediment Laden Flow	High	Domestic PODs Private Land Argenta Road (upper and lower)	High	Very High
			Private residence (fan)	Moderate	High
	Debris Flow	High	Domestic PODs Private Land	High	Very High
			Private residence (fan) Argenta Road (lower)	Low	Moderate
			Argenta Road (upper)	Moderate	High
Argenta Creek North	Flood/Debris Flood/Sediment Laden Flow, Debris Flow	High	Private Land	High	Very High
			Private Residences	Low	Moderate
Argenta-Carter Face	Flood/Debris Flood/Sediment Laden Flow, Debris Flow	High	Private Land Domestic PODs	Moderate	High
			Private Residences	Low	Moderate
Carter Creek	Flood	Low	Domestic PODs Private Property Argenta Road	High	Moderate
	Debris Slide	Moderate	Domestic PODs Private Property Argenta Road	Low	Low
Carter-Hamill Face	Debris Slide, Rockfall	Low	Private Residence Argenta Road	Low	Very Low

Watershed Unit	Hazard Event	Hazard Likelihood P(H)	Elements at Risk	Likelihood of Spatial Impact P(S:H)	Partial Risk P(HA)
Hamill Creek	Flood/Debris Flood	High	Private Property Domestic PODs Duncan River FSR Earl Grey Pass trail	High	Very High
			Private Residences	Moderate	High
	Debris Flow, Debris Slide/Rockfall	Very High	Earl Grey Pass Trail	High	Very High
Clint Creek	Flood/Debris Flood, Debris Flow, Debris Slide/Rockfall	High	Trapper's Cabin	Low	Moderate
Hamill-Lavina Face	Snow Avalanche	Very High	Duncan River FSR	High	Very High
	Ravelling/Debris Slide/Rockfall	High	Duncan River FSR	Moderate	High
	Ravelling/Debris Slide/Rockfall	Moderate	Duncan Dam	Low	Low
Duncan Lake Tributary 1 (Lavina Creek)	Flood/Debris Flood, Debris Flow	Very High	Duncan River FSR	High	Very High
Lavina South Face	Ravelling/Debris Slide/Rockfall	High	Duncan River FSR	Moderate	High
Duncan Lake Tributary 2	Debris Flow	High	Duncan River FSR	Moderate	High
	Snow Avalanche, Ravelling/Debris Slide/Rockfall	High	Duncan River FSR	Low	Moderate
Lavina North Face	Ravelling/Debris Slide/Rockfall	Moderate	Duncan River FSR	Low	Low

Watershed Unit	Hazard Event	Hazard Likelihood P(H)	Elements at Risk	Likelihood of Spatial Impact P(S:H)	Partial Risk P(HA)
Duncan Ridge SE Face	Flood/Debris Flood or Sediment Laden Flow	Low	Glacier Creek FSR, Domestic PODs	High	Moderate
	Debris Flow	High	Glacier Creek FSR	High	Very High
		Moderate	Private Land	High	High
			Private Residences	Low	Low
	Snow Avalanche	High	Glacier Creek FSR	High	Very High
		Moderate	Private Land	High	High
			Private Residences	Low	Low
	Ravelling/Debris Slide/Rockfall	Very High	Glacier Creek FSR	High	Very High
		Moderate	Private Land	High	High
			Private Residences	Low	Low
Birnam Creek	Flood, Debris Flood or Sediment Laden Flow	Moderate	Birnam Creek Bridge	Low	Low
	Ravelling/Debris Slide/Rockfall	Low	MacBeth FSR (Recreation Trail Access)	Moderate	Low
Glacier East SE Face	Debris Flow, Snow Avalanche	Very High	Glacier Creek FSR	High	Very High
	Ravelling/Debris Slide/Rockfall	High	Glacier Creek FSR	High	Very High
Glacier Creek	Flood, Debris Flood or Sediment Laden Flow	Low	Bridges	Low	Very Low
Duncan Ridge NW Face	Debris Slide/Debris Avalanche/Debris Flow, Ravelling/Rockfall	Moderate	Duncan River FSR	High (south of Twin Bays)	High (south of Twin Bays)
	Snow Avalanche	Moderate	Duncan River FSR	Low	Low

7. RECOMMENDATIONS AND MITIGATION OPTIONS

Stakeholder awareness of risks and how to manage the risk is an important part of a regional risk reduction strategy. Communication of the potential risk should be provided to all stakeholders. It is the responsibility of stakeholders to identify potentially affected infrastructure and property based on this assessment, understand the limitations of this assessment and risk analysis, and retain further professional assessment if warranted. Refer to Appendix E for publicly accessible brochures on flood and debris flow hazards.

The following sections presents recommendations and options for mitigation intended to reduce the risk from post-wildfire hazards.

All Areas

1. **Community members should be made aware of the risks** associated with post-wildfire natural hazards and be familiar with information presented in the debris flow and flooding pamphlets attached in Appendix E. This information can help community members reduce their exposure to debris flow and flooding risks.
2. **If a stakeholder has concerns over water quality**, regular testing could be implemented to confirm its suitability for domestic consumption. The BC Source Drinking Water Quality Guidelines can be referenced for acceptable chemical parameters (https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/drinking-water-and-recreation/source_drinking_water_quality_guidelines_bcenv.pdf).
3. **Forestry roads should be assessed and monitored for additional maintenance requirements** associated with the potential for elevated rates of post-wildfire runoff and erosion. Culverts should also be inspected for fire damage and repaired or replaced as required.
4. **Fire guards should be deactivated** with a focus on effective drainage control and removal of unstable fills.
5. **Any planned salvage harvesting should be assessed** with consideration of the potential cumulative effects on hydrogeomorphic hazards within the watershed resulting from the wildfire, existing harvesting and resource roads, as well as planned forest development. The potential impacts to high value downslope elements at risk should be evaluated as part of this assessment.

Argenta Creek

1. **Community members should be aware of the debris flow risks in Argenta Creek** and not enter the creek gully during times of high runoff, short duration summer storms, or if sudden turbidity is observed.

2. **Argenta Creek fan** residents and landowners should be made aware of the potential post-wildfire risks associated with debris flow and flooding on the fan.
3. **The POD access trail that enters the Argenta Creek gully from the south side near 720 m** elevation should have a functional berm installed and maintained by the private land owner to reduce the potential for diversion of runoff or debris in the event of flooding or debris flows in Argenta Creek.
4. **The Argenta Road crossings** should have the culverts maintained free of debris, including trees near the outlet of the upper crossing which could cause partial blockage. MOTT should also consider the option of adjusting the road grade to form a low point at the upper crossing with the intent of reducing the potential for redirected flow on the road in the case of a blocked culvert due to a debris flow or high debris concentration in flood flow.

Argenta North and Argenta-Carter Face

1. **Community members should be aware of the debris flow risks** associated with the areas of high burn severity in the steep gullied terrain to the east of the private land. This area, or immediately downslope of this area, should be avoided during times of high runoff or short duration summer storms.
2. **Forestry roads should be monitored for maintenance requirements** associated with potentially elevated rates of post-wildfire runoff and erosion.

Hamill Creek

1. **Landowners and residents on the Hamill Creek fan should be made aware of post-wildfire flood risks** associated with Hamill Creek, in particular relating to the potential for a flood surge associated with a log jam breach.
2. **The log jam in the lower Hamill Creek canyon should be regularly monitored** to assess change and, if possible, risk of failure. Suitable timing for monitoring would be before, during, and following spring freshet period, as well as before and following the fall wet season. As there are multiple stakeholders associated with this risk, results from monitoring should be shared to assist with risk management decisions. No suitable risk mitigation options for removal of the logjam have been identified.
3. **The Hamill Creek bridge should be monitored** by MoF and BCTS for changes to sediment aggradation that could reduce clearance and increase risk of blockage in the case of debris transport.
4. **Signage should be installed prior to the Hamill Creek bridge on Duncan River FSR** indicating the potential for post-wildfire hazards. Road users should be aware

of the increased risk of flooding hazards at the bridge site and road blockage due to snow avalanches and landslides on the Duncan River FSR.

Glacier Creek

1. **Signage should be installed at the start of Glacier Creek FSR** indicating the potential for post-wildfire hazards affecting Glacier Creek FSR. Road users should be aware of the increased risk of road blockage due to snow avalanches and landslides.
2. **All accessible forestry roads within the fire perimeter in Glacier Creek** were assessed by SCL under separate contract to BCTS for the purpose of assessing post-wildfire impacts within their operating area. Recommendations relating to this assessment was presented to BCTS in fall 2024, with mitigation measures implemented prior to snowfall. A summary of recommendations is as follows:
 - a. Sanitize the road corridor of danger trees before opening the road for industrial or public use.
 - b. Workers should be made aware of the increase in debris flow hazard and should manage exposure at stream and gully crossings as well as stop work and leave the area if significant precipitation events are forecast or occurring.
 - c. Install signage to indicate increase in rock fall hazard.
 - d. Consider potential for increased avalanche hazard when operating during avalanche season and incorporate potential for increased hazard into avalanche safety plan monitoring and measures.
 - e. A snow avalanche start zone is situated upslope of Glacier 7000 road. Historically this path has not reached the Glacier 7000 road but may have potential to if sufficiently burned in the start zone area.
 - f. Clean the road surface and ditch to ensure functional drainage control and increase maintenance monitoring and measures. Seasonal deactivation with cross ditches and waterbars is recommended to mitigate the increased likelihood of plugged ditches and culverts on spur roads.
 - g. Clean and repair/replace culverts as required based on an inspection of all culverts prior to fall (many melted plastic culverts require replacement with culvert or cross ditch).
 - h. Continue regular slope monitoring of the 13 km landslide site on Glacier Creek FSR, as there is potential for increase movement because of the fire. Contributing factors would be increased ground water levels at the site in addition to the potential for increased peak flows in Glacier Creek (assumed at the time of assessment).

- i. It was recommended to close Glacier Creek FSR following the December 2, 2024 debris slide which impacted the road due to the extent of additional unstable material remaining upslope of the road. It was recommended to monitor and reevaluate the site prior to re-opening the road.

Duncan FSR

1. **Duncan River FSR, Duncan Ridge FSR and Duncan 2500 FSR, Lavina 500 FSR and a portion of Lavina FSR** were assessed by SCL under separate contract to BCTS for the purpose of assessing post-wildfire impacts within their operating area. Recommendations relating to this assessment was presented to BCTS in fall 2024, with mitigation measures implemented prior to snowfall. A summary of recommendations is as follows:
 - a. **Similar general maintenance recommendations to Glacier Creek** area presented above.
 - b. **Workers should be made aware of the increase in debris flow hazard** and should manage exposure at the Blind Creek crossing on Lavina 500 FSR.
 - c. **7 km – 8 km Lavina Creek debris flow fan:** In order to control unconfined streamflow and sediment laden flow reaching Duncan River FSR, additional culverts and a larger ditch was prescribed and installed in fall 2024 following two debris flow events. Consideration to alternative control structures was given but deemed not practical at the time. Ongoing monitoring and maintenance of the site will be required to determine if additional work is warranted.

8. CLOSURE

The discussions and recommendations presented above are based on a visual field assessment and additional information, which was reviewed at the time of the assessment. This report has been prepared for use by Ministry of Forests – BC Wildfire Service, which includes distribution as required for purposes for which the assessment was commissioned. The assessment has been carried out in accordance with generally accepted geotechnical practice. Geotechnical judgment has been applied in developing the recommendations in this report. No other warranty is made, either expressed or implied.

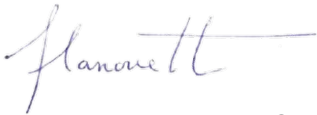
SCL trusts that the information presented above meets your current requirements. If you have any questions or require further information, please do not hesitate to contact the undersigned.

Respectfully submitted,

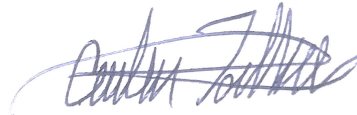
Sitkum Consulting Ltd.

EGBC Permit to Practice no. 1000441

Prepared by:



Florence Lanouette, M.Sc., EIT
Geotechnical Engineer-in-training

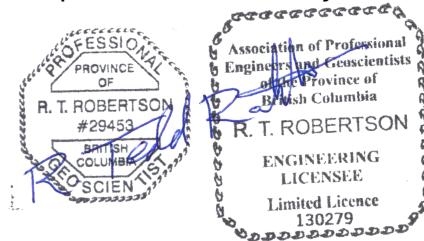


Caitlin Tatham, M.Sc. P.Geo.
Geoscientist



Jennifer Shypitka, P.Geo.
Geomorphologist

Prepared & reviewed by:



²⁰²⁵⁻⁰³⁻³¹
Tedd Robertson, P.Geo. P.L.Eng.
Engineering Geologist – Principal

A draft of this report was reviewed by Sarah Crookshanks, M.Sc. P.Geo., who provided helpful comments which were taken into consideration during the preparation of the final report; however, all analyses and conclusions are the sole responsibility of the authors.

REFERENCES

- Curran, M.P., B. Chapman, G.D. Hope, and D. Scott. (2006) Large-scale erosion and flooding after wildfires: understanding the soil conditions. B.C. Min. For. and Range, Res. Br., Victoria, B.C. Tech. Rep. 030. <http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr030.htm>
- Fyles, J., Geology of the Duncan Lake Area, Lardeau District, British Columbia. B.C. Department of Mines and Petroleum Resources, 1964.
- Jollymore, A., Chernos, M., Plewes, R., Braaten, M., MacDonald, R.J., (2024) DRAFT Partial Watershed Assessment for Glacier Creek, BC. MacDonald Hydrology Consultants Ltd. Prepared for BC Timber Sales. Version 3. (December 2024).
- Jordan, P., Turner, K., Nicol, D., Boyer, D. (2006) Developing a Risk Analysis Procedure for Post-Wildfire Mass Movement and Flooding in British Columbia. 1st Specialty Conference on Disaster Mitigation, Calgary, Alberta, Canada, May 23-26, 2006
- Jordan, Peter. (2012) Sediment yields and water quality effects of severe wildfires in southern British Columbia. In *Wildfire and Water Quality: Processes, Impacts and Challenges* (Proceedings of a conference held in Banff, Canada, 11–14 June 2012) (IAHS Publ. 354, 2012).
- Jordan, Peter. (2013) Summary of observation made on flight of 27 June, 2013 – Hamill, Fry and Campbell Creek watersheds. Ministry of Forests internal memo.
- Jordan, Peter. (2015) Post-wildfire debris flows in southern British Columbia, Canada. *International Journal of Wildland Fire*. <http://dx.doi.org/10.1071/WF14070>
- Holm, K., R. Lee, B. Waddington, M. Sturzenegger, H. Weatherly, M. Jakob. (2019) Flood and Steep Creek Geohazard Risk Prioritization. BGC Engineering Inc. for Regional District of Central Kootenay, Vancouver, B.C., March 31, 2019.
- 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. *Prov. B.C., Victoria, B.C. Land Manag. Handb.* 69. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH69.htm
- Pike, R.G., M.C. Feller, J.D. Stednick, K.J. Rieberger, and M. Carver. (2010) Chapter 12: Water Quality and Forest Management, *Compendium of Forest Hydrology and Geomorphology in British Columbia*. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C., and FORREX Forum for Research and Extension in Natural Resources, Kamloops. B.C. Land Manag. Handb. 66. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66.htm
- Robichaud PR, Beyers JL, Neary DG (2000) Evaluating the effectiveness of post-fire rehabilitation treatments. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR- 63. (Fort Collins, CO)
- Rodman, R. (1996) Floodplain Mapping Program, Duncan and Lardeau Rivers and Meadow Creek Design Brief, Floodplain Maps and Study File. Kohn-Crippen Consultants Ltd. For Ministry of Environment, Lands and Parks, Water Management Division, Victoria, B.C., February 29, 1996.
- Stokes, T.R. 1999. Reconnaissance karst potential mapping for British Columbia. B.C. Min. For. Res. Br., Victoria, B.C. www.for.gov.bc.ca/hfp/values/features/karst/index.htm
- Thiessen, L. (2013) Hamill Creek Bridge and Channel Repair Report, Phase 1. SNT Engineering Ltd. For BCTS Kootenay Lake Field Team, Nelson, B.C., July 29, 2013.

Winkler RD, Moore RD, Redding TE, Spittlehouse DL, Smerdon BD, Carlyle-Moses DE (2010) The effects of forest disturbance on hydrologic processes and watershed response. In 'Compendium of forest hydrology and geomorphology in British Columbia'. (Eds RG Pike, TE Redding, RD Moore, RD Winker, KD Bladon) Land Management Handbook 66, Ch. 7, pp. 179–212. (BC Ministry of Forests and Range, Victoria, BC and FORREX Forum for Research and Extension in Natural Resources: Kamloops, BC)
https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66/LMH66_volume1of2.pdf

Appendix A

Photographs

Argenta Creek Wildfire

Argenta Creek and North Argenta Creek Photos



Photo 1: View looking up into Argenta Creek watershed with extent of high burn severity apparent in the upper elevations. Drone photo Sept. 16, 2024.



Photo 2: Upper Argenta Creek watershed; drone photo Sept. 18, 2024.

Argenta Creek Wildfire

Argenta Creek and North Argenta Creek Photos



Photo 3: Recent debris flow tracks and deposits visible on southwest aspect slope in Argenta Creek drainage.

Argenta Creek Wildfire

Argenta Creek and North Argenta Creek Photos



Photo 4: View downstream above the confluence of Argenta Creek and Argenta Creek South Fork (entering from left of photo). Drone photo Sept. 18, 2024.



Photo 5: Argenta Creek fan with private development; drone capture Sept. 16, 2024.

Argenta Creek Wildfire

Argenta – Carter Face Photos



Photo 6: High burn severity band across Argenta-Carter Face, Sept. 16, 2024

Argenta Creek Wildfire

Hamill Creek and Clint Creek Photos



Photo 7: Trapper's Cabin foundation, photo from helicopter overview flight Aug. 14, 2024.

Argenta Creek Wildfire

Hamill Creek and Clint Creek Photos

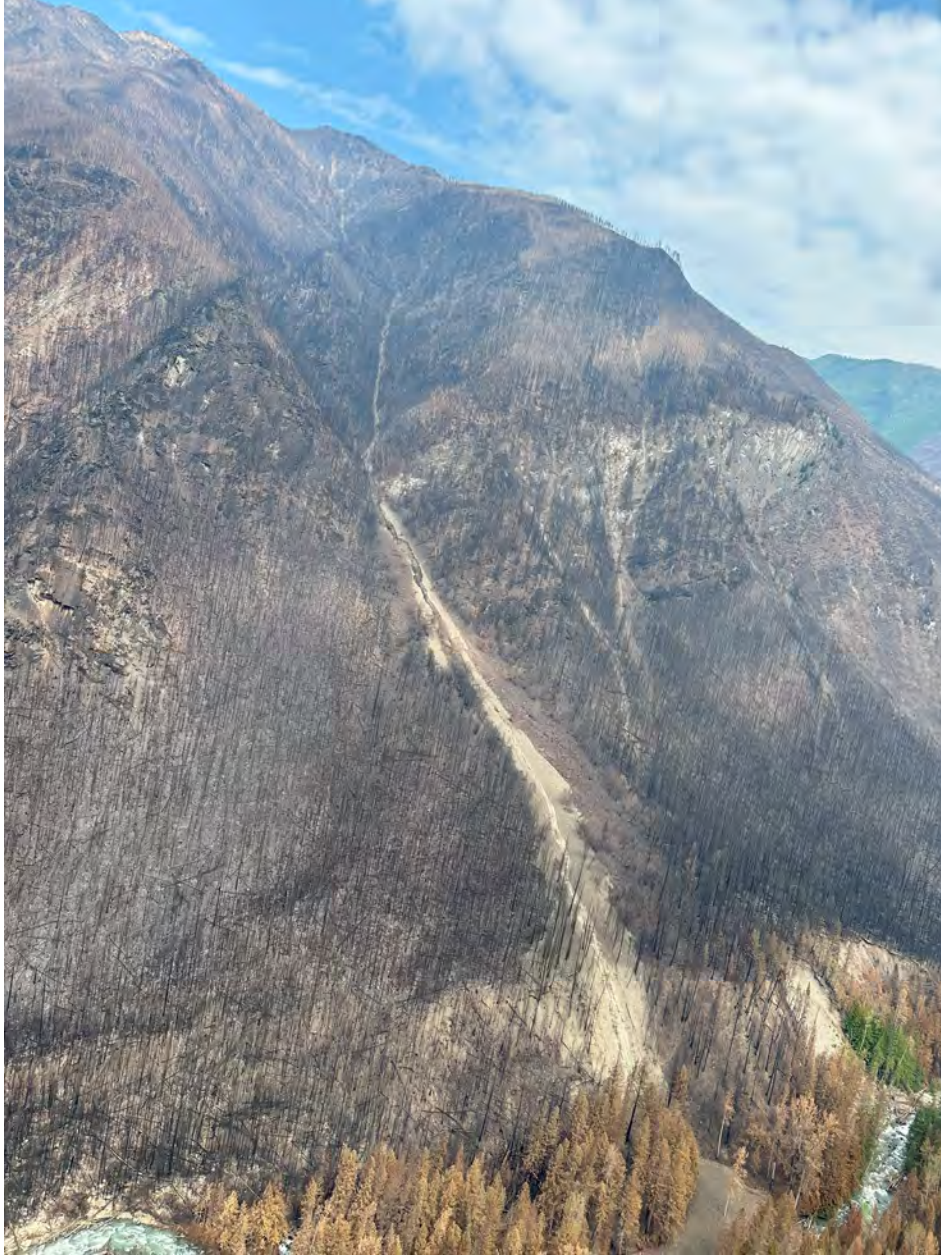


Photo 8: Recent debris flow activity in Hamill Creek; photo from helicopter overview flight Aug. 14, 2024.

Argenta Creek Wildfire

Hamill Creek and Clint Creek Photos



Photo 9: Example of high vegetation and soil burn severity in Hamill Creek, Photo from helicopter overview flight, Aug. 14, 2024.



Photo 10: View upstream in Hamill Creek, note extent of moderate and high vegetation burn severity along valley bottom adjacent to creek. Photo from helicopter overview flight, August 14, 2024.

Argenta Creek Wildfire

Hamill Creek and Clint Creek Photos



Photo 11: Log jam in Hamill Creek canyon; vertical orientation drone photo Dec. 2, 2024.

Argenta Creek Wildfire

Hamill Creek and Clint Creek Photos



Photo 12: View downstream along Hamill Creek from near the apex of the fan. Duncan River FSR bridge and a portion of the fan is visible, along with stream training works along the creek channel which were installed in 2013 following a major flood event. Drone photo October 1, 2024.



Photo 13: Hamill Creek bridge on Duncan River FSR looking downstream; drone photo October 1, 2024.

Argenta Creek Wildfire

Duncan Lake Tributaries (South of Glacier Creek) Photos



Photo 14: Duncan River FSR 6 km avalanche paths; drone photo Sept. 4, 2024.

Argenta Creek Wildfire

Duncan Lake Tributaries (South of Glacier Creek) Photos



Photo 15: Lavina Creek fan with Duncan River FSR and debris flow deposit visible near apex; drone photo Oct. 1, 2024.



Photo 16: Lavina Creek fan with debris flow deposit near apex; drone photo Oct. 1, 2024.

Argenta Creek Wildfire

Duncan Lake Tributaries (South of Glacier Creek) Photos



Photo 17: Lavina Creek debris flow deposit at apex of fan; drone photo Oct. 1, 2024.



Photo 18: Converging debris flow paths in Lavina Creek watershed; drone photo Oct. 1, 2024.

Argenta Creek Wildfire

Duncan Lake Tributaries (North of Glacier Creek) Photos



Photo 19: View looking upstream in Glacier Creek with Birnam Creek visible branching to the north (left) in the background. Note high burn severity on either side of valley, with low burn severity or unburned areas in valley bottom. August 28, 2024 drone photo.

Argenta Creek Wildfire

Duncan Lake Tributaries (North of Glacier Creek) Photos



Photo 20: Avalanche path with recent debris slide blocking road at 12.3 km on Glacier Creek FSR. December 2, 2024.

Argenta Creek Wildfire

Duncan Lake Tributaries (North of Glacier Creek) Photos

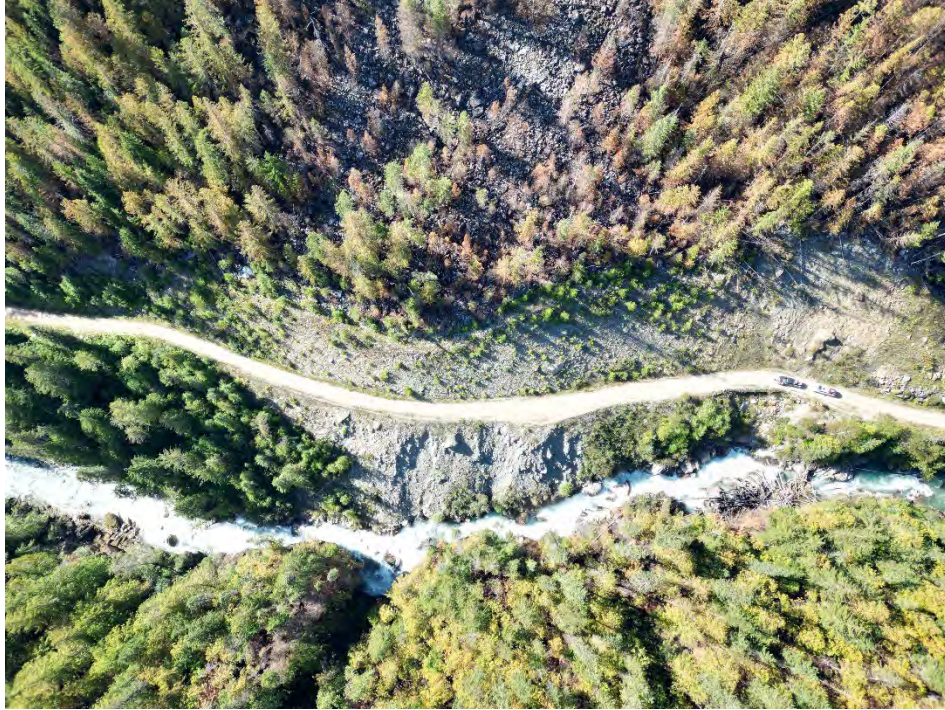


Photo 21: Drone photo with vertical orientation showing slow moving landslide area at 13 km on Glacier Creek FSR. August 29, 2024 photo.



Photo 22: Shallow, steep gully susceptible to debris flows at Birnam FSR located within and downslope of a high burn severity area.

Argenta Creek Wildfire

Duncan Lake Tributaries (North of Glacier Creek) Photos



Photo 23: High vegetation and soil burn severity on the north side of Birnam Creek drainage in Glacier Creek watershed. August 14, 2024 photo from helicopter overview flight.

Argenta Creek Wildfire

Duncan Lake Tributaries (North of Glacier Creek) Photos



Photo 24: Narrow snow avalanche path also subject to small debris flows which impact Glacier FSR on north side of Glacier Creek near 1000 m elevation. An increase in frequency and magnitude of snow avalanches with increased debris loading in the snow can be expected here, as well as an increase in likelihood of small debris flows. August 28 2024 drone photo.

Argenta Creek Wildfire

Duncan Lake Tributaries (North of Glacier Creek) Photos



Photo 25: View downstream in Glacier Creek with Glacier Creek FSR bridge near 1000 m elevation. The bridge appears to have good clearance over a confined section of channel, reducing its vulnerability to flood events. August 28, 2024 drone photo.

Appendix B

Post-Wildfire Natural Hazards Risk Analysis Definitions and Ratings

Appendix C

Post-Wildfire Hydrogeomorphic Hazard Definitions

Post-Wildfire Natural Hazards Risk Analysis

Definitions and Ratings

The following sections provide important definitions for terminology used in this report and are based on definitions presented in Land Management Handbook 69 Post-Wildfire Natural Hazards Risk Analysis in British Columbia (Hope et al. 2015) and Land Management Handbook 56 - Landslide Risk Case Studies in Forest Development Planning and Operations (Wise et al. 2004) (LMH-56).

Hazard: a source of potential harm, or a situation with the potential for causing harm, to a specified *element at risk*. With respect to landslide risk analysis, the landslide itself is the hazard.

Likelihood of occurrence: the qualitative estimate of probability (P), or the chance for an event to occur.

Elements at risk (elements): a thing of value that is known to be at risk. Elements at risk may include human safety, public and private property, transportation system/corridor, utility and utility corridor, domestic or community water quality and supply, fish habitat, wildlife habitat and migration, visual resource in a scenic area, timber value, and soil productivity (adapted from B.C. MoF, 2002).

Hazard analysis, $P(H)$: an estimation of the probability of a specific hazardous event. With respect to landslide hazard analysis, it refers to the probability or likelihood of occurrence for a specific hazardous landslide.

Spatial probability, $P(S:H)$: relates to the potential for an event to reach or have a spatial effect on the location of a considered element, and mathematically can range from a value of 0 (certain not to reach the element) to 1 (certain to reach the element).

Temporal probability, $P(T:S)$: relates to the potential for a mobile element to be at the affected location, if the considered event occurs. If the element is of a fixed location and is always present (such as permanent infrastructure) then the temporal probability is numerically equal to 1, with a value of less than 1 applicable for mobile elements depending on the proportion of time exposed.

Vulnerability, V : a measure of the robustness of an *element at risk* and its relative exposure to a hazard.

Consequence, C : the effect on a specified *element at risk*. With respect to landslide risk analysis, the consequence is the change, loss, or damage to the considered element caused by the landslide. Consequence considers the vulnerability as well as spatial and temporal probabilities of an event affecting an element.

Partial risk analysis, $P(HA)$: the product of the probability of occurrence and the probability of a spatial effect, considering both spatial and temporal probabilities. With respect to landslide risk analysis, it is the product of the probability for a specific hazardous landslide and the probability of that landslide reaching or otherwise affecting a considered element. It can also be referred to as the probability of a specific hazardous affecting landslide. Partial risk does not take into account the vulnerability of the element at risk, or the consequence of the event.

In general terms, risk is defined as the product of probability of occurrence and consequence ($R=PXC$). In the consideration of consequence to a specific element at risk, the vulnerability or robustness of the specific element must be understood. The vulnerability of specific elements is generally best assessed by specialists with a greater knowledge of the element than the terrain stability professional may have. As a result, it is generally appropriate for a terrain stability professional to carry out a *partial risk analysis*, in which the likelihood of a specific hazardous landslide is determined, and whether or not a specific element at risk could be spatially affected by

the hazardous landslide. The vulnerability of the specific element, including an estimation of consequence, is not considered in a partial risk analysis (Wise et al. 2004; LMH 56).

The following tables outline the rating definitions presented in this report. Table 1 provides the qualitative descriptions for the likelihood of occurrence ratings for a considered hazard event (P(H)).

Table B1: Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities. Ratings are modified from Land Management Handbook 56 (Wise et al., 2004) and EGBC Landslide Assessment Guidelines (2023).

Hazard Likelihood P(H)	Description	Hazard Criteria	Annual Probability Range and Return Frequency	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.	>0.20 (>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 – 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%

The five-year cumulative probability presented in Table 1 assumes that the likelihood of the hazard remains constant during the initial five-year period following the fire. The likelihood of some hazards may decrease during this period; therefore, this five-year cumulative probability should be interpreted as an upper limit for the likelihood of some hazards.

Table 2 presents the relative ratings for the likelihood of an event reaching or affecting an element at risk, given that a hazardous event occurs.

Table B2: Qualitative descriptions of the likelihood of spatial interaction and related quantitative probabilities. Ratings are modified from Land Management Handbook 56 (Wise et al., 2004).

Likelihood of Spatial Impact P(S:H)	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 3 presents the qualitative risk matrix that shows how partial risk ratings are derived from the combination of the likelihood of occurrence of a hazardous event and the likelihood that the event will reach or have a spatial effect on a specific element at risk. These ratings do not take into account the vulnerability of the element, or the potential consequence of the event. The partial risk ratings are also relative and are not equivalent in probability to the hazard ratings.

Table B3: Matrix of post-wildfire natural hazard partial risk P(HA)

Hazard Likelihood P(H) (Table B1)	Spatial Impact Likelihood P(S:H) (Table B2)		
	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

Table 4 presents ratings used for describing landslide magnitude based on approximate volume and affected area ranges.

Table B4: Magnitude ratings and approximate ranges of landslide area and volume¹

Magnitude Rating	Quantitative Range	
	Area affected (ha)*	Minimum Volume involved (m ³)**
Very Large	>5	50,000
Large	0.5-5	5,000-50,000
Medium	0.05-0.5	500-5,000
Small	0.005-0.05	50-500
Very Small	<0.005	< 50

¹adapted from Wise et al. (2004)

*1 ha = 10,000 m²

**Based on planimetric area and assumed depth/thickness of 1 m.

Table B5: Vegetation burn severity classification for coniferous forest

Vegetation burn severity class	Definition	BARC class	Typical soil burn severity class
High (black)	Canopy trees blackened (charred) and dead, needles consumed, understorey burned	High	H or M
Moderate (brown or red)	Trees burned and dead, scorched needles remain on canopy trees, understorey burned and blackened	Moderate	M or H, can be L
Low (green)	Canopy unburned, trunks partially burned, understorey lightly or patchily burned	Low	L, can be M or H
Unburned	Vegetation in natural unburned state	Unburned	

Table B6: Soil burn severity classification

Soil and forest floor factors	Soil burn severity		
	High	Moderate	Low
Litter	Consumed	Mostly consumed	Scorched, charred, patchily consumed
Duff (FH layers)	Consumed in most locations	Deep char, may be consumed	Intact, surface char
Woody debris — small	Consumed	Partly–completely consumed	Partly consumed, charred
Woody debris —logs	Many consumed, others deeply charred	Charred	Charred
Ash colour (if still present)	Fine, white or grey	Greyish or blackened	Black
Mineral soil exposure (may still be covered with loose ash or charcoal)	>40%	<40%	Little
Mineral soil	Altered structure, porosity, etc.; often grey or reddish around burned large fuel; often strongly water repellent	Unchanged; water repellency is slight or patchy	Unchanged
Depth to live roots or rhizomes (in mineral soil)	>5 cm	0–5 cm	0 cm

References:

British Columbia Ministry of Forests 2002. Forest road engineering guidebook, 2nd ed. Forest Practices Code of British Columbia, Victoria, B.C.

Engineers and Geoscientists BC. 2023. Professional Practice Guidelines - Landslide Assessments in British Columbia v. 4.1.

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. Prov. B.C., Victoria, B.C. Land Manag. Handb. 69.

www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH69.htm

Wise, M.P., G.D. Moore, and D.F. VanDine (editors). 2004. Landslide risk case studies in forest development planning and operations. B.C. Min. For., Res. Br., Victoria, B.C. Land Manage. Handb. No. 56.

www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh56.htm

Soil, Slope, and Rock Classification

Course Grained Soils¹ (Cohesionless):

Density	Field Test
Very Loose	Easily excavated with a spade
Loose	Some resistance to spade
Compact	Considerable resistance to space
Dense	Requires pick for excavation
Very Dense	High resistance to pick

Fine Grained Soils¹ (Cohesive):

Consistency	Field Test
Very Soft	Easily excavated with a spade
Soft	Easily penetrated by thumb
Firm	Readily penetrated by thumb
Stiff	Readily indented by thumb
Very Stiff	Penetrated by thumbnail
Hard	Difficult to indent with thumb

Rock Strength¹:

Strength	Field Identification
Extremely Weak	Indented by thumbnail
Very Weak	Crumbles under firm blow of hammer; can be peeled with a pocket knife
Weak	Can be peeled by pocket knife (difficult); shallow indents from firm blow of hammer point
Medium Strong	Cannot be scraped or peeled with knife; fractures with single blow of hammer.
Strong	Requires more than one blow of hammer to fracture
Very Strong	Requires many blows of hammer to fracture
Extremely Strong	Can only be chipped by hammer

Spacing of Discontinuities in Rock¹:

Spacing	Spacing Width (m)
Extremely Close	<0.02
Very Close	0.02 – 0.06
Close	0.06 – 0.20
Moderately Close	0.2 – 0.6
Wide	0.6 – 2.0
Very Wide	2.0 – 6.0
Extremely Wide	>6.0

Soil Description^{1,4}:

Noun	Gravel, sand, silt, clay	> 35% and main fraction
"and"	and gravel, and silt, etc	> 35%
Adjective	gravelly, sandy, silty, etc.	20-35%
"Some"	some sand, some silt, etc.	10-20%
"Trace"	Trace sand, trace silt, etc	1-10%

Soil Thickness^{2,3}:

Thickness	
Blanket	>1.0 m
Veneer	<1.0 m

Soil Drainage⁵ (adapted):

Rapidly drained	Water is removed from the soil rapidly in relation to supply.
Well drained	Water is removed from the soil readily but not rapidly.
Moderately Well drained	Water is removed from the soil somewhat slowly in relation to supply.
Imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Some mottling is common.
Poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Soils are generally mottled and/or gleyed.
Very Poorly drained	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Typically associated with wetlands.

Slope Gradient³ (adapted):

Slope Gradient	Percent (%) Range	Degree Range
Flat	0-5	0-3
Gentle	6-26	4-15
Moderate	27-49	16-26
Moderately Steep	50-70	27-35
Steep	71-90	36-42
Very Steep	>90	>42

Surface Configuration² (adapted):

Surface Configuration	Relief (metres)
Uniform	<1.0
Slightly Irregular	1.0 – 2.0
Irregular	2.0 – 4.0
Very Irregular	>4.0

Slope Shape³ (modified) and Features:

Based on the overall shape of the slope between distinct slope breaks; includes concave , convex and straight and benched shapes.
Gullies ⁶ (modified): sidewalls >3m high (measured along the fall line); sidewall gradients >50%; channel gradients typically >20% (may be less for some sections); may or may not contain an active stream channel.
Swailes : any linear depressions in the landscape that do not meet the gully criteria above; generally shallower with lower channel and sidewall gradients; may or may not contain an active stream channel.

Qualitative landslide magnitude ratings⁷

Magnitude Rating	Typical Area affected (ha)	Typical Volume Involved (m ³)
Very Large	>5	50,000
Large	0.5 - 5	5,000 – 50,000
Medium	0.05 – 0.5	500 – 5,000
Small	0.005 – 0.05	50 - 500
Very Small	<0.005	<50

REFERENCES:

1. Canadian Geotechnical Society, Canadian Foundation Engineering Manual, 4th Edition, *Identification and Classification of Soil and Rock*, 2006.
2. Ministry of Forests, A Guide for Management of Landslide Prone Terrain in the Pacific Northwest, 2nd Edition, *Land Management Handbook #18*, 1994.
3. Ministry of Environment, Terrain Classification for British Columbia, Revised Edition, *Manual 10 (Version 2)*, 1997
4. Ministry of Forests, Forest Road Engineering Guidebook, 2nd Ed., 2002.
5. Ministry of Environment Lands and Parks and Ministry of Forests, Field Manual for Describing Terrestrial Ecosystems, LMH#25, 1998.
6. Ministry of Forests, Gully Assessment Procedures Guidebook 1995
7. Ministry of Forests, Landslide Risk Case Studies in Forest Development Planning and Operations, LMH#56, 2004.

Appendix D

Point of Diversion Tables

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Argenta Creek Main	Argenta Creek	PD24939	C048151	Domestic	50.165176	-116.9044051
Argenta Creek Main	Argenta Creek	PD24939	F005822	Domestic	50.165176	-116.9044051
Argenta Creek Main	Argenta Creek	PD24939	F005822	Irrigation: Private	50.165176	-116.9044051
Argenta Creek Main	Argenta Creek	PD24940	C039289	Irrigation: Private	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24940	C039293	Irrigation: Private	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24940	C039294	Irrigation: Private	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24940	C100149	Domestic	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24940	C113165	Irrigation: Private	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24940	C113168	Domestic	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24940	C113169	Domestic	50.1662872	-116.906814
Argenta Creek Main	Argenta Creek	PD24941	C052465	Domestic	50.166701	-116.908047
Argenta Creek Main	Argenta Creek	PD24941	C052466	Domestic	50.166701	-116.908047
Argenta Creek Main	Argenta Creek	PD24943	C040580	Domestic	50.1665777	-116.9089716

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Argenta Creek Main	Argenta Creek	PD24943	C045977	Domestic	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24943	C045977	Irrigation: Private	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24943	C046408	Domestic	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24943	C046408	Irrigation: Private	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24943	C058159	Domestic	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24943	C059264	Irrigation: Private	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24943	F019088	Domestic	50.1665777	-116.9089716
Argenta Creek Main	Argenta Creek	PD24944	C044224	Irrigation: Private	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	C044981	Domestic	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	C044981	Irrigation: Private	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	C044982	Domestic	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	C044982	Irrigation: Private	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	C046197	Irrigation: Private	50.1668323	-116.9103337

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Argenta Creek Main	Argenta Creek	PD24944	C100155	Domestic	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	F019043	Domestic	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24944	F019043	Irrigation: Private	50.1668323	-116.9103337
Argenta Creek Main	Argenta Creek	PD24946	C057359	Irrigation: Private	50.1669797	-116.9111421
Argenta Creek Main	Argenta Creek	PD24946	C058353	Irrigation: Private	50.1669797	-116.9111421
Argenta Creek Main	Argenta Creek	PD24946	C059262	Irrigation: Private	50.1669797	-116.9111421
Argenta Creek Main	Argenta Creek	PD24946	C059263	Irrigation: Private	50.1669797	-116.9111421
Argenta Creek Main	Argenta Creek	PD24948	C028846	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C028846	Irrigation: Private	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C037485	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C039290	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C044223	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C044223	Irrigation: Private	50.1670424	-116.9116183

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Argenta Creek Main	Argenta Creek	PD24948	C050273	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C050273	Irrigation: Private	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C054346	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C054385	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C054385	Comm. Enterprise: Enterprise	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C130112	Domestic	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24948	C130112	Irrigation: Private	50.1670424	-116.9116183
Argenta Creek Main	Argenta Creek	PD24951	C114373	Domestic	50.1671056	-116.9121208
Argenta Creek Main	Argenta Creek	PD24951	C133001	Domestic (WSA01)	50.1671056	-116.9121208
Argenta Creek Main	Argenta Creek	PD24952	C050271	Domestic	50.1671197	-116.9122909
Argenta Creek Main	Argenta Creek	PD24952	C050271	Irrigation: Private	50.1671197	-116.9122909
Argenta Creek Main	Argenta Creek	PD24954	C035469	Domestic	50.1671339	-116.9124627
Argenta Creek Main	Argenta Creek	PD24954	C067989	Power: Commercial	50.1671339	-116.9124627

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Argenta Creek Main	Argenta Creek	PD24954	C113785	Domestic	50.1671339	-116.9124627
Argenta Creek Main	Argenta Creek	PD24954	C133028	Domestic (WSA01)	50.1671339	-116.9124627
Argenta Creek Main	Argenta Creek	PD24956	C133028	Domestic (WSA01)	50.1662849	-116.9196626
Argenta Creek Main	Argenta Creek	PD69952	C108609	Domestic	50.166304	-116.9208303
Argenta-Carter Face	Seamark Brook	PD24934	C044401	Domestic	50.1781862	-116.9054928
Argenta-Carter Face	Seamark Brook	PD24934	C044401	Irrigation: Private	50.1781862	-116.9054928
Argenta-Carter Face	Mautner Brook	PD24936	C029664	Domestic	50.1778132	-116.9052907
Argenta-Carter Face	Mautner Brook	PD24936	F043605	Domestic	50.1778132	-116.9052907
Argenta-Carter Face	Mautner Brook	PD24936	F043606	Domestic	50.1778132	-116.9052907
Argenta-Carter Face	Hugh Spring	PD24938	C037484	Domestic	50.1764743	-116.906912
Argenta-Carter Face	Hugh Spring	PD24938	C038607	Irrigation: Private	50.1764743	-116.906912
Argenta-Carter Face	Hugh Spring	PD24938	C038608	Domestic	50.1764743	-116.906912
Argenta-Carter Face	Hugh Spring	PD24938	C038608	Irrigation: Private	50.1764743	-116.906912

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Argenta-Carter Face	Hugh Spring	PD24938	C038609	Irrigation: Private	50.1764743	-116.906912
Argenta-Carter Face	Hugh Spring	PD24938	C039370	Domestic	50.1764743	-116.906912
Argenta-Carter Face	Betty Spring	PD24960	C056715	Irrigation: Private	50.1752776	-116.9097769
Argenta-Carter Face	Peace Spring	PD24962	C038232	Domestic	50.1746335	-116.9098377
Argenta-Carter Face	Peace Spring	PD24962	C038232	Irrigation: Private	50.1746335	-116.9098377
Argenta-Carter Face	Peace Spring	PD24962	C053520	Domestic	50.1746335	-116.9098377
Argenta-Carter Face	Peace Spring	PD24962	C053520	Irrigation: Private	50.1746335	-116.9098377
Bulmer-Argenta Face	Gale Spring	PD24887	C054938	Domestic	50.1362333	-116.9101048
Bulmer-Argenta Face	Pollard Springs	PD24968	C046409	Domestic	50.165603	-116.9134426
Bulmer-Argenta Face	Pollard Springs	PD24969	C046409	Domestic	50.1653096	-116.9133605
Bulmer-Argenta Face	Pollard Springs	PD24971	C046409	Domestic	50.1649136	-116.9133871
Bulmer-Argenta Face	Galas Spring	PD24973	C104797	Land Improve: General	50.1645946	-116.9135906
Carter Creek	Tanner Spring	PD184259	C126490	Domestic	50.1865398	-116.9059472

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Carter Creek	Tanner Spring	PD184259	C126497	Domestic	50.1865398	-116.9059472
Carter Creek	Tanner Spring	PD184259	C131902	Domestic	50.1865398	-116.9059472
Carter Creek	Tanner Spring	PD184259	C131902	Irrigation: Private	50.1865398	-116.9059472
Carter Creek	Tanner Spring	PD184259	C131903	Irrigation: Private	50.1865398	-116.9059472
Carter Creek	Carter Creek	PD24916	C049785	Domestic	50.1869291	-116.9087585
Carter Creek	Carter Creek	PD24916	C059113	Domestic	50.1869291	-116.9087585
Carter Creek	Carter Creek	PD24916	C114457	Power: Residential	50.1869291	-116.9087585
Carter Creek	Carter Creek	PD24916	C116283	Domestic	50.1869291	-116.9087585
Carter Creek	Carter Creek	PD24916	C116283	Irrigation: Private	50.1869291	-116.9087585
Carter Creek	Carter Creek	PD24918	C035693	Domestic	50.1868038	-116.908962
Carter Creek	DeWitt Brook	PD24920	C063120	Domestic	50.1914844	-116.9060394
Carter Creek	DeWitt Spring	PD24922	C100141	Domestic	50.1913385	-116.9045258
Carter Creek	DeWitt Spring	PD24922	C107732	Domestic	50.1913385	-116.9045258

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Carter Creek	DeWitt Spring	PD24922	C107732	Irrigation: Private	50.1913385	-116.9045258
Carter Creek	Tanner Spring	PD24925	C063131	Domestic	50.1865665	-116.9061395
Carter Creek	Thomas Brook	PD24927	C038233	Domestic	50.1847205	-116.9059551
Carter Creek	DeWitt Spring	PD79229	C120583	Domestic	50.1912755	-116.9038411
Carter Creek	DeWitt Spring	PD79229	C120583	Irrigation: Private	50.1912755	-116.9038411
Carter Creek	DeWitt Spring	PD79229	C120583	Land Improve: General	50.1912755	-116.9038411
Carter Creek	DeWitt Spring	PD79229	C120973	Irrigation: Private	50.1912755	-116.9038411
Carter Creek	DeWitt Spring	PD79229	C120974	Domestic	50.1912755	-116.9038411
Carter Creek	DeWitt Spring	PD79229	C120974	Irrigation: Private	50.1912755	-116.9038411
Glacier Creek	Glacier Creek	PD184123	C130483	Domestic	50.3109505	-116.8838163
Glacier Creek	Glacier Creek	PD184123	C130483	Livestock & Animal: Stockwatering	50.3109505	-116.8838163
Hamill Creek Fan	Hamill Creek	PD25010	C053479	Domestic	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C053479	Irrigation: Private	50.2001454	-116.9426491

Watershed Unit	Source Name	PD Number	Licence Number	Purpose	Latitude	Longitude
Hamill Creek Fan	Hamill Creek	PD25010	C111788	Domestic	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C111789	Domestic	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C111789	Irrigation: Private	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C111793	Irrigation: Private	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C111794	Irrigation: Private	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C111795	Irrigation: Private	50.2001454	-116.9426491
Hamill Creek Fan	Hamill Creek	PD25010	C118330	Irrigation: Private	50.2001454	-116.9426491

Appendix E

Debris Flow and Flooding Risk Awareness Pamphlets

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 (<https://maps.rdck.bc.ca/>).
- 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.

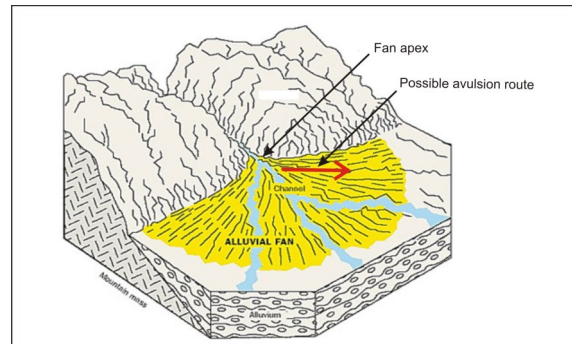


Figure 3. Schematic diagram of an alluvial fan, showing a possible flow route and geological features.

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: <http://www2.gov.bc.ca/gov/content/safety/emergency-preparedness-response-recovery>

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 upstream. 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

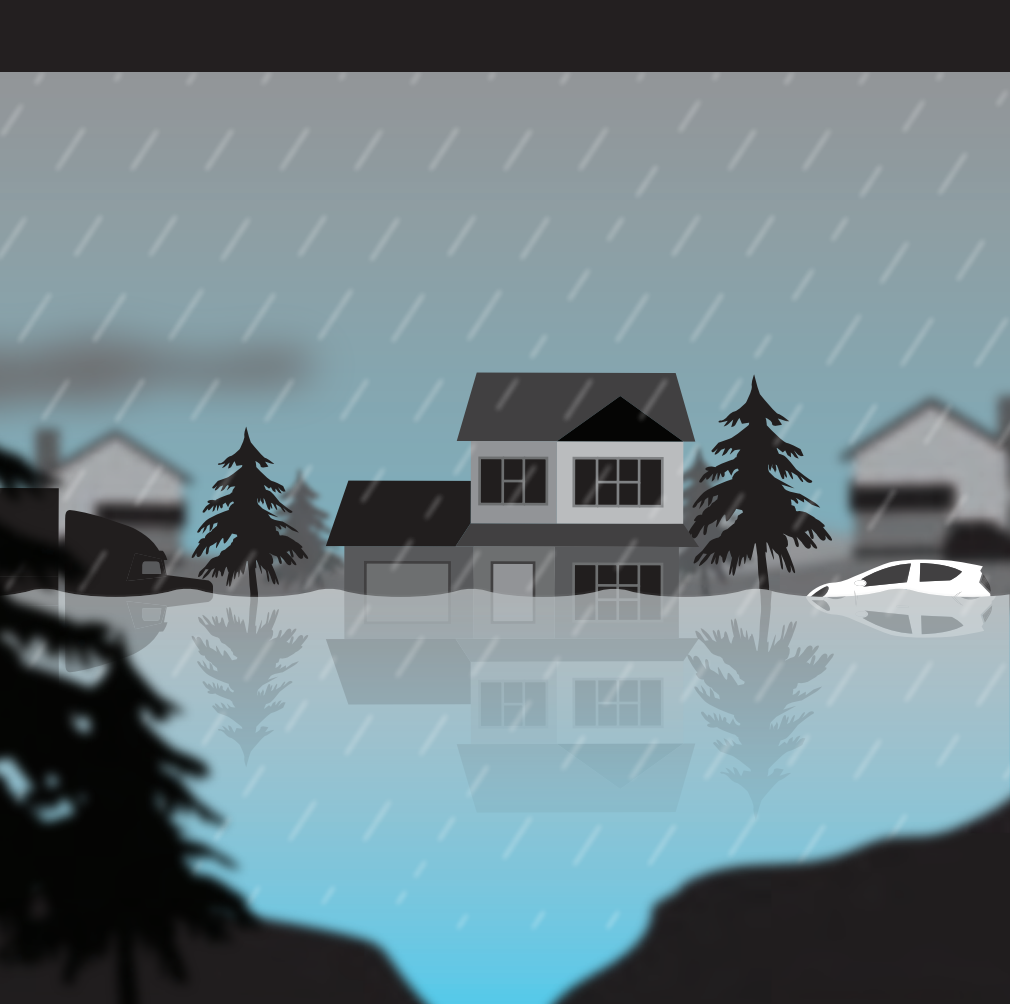
***Not all debris flows are preceded by these indicators.
Following the advice in this document does not ensure your safety.***

To report the potential emergency, call the 24-hour toll-free number: 1 800 663-3456



PreparedBC

Flood Preparedness Guide





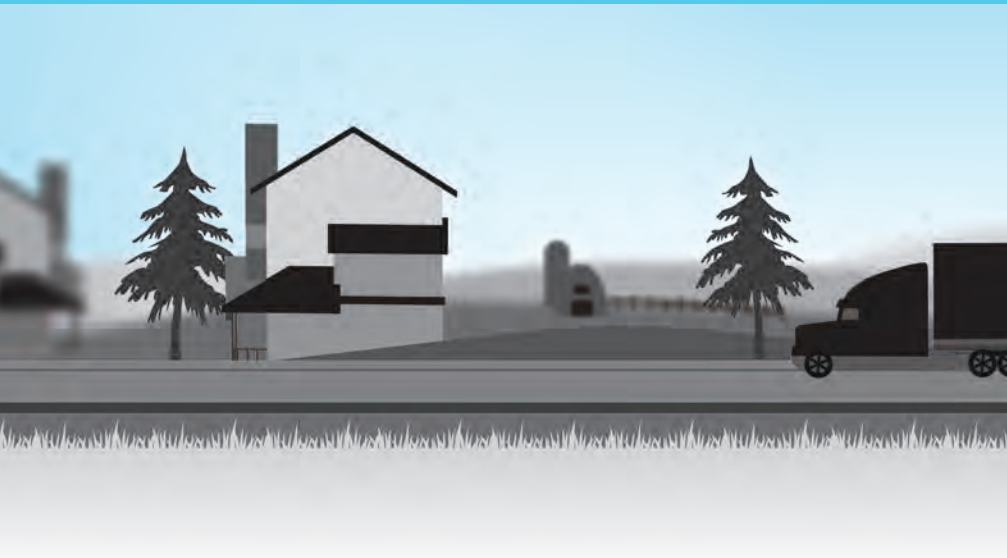
Floods in B.C.

Floods are common in B.C. and can happen at any time of year. The most severe floods usually occur in spring and early summer due to heavy rain and melting snow. They can also be caused by storm surges, ice jams or damage to structures like dikes or dams.

Climate change and related extreme weather events have increased the flood risk. Rising temperatures, changing freeze-thaw cycles and rising sea levels can all contribute to flooding.

Floods can damage buildings, cause power outages, disrupt transportation and create landslides. Fast-moving flood waters can also be a hazard for people and pets.

If you live somewhere that could experience a flood, this guide is a must-read! It will help you prepare and know what to do if a flood occurs.



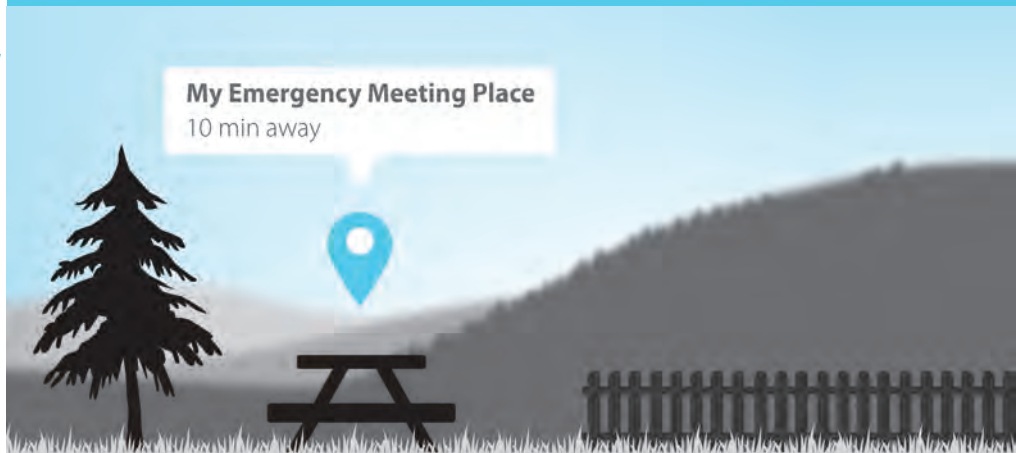
Before a Flood

HAVE A PLAN

Having an emergency plan is one of the best steps you can take to prepare for a flood. It can be as easy as starting a conversation at home.

The following section will walk you through topics to consider as part of your basic emergency plan. As you discuss them, use the spaces provided to write notes.

TIP: You can also find and download our fill-in-the-blanks emergency plan at: PreparedBC.ca/EmergencyPlans



CHOOSE EMERGENCY MEETING PLACES

During an emergency, such as a flood, it's important to gather with the people you live with to make sure everyone is safe. You might not be together when disaster strikes.

You can make it easier to find each other by choosing emergency meeting places ahead of time. Pick one spot close to your home, such as a nearby hill or a neighbour's house. Then pick an alternate spot away from your immediate neighbourhood, such as a library or community building.



Our meeting place close to home is:



Our meeting place away from home is:

KNOW HOW YOU WILL COMMUNICATE

It's a good idea to save or write down a list of people you can call for help during an emergency.

Ideally, at least one contact should live far enough away that they won't be affected by the same emergencies. It's also helpful to have at least one contact who lives in your community.

Name	Phone & Email
.....	
.....	
.....	
.....	

Follow these guidelines for staying connected:



Keep your phone fully charged. Conserve battery life by dimming your screen and avoiding power-hungry apps and video.



Consider a virtual meeting place. Create a closed Facebook group for everyone in your home to check in during an emergency.

TIP: Details like contact info and meeting places can change over time. Make sure you review and update your emergency plan at least once every year.

KNOW WHERE TO FIND INFORMATION

For reliable information during an emergency, always start with local sources. This could be your band office, municipality, regional district or local authority. Know in advance how they'll share vital information, whether it's through their website, social media, phone or local radio.



Websites

.....

.....

.....



Social Media

.....

.....

.....



Phone Numbers

.....

.....

.....



Radio Stations

.....

.....

.....



EmergencyInfoBC

TIP: Depending on the emergency, you can also check provincial channels for information. Emergency Info BC shares information about large emergencies that may require support from the provincial government:



EmergencyInfoBC.ca



[@EmergencyInfoBC](https://twitter.com/EmergencyInfoBC)

RESEARCH INSURANCE COVERAGE

Check with your insurance representative to determine if sewer backup and/or residential flood insurance is available for your property. You can also contact the Insurance Bureau of Canada at 1-844-227-5422 for information regarding home insurance. Add your insurance information to your emergency plan to ensure it's handy when you need it.

MAKE GRAB-AND-GO BAGS

If flood waters get too close to your home, it may become unsafe to stay and you'll need to leave quickly. This is easier to do if you take time to build grab-and-go bags in advance. Fill backpacks or carrying bags with the supplies everyone in your home will need to keep comfortable.

Everyone's needs will be different, but our checklist on the next page is a good place to start.

TIP: For some, it's easier to gather these items over time, instead of all at once. Get more ideas on building grab-and-go bags at PreparedBC.ca/Grab-and-Go



Flood Preparedness Guide

Basic Survival

- ☐ Bottled water
- ☐ Ready-to-eat food, like granola bars

Warmth & Safety

- ☐ Emergency blanket
- ☐ Seasonal clothing
- ☐ Flashlight
(battery-powered or hand-crank)
- ☐ Whistle

Communication

- ☐ Phone charger
- ☐ Battery bank
- ☐ Handheld radio
(battery-powered or hand-crank)
- ☐ Extra batteries

Health & Sanitation

- ☐ First aid kit
- ☐ Toothpaste, toothbrush and
other toiletries

.....
If applicable:

- ☐ Spare glasses/contact lenses
- ☐ Personal medication

Peace of Mind

- ☐ Pen and notepad
- ☐ Cash in small bills
- ☐ Copy of important documents
such as insurance papers
- ☐ Copy of your emergency plan

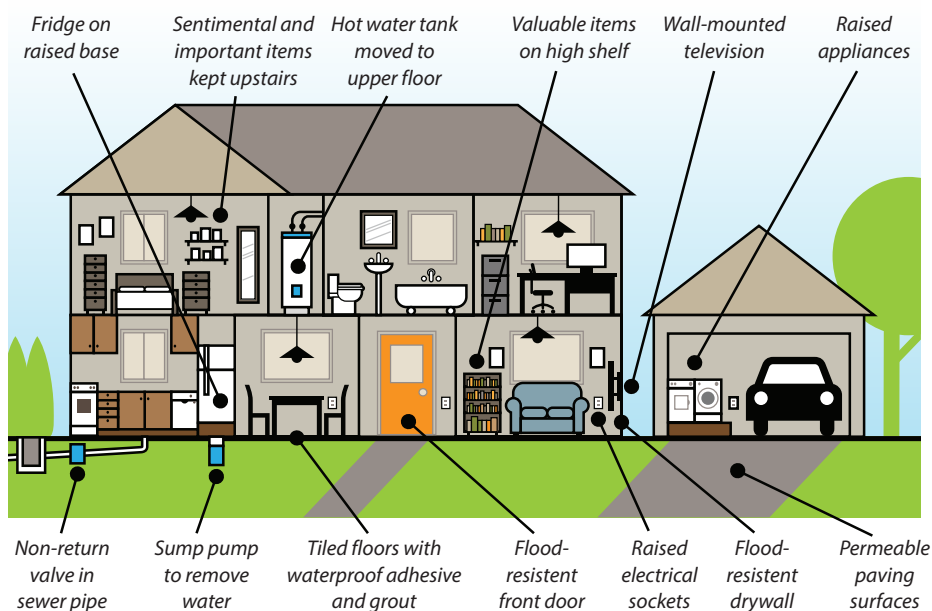
TIP: Food, water, batteries and other items in your grab-and-go bag can expire over time. Check and replace the contents at least every 6 months.

PROTECT YOUR HOME & PROPERTY

There are simple steps you can take in and around your home and property to help prevent flood damage.

Here are steps everyone should take:

- ☐ Store valuables and important items or documents in water-tight containers or in higher places, like on a tall shelf or upper floor.
- ☐ Clean your gutters regularly.
- ☐ Keep nearby storm drains clear of debris.
- ☐ In the winter, clear snow at least 3-5 feet away from your home's foundation.



Flood Preparedness Guide

If you can, also consider these home improvement projects:

- ☐ Raise large appliances, furnaces, hot water heaters, and electrical panels onto wood or cement blocks above the potential water level. (If an item can't be raised, consider anchoring it and protecting it with a floodwall or shield.)
- ☐ Anchor any oil tanks or fuel supplies to the floor.
- ☐ Install backflow valves on basement floor drains, washing machine drains, toilets and sink drains.
- ☐ Install a sump pump.
- ☐ Install tiled floors with waterproof adhesive and grout.
- ☐ Install flood-resistant exterior doors.
- ☐ Raise electrical sockets on the ground floor of your home.
- ☐ Install flood-resistant drywall.
- ☐ Apply weather protection sealant around basement windows and the base of ground-level doors.
- ☐ Install permeable paving surfaces for sidewalks and driveways.
- ☐ Make sure your gutter downspouts extend at least 2 metres from your basement wall. Water should drain away from your property and neighbouring properties.
- ☐ Install permanent safeguards, such as self-closing flood barriers, designed to keep water out of your home for as long as possible.
- ☐ Enhance your landscaping so water drains away from your foundation.



During a Flood

IF FLOODING IS IMMINENT

The most important thing you can do is follow all evacuation alerts and orders and follow all instructions from your band office, municipality, regional district or local authority. Trust in your preparedness work and your emergency plan.

If flooding is imminent but you have not yet been instructed to evacuate, follow these tips:

Flood Preparedness Guide



- Monitor local radio stations, television news and social media for the latest information from your local officials on sandbagging stations, possible evacuation procedures and routes.
- Only use tap water if it has been tested and deemed safe by your local authority. Use bottled or boiled water for drinking, brushing your teeth, dishwashing and cooking.
- If a flood warning is in effect (**see page 14**), shut off electricity to areas that are at risk of flooding and move small appliances, electronics and smaller furniture to upper floors or areas not likely to be affected.

FLOOD ADVISORIES

The River Forecast Centre issues advisories about current or expected flood risks. There are three stages of notification:

1

High Streamflow Advisory

River levels are rising or expected to rise rapidly, but no major flooding is expected. Minor flooding in low-lying areas is possible.

2

Flood Watch

River levels are rising and will approach or may exceed the river bank. Flooding of areas adjacent to affected rivers may occur.

3

Flood Warning

River levels have exceeded the river bank or will exceed the river bank imminently, and flooding of areas adjacent to affected rivers will result.

These advisories and warnings can be found on the River Forecast Centre website: bcrfc.env.gov.bc.ca/warnings/index.htm

TIP: You can also follow @EmergencyInfoBC on Twitter to get notifications for Flood Watches and Flood Warnings.



EmergencyInfoBC



@EmergencyInfoBC

BUILDING A SANDBAG DIKE

You can prevent or reduce flood damage to your home by building a sandbag dike. It takes two people about one hour to fill and place 100 sandbags, giving you a 1-x-20-foot wall. Contact your band office, municipality, regional district or local authority for information on obtaining sandbags.

BAGS REQUIRED PER 100 LINEAR FEET OF DIKE

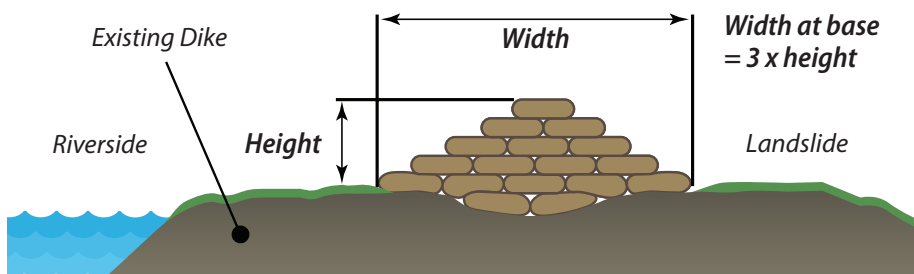
<i>Height above dike</i>	<i>Bags required</i>
<i>1/3 metre</i>	<i>600</i>
<i>2/3 metre</i>	<i>2,000</i>
<i>1 metre</i>	<i>3,400</i>



Plan of bottom layer



Method of lapping bags



- Locate the sandbag dike on high ground as close as possible to your home.
- Dig a bonding trench, one sack deep by two sacks wide.
- Alternate the direction of sacks (e.g. bottom layer length-wise with dike, next layer crosswise).
- Sacks should be approximately half-filled with clay, silt or sand.
- Tying or sewing of sacks is not necessary.
- Lap unfilled portion under next sack.
- Press firmly in place.



KNOW YOUR EVACUATION STAGES

Be prepared. Understand the evacuation stages used in B.C., and what to do for each. This will help you respond quickly and confidently.

Evacuation Alert:

Be ready to leave on short notice.

Evacuation Order:

You are at risk. Leave IMMEDIATELY.

Evacuation Rescind:

The risk to life and safety has passed.

Evacuation Alert

This means be ready to leave on short notice. If you're under alert, take the following steps:

- Gather your grab-and-go-bags, emergency plan, copies of important documents and cherished mementos. Have them at the front door or already packed in your vehicle.
- Make sure vehicles are parked away from streams and waterways.
- Remove toxic substances such as pesticides and insecticides from the flood area to prevent pollution.
- DO NOT attempt to shut off electricity if any water is present.
- Use sandbags to block floor drains and toilets to prevent sewage back-up.



TIP: Always keep your vehicle's gas tank half full in case you need to evacuate on short notice.

Evacuation Order

This means you are at risk and must leave IMMEDIATELY. Follow all directions from officials and evacuate using the route(s) they've identified. Heed the following advice as you evacuate:

- Do not attempt to cross rivers or flowing streams.
- Do not drive or walk across flooded roads – 15 centimetres (six inches) rushing water can knock an adult off their feet; 30 centimetres (one foot) of water can sweep away a vehicle.
- If your car begins to flood, abandon it quickly and head to higher ground.

An Emergency Support Services (ESS) reception centre may be opened for evacuated residents who are without access to other supports, such as insurance coverage or friends and family who can help. Services may include: food, lodging, clothing, emotional support, information about the crisis and family reunification.

Evacuation Rescind

Once officials determine the risk to life and safety has passed, the evacuation order will be rescinded and you can return home. Continue to stay tuned for other possible evacuation alerts or orders.



COPING WITH FLOOD STRESS

Alerts, evacuations, loss and worry – floods can affect us all. If you are feeling stressed or anxious, here are some things you can do to help you cope.

Take care: Stress takes a toll on your physical and mental health. Eating well, exercising and getting enough sleep lowers stress and helps us cope.

Reach out: Talking helps, whether it's with family, friends, a doctor or counsellor. Crisis lines are available to listen and help at any time. You can contact:

- BC Mental Health Support Line, available 24 hours a day at 310-6789 (no area code).
- KUU-US Indigenous Crisis Line at 1-800-588-8717.

Help others: Take care of the vulnerable. Assisting others can help you regain a sense of purpose and community as you confront the challenges together.



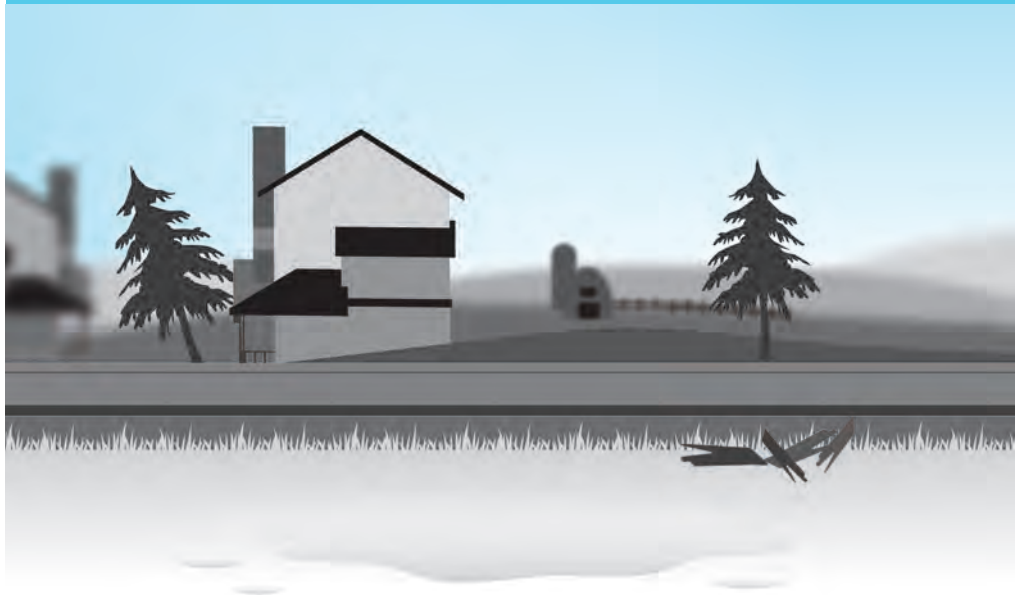
After a Flood

RETURNING HOME

Returning home after widespread flooding can be overwhelming. Use extreme caution and take it one step at a time.

Talk to your neighbours. We're all in this together and reaching out to people in your community, as well as accepting help, can be both comforting and encouraging.

Consider creating a cleanup and recovery plan. Just like having an emergency plan, it will help you organize what needs to be done so tasks don't seem overwhelming.



Tips for returning home:

- Do not return home until authorities say it is safe and they have cleared your home of structural, electrical or other hazards.
- Stay out of any buildings if floodwaters remain around or in the building.
- Do not enter a building if you see buckled walls or floors.
- Ensure your electricity has been turned off. DO NOT attempt to turn the power back on in your home until the wiring has been inspected by a professional.
- If water needs to be drained, do so slowly addressing about 1/3 of the water per day. This ensures the structure of your home won't buckle.
- DO NOT heat your home above the temperature outside until all water has been removed.

MANAGING MOULD AND HEALTH RISKS

Cleaning up after a flood can pose health risks. You may see or smell mould on clothing, drywall, furniture, cardboard boxes or books, but it may also be hidden under or behind items like carpet, cushions or walls.

Mould grows in wet and damp conditions. It's less likely to grow if your home and furnishings are dry within 48 hours after a flood. This will help prevent mould, which can continue to damage your home long after.

Pregnant women, children, older adults, pets and those with asthma, allergies or other health problems should not be in or near the area where the mould is being cleaned up.

Identify all mouldy items. Place and seal items in a plastic bag and dispose it. It's important to wash your hands thoroughly after mould cleanup, as well as change your clothes.

If you rent your home, speak to your landlord about any moisture or mould problems. It may be the responsibility of the owner or landlord to address the problem. If you own a condo unit or workspace, be sure to consult with the Condominium Board before taking any action.

Consider seeking professional assistance to identify the right corrective actions to be taken inside your home.

TIP: Before you start your cleanup activities, call your insurance representative or company. Most insurers have a 24-hour claims service. See **page 25** for more info.

HOW TO CLEAN YOUR HOME

Before you begin cleaning up, be sure to open all interior and exterior doors and windows, allowing air to flow freely through the space. Do not use fans if mould is present, as this can spread the mould to new areas.

Scrub all washable surfaces with a household bleach solution or unscented soap solution. These areas include window sills, concrete surfaces, hard surfaces and tiles. Dry the surfaces quickly.

Essential list of items for cleaning mould:

- | | |
|---|---|
| ☐ Bucket | ☐ Protective rubber gloves |
| ☐ Stiff bristle brush | ☐ Waterproof rubber boots |
| ☐ Cleaning clothes | ☐ Dish detergent |
| ☐ Goggles | ☐ Household bleach |
| ☐ N-95 respirators, or ones that provide more protection (check packaging for “N-95”) available at hardware stores. Be sure to read the directions for proper use. | |

Cleaning solutions:

- A bleach solution is made up of 1-part bleach to 10-parts clean water.
- You can make a baking soda solution by adding a ¼ tablespoon of baking soda to a spray bottle of warm water.
- A soap solution can be made by combining unscented detergent and warm water.



Mould cannot be properly cleaned from many porous materials. Instead, dispose of materials that cannot be dried within 48 hours.

What to discard:

- ☐ Remove and discard flooring that has been soaked by flood water.
- ☐ Remove all wet drywall, going at least 30 cm above the flood water level.
- ☐ Dispose of all wet items that do not dry quickly, including:
 - insulation and drywall
 - paper and cardboard products
 - carpets
 - pillows and cushions
 - particleboard furniture
 - furniture coverings
 - mattresses and box springs
 - perishable foods, foods or medicines packaged in cardboard or plastic
 - stuffed toys

NOTE: Mould that comes back after cleaning is usually an indication that the source of moisture has not been removed. If this happens, always seek professional assistance.

NOTE: Painting or caulking over mouldy surfaces like drywall does NOT kill mould and does not stop it from growing back. If the mould is underneath the paint, the drywall will need to be removed and replaced.

PSYCHOLOGICAL CARE

Fear and anxiety are natural reactions to stressful events and can stir up past traumas. To help yourself and your loved ones:

- Accept offers of help. Seek counselling or spiritual guidance.
- Focus on positive memories and the skills you've used to get through other hard times.
- Be aware of how children are reacting. Reassure them and encourage them to express themselves.
- Give yourself and your loved ones permission to grieve.
- Practice cultural or spiritual customs that bring you comfort.

Watch for warning signs of extended anxiety and contact a medical professional or trusted community leader if the following symptoms last more than two to four weeks:

- Trouble with eating and sleeping.
- Feeling depressed or hopeless; showing low energy or crying often.
- Being anxious and fearful.
- Trouble focusing on daily activities.
- Recurring thoughts or nightmares.

Flood Preparedness Guide

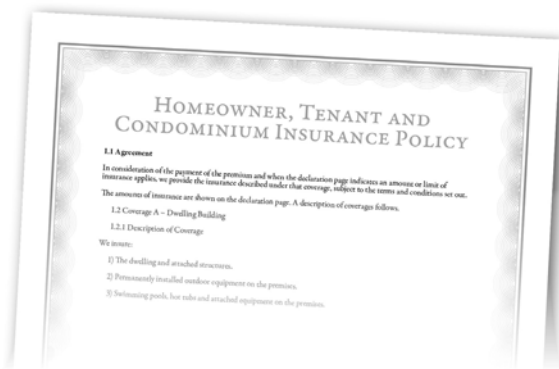
TIP: Don't be afraid to seek help after a traumatic event, such as a flood and related evacuation. B.C.'s Mental Health Support Line is open 24 hours a day at 310-6789 (no area code). Counselling is also available through the First Nations Health Authority. Visit **www.fnha.ca** or call the KUU-US Indigenous Crisis Line at 1-800-588-8717.

CLAIMING INSURANCE

Before you start your cleanup activities, call your insurance representative or company. Most insurers have a 24-hour claims service. Be as detailed as possible when providing information.

List all damaged or destroyed items. If possible, assemble proofs of purchase, photos, receipts and warranties. Take photos of the damage. Keep all receipts related to clean up and living expenses if you've been displaced. Ask your insurance representative about what expenses you may be entitled to and for how long.

If you do not know the name of your insurer or your insurance representative, contact Insurance Bureau of Canada's Consumer Information Centre at 1-844-2ask-IBC.



ADDITIONAL RESOURCES

PreparedBC: [PreparedBC.ca](https://preparedbc.ca)

EmergencyInfoBC: [EmergencyInfoBC.ca](https://emergencyinfobc.ca)

River Forecast Centre: bcrfc.env.gov.bc.ca/warnings/index.htm

First Nations Health Authority: fnha.ca

First Nations' Emergency Services Society: fness.bc.ca

Government of Canada: canada.ca/Flood-Ready

Natural Resources Canada: nrcan.gc.ca/hazards/floods

FloodSmart Canada: floodsmartcanada.ca

Ready.gov: ready.gov/floods

DriveBC: [DriveBC.ca](https://drivebc.ca)

Canadian Mental Health Association, BC Division: cmha.bc.ca

HealthLinkBC: healthlinkbc.ca

BC Centre for Disease Control: bccdc.ca

Insurance Bureau of Canada: [IBC.ca](https://ibc.ca)

[illegible]

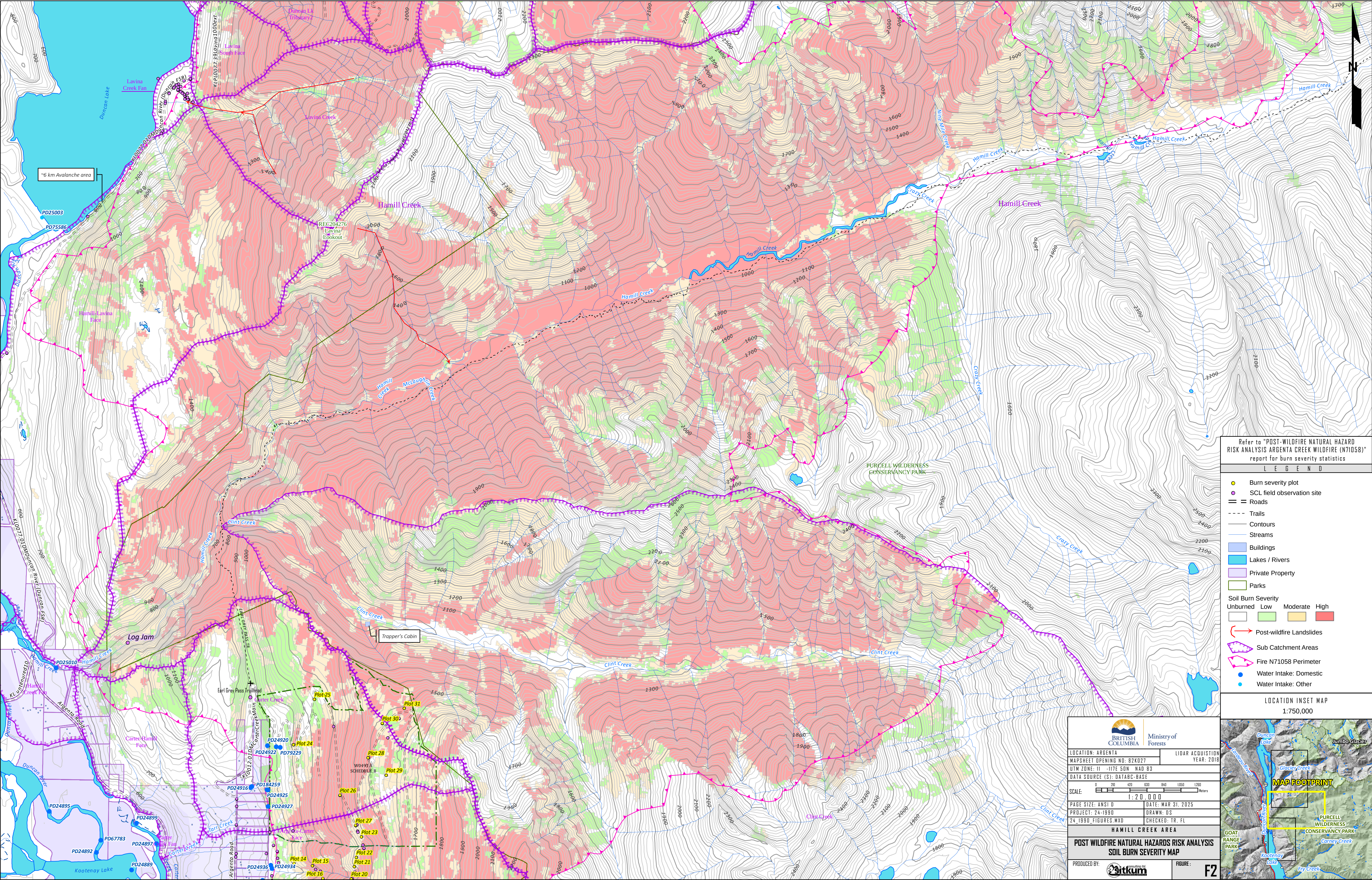


PreparedBC



Appendix F

Figures



Refer to "POST-WILDFIRE NATURAL HAZARD
RISK ANALYSIS ARGENTA CREEK WILDFIRE (N71058)"
report for burn severity statistics

LEGEND

- Burn severity plot
- SCL field observation site
- Roads
- Trails
- Contours
- Streams
- Buildings
- Lakes / Rivers
- Private Property
- Parks
- Soil Burn Severity
 - Unburned
 - Low
 - Moderate
 - High
- Post-wildfire Landslides
- Sub Catchment Areas
- Fire N71058 Perimeter
- Water Intake: Domestic
- Water Intake: Other

LOCATION INSET MAP
1:750,000



BRITISH COLUMBIA

Ministry of Forests

LOCATION: ARGENTA		LIDAR ACQUISITION	
MAPSHEET OPENING NO: 82K027		YEAR: 2018	
UTM ZONE: 11 -N17E 50N NAD 83			
DATA SOURCE (S): DATABC-BASE			
SCALE: 1:20,000			
PAGE SIZE: ANSI D		DATE: MAR 31, 2025	
PROJECT: 24-1990		DRAWN: DS	
24_1990_FIGURES.MXD		CHECKED: TR, FL	
HAMILL CREEK AREA			
POST WILDFIRE NATURAL HAZARDS RISK ANALYSIS SOIL BURN SEVERITY MAP			
PRODUCED BY: 		FIGURE: F2	

