MINISTRY OF FORESTS: POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS – SUMMARY OF HAZARDS AND RISKS FOR WEST KOKANEE FIRE (N72615)

NOTE: Please read the full report attached for details that support the hazard and risk estimates outlined below. See appendix of this report for important limitations. Contact the author for more information.

FIRE NUMBER: N72615 West Kokanee	**FIRE YEAR:** 2023	**DATE OF REPORT:** November 2, 2023

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REPORT PREPARED FOR: Southeast Fire Centre, District Manager

FIRE SIZE, LOCATION, AND LAND OWNERSHIP: 46 ha on Crown land 15 km northeast of Nelson.

VALUES AT RISK:

1. Private residences
2. Domestic surface water quality
3. Secondary public roads and Highway 3A

WATERSHEDS AFFECTED	**TOTAL AREA**	**AREA BURNED**	**BURN SEVERITY** (% of watershed area)
Bourke Creek	83 ha	18 ha (22%)	2% H, 17%M
Morley Creek	112 ha	4 ha (4%)	1%H, 3%M
Sitkum Creek	2850 ha	31 ha (1%)	0% H, 1% M
Kokanee Creek	9600 ha	10 ha (0.1 %)	0% H, 0%M

SUMMARY OF POST-FIRE HAZARD AND RISK

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

NOTE: ***Please read the full report below for details that support the hazard and risk estimates.***

Debris flood or flow on Bourke Creek impacting private residences and secondary roads
Hazard P(H)[1] = moderate   Probability of spatial impact P(S:H)[2] = moderate   Partial Risk[3,4] = moderate

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

Water quality impacts to surface domestic water users on Bourke Creek
Hazard P(H)[1] = moderate   Probability of spatial impact P(S:H)[2] = high   Partial Risk[3,4] = high

ATTACHMENTS

See attached report, map, photos and appendix.

Post-Wildfire Natural Hazards Risk Analysis, Fire N72615, West Kokanee

Sarah Crookshanks, P.Geo., Ministry of Forests

November 2, 2023

1. Introduction and Methods

The West Kokanee fire (N71691) began on August 7, 2023 and burned 46 ha of forest on the ridgetop between Sitkum Creek and Kokanee Creek, 15 km northeast of Nelson. The West Kokanee fire is immediately adjacent to the 2017 Morley Creek fire. Because the fire is located in steep terrain above a densely rural populated area, a post wildfire natural hazards risk analysis was considered a high priority despite its small size. The fire was declared under control by BCWS by August 16.

Field work in the burned area and on the fan was conducted on September 22, September 28, and October 12. Peter Jordan (MOF, Research Emeritus) and Gareth Wells (MOF, Research Geomorphologist, Kamloops) assisted with field work on October 12.

Due to the fire's small size, no heli-reconnaissance was deemed necessary. Instead, burn severity mapping was confirmed by traversing the burned area. Terrain and channel conditions were assessed using field observations, lidar data, and historical reports. Hazard and risk rating definitions are discussed in Appendix A.

This report focuses on the Bourke Creek watershed. While the fire also burned small portions of the Morley Creek, Sitkum Creek and Kokanee Creek watersheds, the incremental hazard in these watersheds is minimal given the low proportions of the drainages that burned (see summary table above and Figure 1).

2. Potential Post-Wildfire Hazards

Debris flows and floods following wildfires can occur in summer following high-intensity rainfall on severely burned soils. Local examples include the 2004 Kuskonook Creek debris flow after the 2003 fire, and debris floods in 2023 on tributaries to Trozzo Creek following the 2021 fire. This hazard is greatest in the two to three years after the fire. Debris flows and floods can also occur during spring runoff as a result of rapid snowmelt in burned areas (for example, the debris flows in Middle Van Tuyl, South Van Tuyl, and Memphis Creeks which occurred in 2008, 2009, and 2010, following the 2007 Springer fire and the debris slides and debris flow/flood along Little Slocan South Road which occurred in 2023 originating from the 2020 Talbott Creek fire). This hazard is due to increased snow accumulation, more rapid snowmelt, and higher groundwater levels in burned areas, and can persist for many years until revegetation occurs. Fall rains can also cause post-wildfire geohazard events, though this initiation mechanism is less common in the Kootenay Boundary Region and the only known local example is from the 2005 Mount Ingersoll Fire.

Severe wildfires result in the removal of the canopy and combustion of the organic material on the forest floor. In some cases, the fire also may also cause changes to the soil structure and create a water repellent layer a few centimeters below the soil surface. The removal of a canopy after a fire allows more precipitation to reach the ground and the loss of the forest floor reduces the water storage capacity in the soil. Soil structural changes and water repellency reduce the infiltration capacity of the soil. During an intense rainstorm, these factors cause higher rates overland flow and more water to enter stream channels over a shorter period, increasing the likelihood of initiating a post-wildfire geohazard event. If the organic layer has been completely consumed by the fire, the exposed mineral soil and ash is susceptible to erosion by overland flow, which may impact water quality and contribute to debris flow or flood bulking.

3. Terrain and Watershed Description

Bourke Creek appears to be susceptible to debris flows given the morphology of the watershed (Melton ratio = 1.3, stream length = 2.4 km) and previous event reports (discussed below). The channel gradient is over 40%, moderating to 20% closer to valley bottom. These gradients are within the range of debris flow initiation and transport. The fan slope is 17%, which indicates it was originally formed by debris flow processes.

The headwater area of Bourke Creek is composed of convex slopes, from 15% near ridgetop up to > 60%. The lidar hillshade imagery shows a series of minor swales entering the main channel from the east.

The Bourke Creek channel is highly incised and contains a large volume of log debris. A 3000 m^3 debris slide occurred in the watershed in 1999, initiating from a switchback on the main Sitkum Forest Service Road (Nicol, 1999). The slide deposited around 500 m^3 of material at the confluence with Bourke Creek, then transitioned into a debris flow which travelled approximately 650 m downstream along a channel gradient of 40%. Most of the debris (~2000 m^3) was deposited in the Bourke Creek channel above the fan around 800 m elevation where the channel gradient moderates to 25%. Some sediment was carried further downstream impacting water users and causing some nuisance flooding. The landowner at 4163 Alpine Road was told by the previous landowner that muddy water ran down their driveway during this event.

The steep fan slope and many large and small boulders present on the fan suggest that debris flow activity formed the fan many years ago. Except for the 1999 debris slide, a review of historical air photos does not show any evidence of debris flow activity over the past 50 years.

4. Post-Wildfire Hazard Assessment and Burn Severity

The fire burned 22% of the Bourke Creek watershed and is located in the headwater area. The vegetation burn severity is mostly moderate with small patches of high and low burn severity (Figures 1 through 5). Soil burn severity generally aligns with the vegetation burn severity. In the moderate soil burn severity areas, the forest floor was mostly consumed leaving grey ash. Many of the twigs and logs were charred, not consumed, and shallow live roots were noted at some plots. Despite the moderate soil burn severity, severe water repellency was observed throughout the burn area (Figures 6 and 7). Most test plots had ~1 cm of grey ash overlying the mineral soil, with strong water repellency 3 cm below the surface. This 3 cm of “wettable” soil may provide some storage before overland flow is generated. Water repellency was also observed this year in test plots in the area burned by the 2017 Morley Creek fire, suggesting the repellency may be attributed to widespread drought as well as or instead of the fire.

Rain splash erosion is widespread, but evidence of overland flow was not observed. Many of the moderately burned trees have dropped orange needles on the soil, which should provide some protection from erosion.

The Bourke Creek drainage is adjacent to the Morley Creek fire, where a post-wildfire debris flood occurred in 2019 two years after the fire. The West Kokanee burn severity is more moderate than the Morley Creek fire, yet widespread and strong water repellency was observed in both cases immediately after the fires. During the field assessment on October 12th, the burned area from the 2017 Morley Creek fire was traversed. Vegetation regrowth in the high burn severity areas was minimal (~25% coverage), and comprised of mostly fireweed, grasses, herbs, along with isolated lodgepole pine, aspen, huckleberry, and other deciduous shrubs. Patches of strong water repellency were observed at many locations, which may be due to the dry conditions as opposed to a relict from the fire from 6 years ago. Further research on post-wildfire and drought-related water repellency is needed.

The post-wildfire debris flow or flood hazard in Bourke Creek is rated as moderate. The burned area is in the headwater area of a steep debris flow prone watershed. The strong and widespread water repellency observed throughout the burned area is somewhat mitigated by the needlecast, moderate soil burn severity and water storage capacity of the soil above the water repellent layer.

5. Elements at Risk and Partial Risks

Several private bridges cross Bourke Creek above the fan. Avulsion is possible at the bridge located 0.25 km up Sitkum FSR, but it is considered highly unlikely. If a debris flow event were avulse here, it would run down the FSR for 50 m, then drain into the forest below the road. Most events are expected to continue down the channel.

Several debris flow or debris flood avulsion scenarios on the fan were investigated during the field assessments. At the apex of the fan, the water diversion structure composed of a concrete open tank and culvert (Figure 9) presents another low likelihood of avulsion. Given the terrain, it is more likely that a flood or flow event will continue down the main channel. At the private road crossing at the end of Nielson Road, a 1 m culvert is overlain by 3 m of fill on the upstream side and 5 m of fill on the downstream side (Figure 10). The culvert crossing is at a prominent grade dip in the road, minimizing the likelihood of an avulsion down the west side of the Bourke Creek fan. Downstream of the private road crossing, the channel is incised with a minimal gradient for 30 m until just upslope of Alpine Road. The water diversion structure, private road crossing, and incised channel all provide opportunities for partial debris deposition of material upstream of any houses.

If a debris flow or flood were to occur on Bourke Creek, the most likely scenario is that the culvert at the private road crossing would be plugged, and water and debris would overtop the private road and run through the property at 4163 Alpine Road perhaps impacting or flowing around several small guest cabins built along the channel. Following the 1999 debris flow event, muddy water reportedly ran down the driveway at this site. The flow would then most likely cross Alpine Road and continue down Granger Road, with a low likelihood of impacting homes further downslope.

The 1999 debris slide provides an indication of the possible post-wildfire debris flow runout on the Bourke Creek fan. The 1999 event suggests that some post-wildfire debris flow material would be deposited above the fan and not reach elements at risk. Post-wildfire events are likely be smaller, since they are more likely to initiate from in-channel erosion and entrainment. Furthermore, the 1999 event likely scoured some of the Bourke Creek channel, though the extent of erosion is unknown, resulting in less sediment available to be eroded by any subsequent events. A debris flood would have a greater runout potential, perhaps causing nuisance flooding to multiple properties on the fan.

Due to its location along the outer margins of the fan, the likelihood of spatial impact to the highway is estimated as low. Secondary roads (Alpine Road and Granger Road) are more likely to be impacted by a geohazard event.

Bourke Creek Improvement District has 50 water licences on Bourke Creek and provides water to many properties. It is possible that domestic water users on Bourke Creek will experience water quality impacts due to increased fire-related sediment load. Sedimentation is expected to be episodic, occurring during spring freshet and in response to significant rainstorms. Sediment may be generated by overland flow eroding and transporting sediment and ash into a creek or by a debris flow or debris flood.

Table 1. Partial risk summary for the West Kokanee fire.

Drainage	Process	Value at Risk	Hazard	Likelihood of spatial effect	Partial Risk
Bourke Creek	Debris flow or flood	Private residences and secondary roads	Moderate	Moderate	Moderate
Bourke Creek	Debris flow or flood	Highway 3A	Moderate	Low	Low
Bourke Creek	Debris flow or flood	Domestic water quality	Moderate	High	High

6. Summary of Recommendations

I recommend that the RDCK forward this report to residents on the Bourke Creek fan and the Bourke Creek Improvement District. During freshet and high intensity summer or fall rainstorm events, residents should be aware of any sudden changes in stream conditions, such as a rapid increase or decrease in flow, flow pulses or unusually high sediment load/debris transport.

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7. References

Nicol, D.R. 1999. Bourke Creek Landslide memo. Addressed to Ken Haynes at the Kootenay Lake Forest District. Dated May 6, 1999.

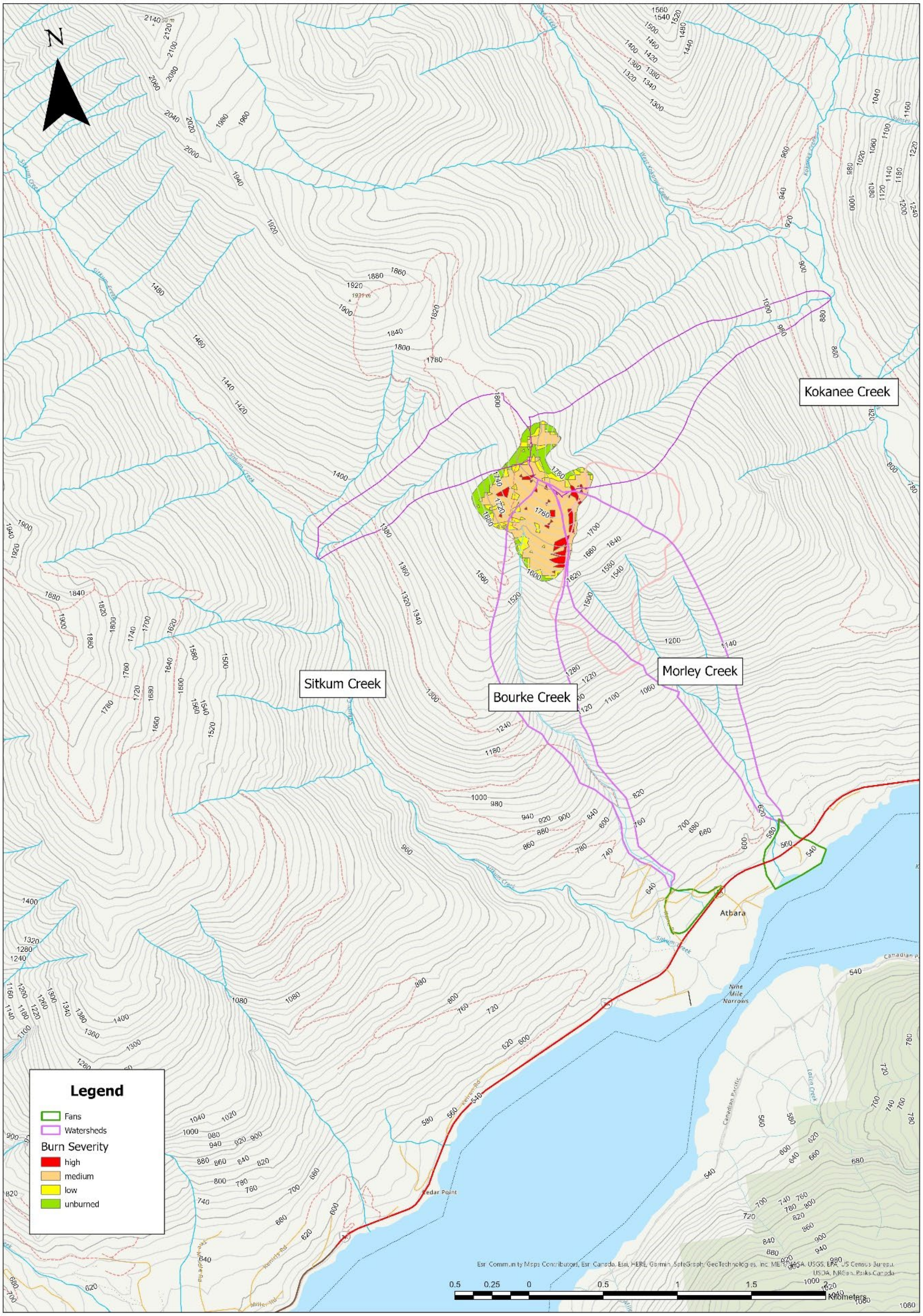

Figure 1 Burn severity map of the West Kokanee fire showing estimated classes derived from Sentinel-2 imagery (prefire: August 2, 2023, post-fire: August 27, 2023).

Figure 2. Moderate burn severity in the Bourke Creek watershed.

Figure 3. Needlecast in the Bourke Creek watershed.

Figure 4. Swale and moderate burn severity in the Bourke Creek watershed.

Figure 5. High burn severity in the Bourke Creek watershed.

Figure 6. Strong water repellency, needlecast, grey ash, charred small woody debris, and rain splash erosion.

Figure 7. Strong water repellency at 3 cm depth.

Figure 8. Morley Creek watershed from the 2017 burned area. Note the sparse vegetation regrowth.

Figure 9. Water diversion structure at the apex of the Bourke Creek fan.

Figure 10. Private road crossing with culvert at the end of Nielson Road.

Figure 11. Bourke Creek upslope of Alpine Road.

Appendix A

Scope of reconnaissance reports

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

Definitions of hazard and risk

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

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

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

Table A1. Post-wildfire risk matrix partial risk matrix.

Hazard likelihood (Table A1)	**Spatial impact likelihood (Table A2)**		
	H	**M**	**L**
H	VH	H	M
M	H	M	L
L	M	L	VL

Report Standards

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

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

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

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

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

EGBC Guidelines for Legislated Landslide Assessments 2023
https://tools.egbc.ca/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMW2FC5GZAROI4ZBZ7KMIRPIFG7JN/Landslide%20Assessments%20in%20British%20Columbia

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

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

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

Statement of Limitations

Reconnaissance reports are typically done under constrained timelines with limited information. These reports are typically done in the office based on mapping and satellite imagery, and perhaps an overview flight. No subsurface investigation was carried out.

This assessment and its contents are intended for the sole use of post-wildfire hazard management by provincial agencies, First Nation governments and local governments as set out in the “Scope” above. The author does not accept any responsibility for the accuracy of any of the data, the interpretation, or the conclusions contained or referenced in the report when the report is used or relied on for any other purpose.

The Province and the author accept no responsibility for damages, if any, suffered by a third party as a result of a decision made or an action based, or lack thereof, on this report. Any such unauthorized use of this report is at the sole risk of the user.

Post-wildfire hydrogeomorphic hazards in BC are not well understood and therefore hazard and risk assessments are estimates only. Numeric probability ranges do not imply precision.

Boundaries are approximate and should be confirmed prior to design and implementation of risk mitigation strategies.