Hydrologic Risk Assessment for Rose Swanson Watersheds

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Prepared at the request of

BC Timber Sales
Okanagan-Columbia Business Area
2501 – 14th Avenue
Vernon, BC, V1T 8Z1

Prepared by

WaterSmith
450 Cadder Avenue
Kelowna, BC, V1Y 5N3

WATERSMITH

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Hydrologic Risk Assessment for Rose Swanson Watersheds

1 Introduction

WaterSmith Research Inc. (WaterSmith) was retained by BC Timber Sales (BCTS) to complete a hydrologic risk assessment for catchments draining northward from Mount Rose and Mount Swanson (collectively referred to as *Rose Swanson*), with a particular focus on groundwater (Figure 1). BCTS has operating area in the upper elevations (hereafter referred to as the *area of interest [AOI]*). BCTS aims to develop ~40 ha of harvest area (commercial thin and/or group retention) within the AOI. This assessment was completed to identify hydrologic risks at the catchment scale based on the current watershed condition, and provide guidance to BCTS on how to minimize the potential for hydrologic impacts from their operations.

In total, six small catchments were delineated for assessment purposes (*Basins A* through *F*) (all catchments hereafter referred to as the *study watersheds* or *study area*) (Figure 1). During the assessment, most stream channels were generally either not identifiable in the study watersheds (e.g., non-classified drainages [NCD], unchannelized drainages), or are ephemeral (hereafter collectively referred to as *natural watercourses*). The points of interest (POI) for Basins A through E are located at the interface between the upslope forested areas and the downslope residential/rural development areas bordering Salmon River Road (Figure 2). For Basin F, the POI is at the intersection with Chamberlaine Road. The watershed areas range from 6 ha (Basin F) to 269 ha (Basin E), with a mean watershed area of 81 ha. No sub-basins were delineated within the study watersheds for assessment purposes. BCTS is the only major forest licensee operating in the study area. Private land exists in the lower portions of the watersheds. A woodlot owned by Splatsin te Secwépemc (Splatsin) is located to the west of the AOI. It overlaps a substantial portion of Basin A, and small portions of Basins B and C.

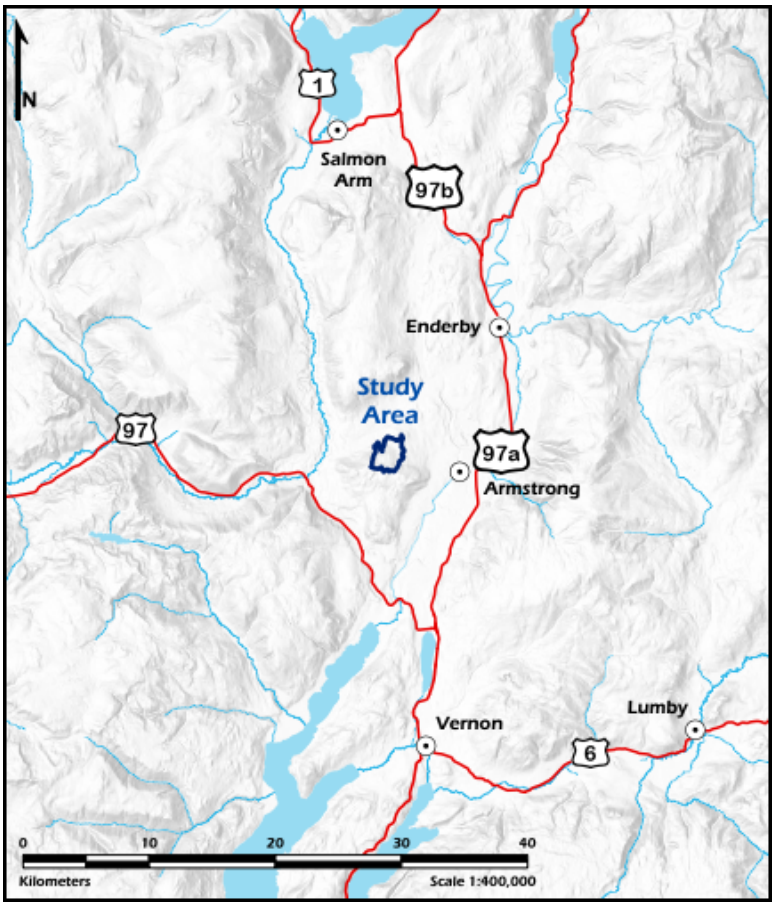


Figure 1. Location of the study area.

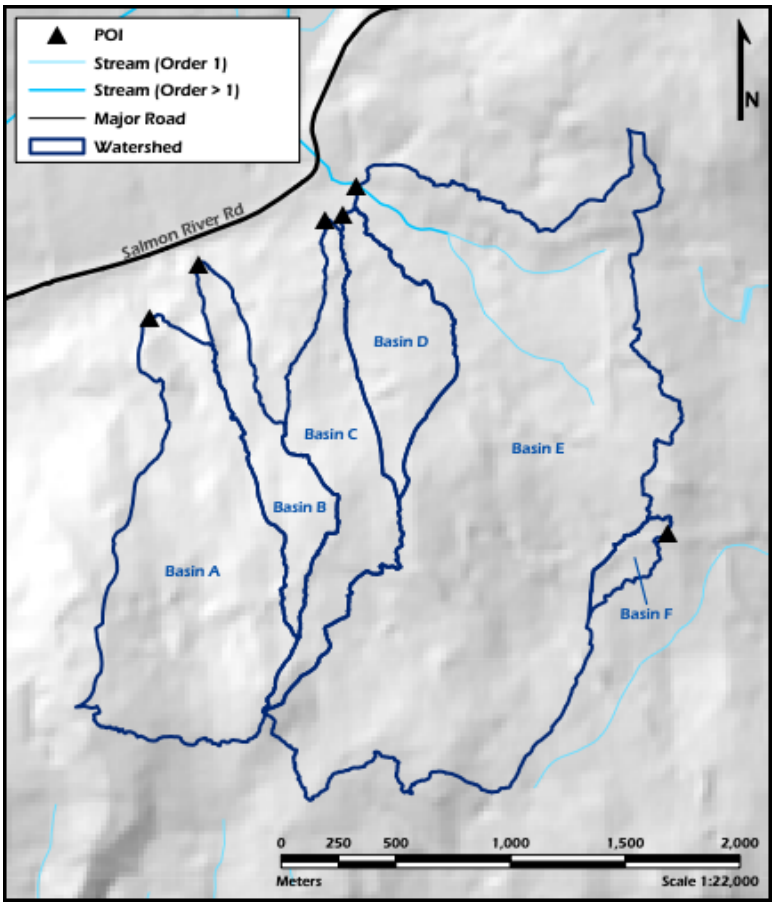


Figure 2. Boundaries and POIs for the study watersheds.

2 Terms of reference

The study area drains into the Slack Creek Watershed, which drains into the Salmon River. Slack Creek is mapped in government data as passing through the valley bottom north of the study area; however, the drainage is unchannelized. There also is no channelized surface connection between the study area and the valley bottom. Nonetheless, there are channelized sections of stream within the study area (e.g., lower reaches of Basin E), and groundwater activity is extensive in the area. Rural and agricultural development are extensive downstream from the study area, with a more limited amount of development in the study area (located primarily in Basin E). Numerous water licences and groundwater wells are located within and/or in close proximity to the study area. The local community (including the Rose Swanson Select Committee) is concerned about surface water and groundwater supplies, and the potential for upslope forest development to impact these resources (e.g., downstream flooding, decreased water supply). Some timber harvest has occurred historically within the study area, comprised primarily of selection harvesting and clearing of pasture areas on private land.

BCTS requested a hydrologic risk assessment to address these concerns (surface water and groundwater).

The assessment evaluates partial risk following an approach that is broadly consistent with Land Management Handbook 56 [*Wise et al.*, 2004]. That is, it addresses risk to the physical hydrologic condition (i.e., partial risk), but does not incorporate vulnerability or consequence ratings for societal values (e.g., the value of water quality in the watershed). For the purposes of the project, a hydrologic risk assessment is a professional analysis of existing and potential forest development related effects on water and water related resources, conducted at the catchment scale. It includes the following components:

1. an overview of catchment characteristics, including stream morphology (where present);
2. an overview of cumulative hydrologic effects from past forest cover disturbance, accounting for hydrologic recovery of regenerating forest stands;
3. identification of hydrologic risks related to potential future forest development;
4. consideration of climate change influences; and
5. development of specific recommendations for risk mitigation related to forest development (historical and/or future).

Further to the standard assessment components outlined above, the assessment addressed the potential impacts of forest development on the quantity of groundwater supply (within the limits of the author's area of professional practice). The detailed assessment of potential future forest development was limited to the AOI. The assessment did not include a detailed review of potential development beyond the AOI (e.g., potential activities in the woodlot or on private land).

Appendices are included with this report that summarize important field observations (Appendices 1-3), precipitation intensities for the highest elevation in the study area (Appendix 4), mapping for the study area (Appendices 5-7), and the maximum forest harvest available under a specific peak flow risk scenario (Appendix 8).

3 Watershed description

3.1 Physiography

Most of the study watersheds drain in a northerly direction from Rose Swanson, which is part of the Thompson-Okanagan Plateau. Basin F drains northeast. The study area ranges in elevation from 537 m to 1049 m [*Google Earth*, 2025]. Soils

within the study area are primarily well drained silty loam, with the eastern portion of the study area having loam or sandy loam soils. The parent material is dominantly glacial till, but colluvial material is present in the headwaters and in the eastern portion of the study area. The majority of the study area is underlain by metamorphic rock, with the southwest corner underlain by sedimentary rock [*iMapBC*, 2025].

The following aquifers are mapped within or in close proximity to the study area (material composition and vulnerability ratings indicated) [*iMapBC*, 2025] (see groundwater map in Appendix 7):

- Hullcar Unconfined Aquifer, sand and gravel, high vulnerability
- Hullcar Confined Aquifer, confined sand and gravel, moderate vulnerability
- Aquifer 355, bedrock, inferred to be confined, moderate vulnerability
- Hullcar Perched Aquifer, unconfined sand and gravel aquifer, high vulnerability

3.2 Biogeography

Two biogeoclimatic ecosystem classification (BEC) zones are represented in the study area. Interior Douglas-fir (IDF) (IDFxh1) at low elevation transitions to Interior Cedar Hemlock (ICH) (ICHxm1) at an elevation of approximately 550 m [*iMapBC*, 2025].

3.3 Fisheries

The study watersheds have no downstream connection to fish bearing channels (e.g., Salmon River), and are likely not inhabitable by fish.

3.4 Landscape activity

The study area is a mixed-use area incorporating forest development on public land, recreation (e.g., hiking, all-terrain vehicle use), and likely hunting. A series of popular hiking trails in the area is maintained by the Armstrong Spallumcheen Trails Society. Extensive rural and agricultural development exist within the study area (primarily Basin E) and downstream. An extensive road network (municipal, private, forestry) exists in the study area. Numerous water licences are located within or in close proximity to the study area for multiple uses, including domestic consumption, private irrigation, and livestock and animal watering [*iMapBC*, 2025]. Numerous groundwater wells are also located within or in close proximity to the study area.

3.5 Local climate

Mean annual precipitation is ~488 mm in Armstrong, BC (Environment Canada station #1160485, 373 m elevation, 1971-2000 period of record, located ~9 km east of the study watershed). Monthly precipitation is highest in June and December, and lowest in March and April. Approximately 26% of the precipitation at the climate station falls as snow. Annual precipitation at the highest elevations in the study area is likely 25-50% greater than that recorded at the climate station, with a much larger portion falling as snow.

3.6 Hydrologic regime

The hydrologic regime of the study watersheds is snowmelt dominated, but periodically intense rainfall during spring freshet likely contributes substantially to peak flows. The mean annual maximum snowpack accumulation is ~129 mm (water equivalent) at the Carrs Landing (Upper) manual snow survey station (BC Environment station #2F17, 12 year record, 980 m elevation), located ~32 km south of the study area boundary. The mean timing of the peak snowpack survey was March 6. The snowpack accumulation at this monitoring station is likely similar to that at the highest elevations in the study area.

The mean annual maximum surface flow was estimated to vary from 0.004 to 0.074 m^3/s for Basins A through F based on a drainage area adjustment of flows from the Deep Creek at Armstrong hydrometric station (Water Survey of Canada station #08NM119; 15 year record), located ~5 km east-southeast of the study area. The peak surface flow likely typically occurs between early March and late April. The mainstem watercourses in the study watersheds are likely typically dry outside of spring freshet, except for possibly some locations in Basin E. Mean annual runoff in the study area was estimated as 48 mm (08NM119; 8 year record).

4 Methods

This assessment included field and office reviews of the current condition within the study watersheds.

4.1 Field assessment

Russell Smith (WaterSmith) completed an overview level ground-based field review on October 28, 2024. Several factors were considered during the field assessment, including:

- identification and review of natural watercourses originating in the study watersheds;
- the capacity and structural integrity (based on visual inspection) of readily accessible and important drainage structures along and downstream from natural watercourses in the study watersheds;
- the horizontal and vertical proximity of other structures (e.g., residences) (where present) to the natural watercourses;
- the distribution of groundwater activity in the area and its proximity to the AOI; and
- a review of surface erosion and slope failures (where present) at select locations on upslope areas (e.g., along most main roads and a limited selection of secondary roads and trails).

Identified disturbances were assessed for connectivity to the drainage network. Soil permeability (using soil texture and coarseness as an indicator), soil erodibility, and disturbances along watercourses were identified. Cumulative hydrologic effects progressing from the headwaters to the POIs were of particular interest during the field review. Photos from field observation sites are provided in Appendix 1, and the site locations are identified on the current condition map in Appendix 5.

4.2 Office assessment

An office assessment was conducted that included reviews of previous hydrology reports (where available), physiographic and hydrometeorological data, and satellite imagery [*Google Earth*, 2025; *Bing Aerial*, 2025]; and an ECA analysis. The ECA analysis was completed for assessing the potential impacts of current and potential future forest cover disturbance on the quantity and timing of runoff. The results from the field and office assessments were combined to evaluate the overall runoff condition in the study watersheds. These results were further combined with an assessment of the natural watercourses and structures at risk, and the distribution of mapped groundwater to identify mitigation strategies.

4.2.1 Risk assessment

The watershed risk assessment was implemented using an approach broadly consistent with Land Management Handbook 56 [*Wise et al.*, 2004]. For the study watersheds, partial risk ratings were assigned specific to peak flow, low flow, surface erosion, landslide, and riparian function based on a five-point rating system (i.e., very low, low, moderate, high, and very high). **Partial risk was defined as the likelihood of a hydrologic disturbance (e.g., elevated peak streamflow, decreased low flow, road surface erosion, landslide, or stream bank failure due to riparian disturbance) generating a material adverse impact on the**

integrity of a watercourse, water volume, or the integrity of structures within a drainage unit; or on water quality at the outlet of a drainage unit (e.g., POI). For the current watershed condition (Section 7.1), partial risk represents the severity of hydrologic impacts at the current level of landscape disturbance, and the likelihood of ongoing impacts associated with this landscape disturbance. Mitigation strategies were formed based on identified risks.

Peak flow risks were separated into natural watercourse (e.g., stream channel, NCD, unchannelized drainage) versus structure related risks. This separation was implemented to help with identifying environmental concerns (e.g., channel morphology, sediment transport) versus public safety concerns (e.g., integrity of stream crossings, roadways, residential structures). **Partial risk for peak flows was evaluated as the product of the estimated likelihood of a significant peak flow increase combined with the estimated likelihood that a large peak flow event could impact element(s) at risk along the mainstem watercourse in a drainage (Figure 3)**. The latter is essentially an evaluation of the sensitivity of the natural watercourses or structures of interest. **The value to society of the elements at risk was not considered in evaluating partial risk**.

Partial risk of peak flow increase		**Likelihood of a peak flow impacting element at risk (i.e., sensitivity)**				
		Very low	Low	Moderate	High	Very high
Likelihood of a significant peak flow increase	Very low	Very low	Very low	Very low	Low	Moderate
	Low	Very low	Very low	Low	Moderate	High
	Moderate	Very low	Low	Moderate	High	Very high
	High	Low	Moderate	High	Very high	Very high
	Very high	Moderate	High	Very high	Very high	Very high

Figure 3. Partial risk matrix combining the estimated likelihood of a significant peak flow increase with the estimated likelihood that a large peak flow event could impact element(s) at risk (i.e., sensitivity) along the mainstem watercourse in a drainage.

4.2.1.1 Likelihood of a peak flow impacting elements at risk – natural watercourses

The likelihood of a peak flow impacting the integrity of a natural watercourse (i.e., watercourse sensitivity) was defined as the susceptibility of the watercourse to morphological change (e.g., bedload transport, downward scour) due to high streamflow. It is influenced by a combination of factors, including the stream/slope gradient; the floodplain cross-sectional profile; the size and mobility of stones along the watercourse; the abundance, size, and function of large wood along the watercourse; the condition and function of the riparian vegetation along the watercourse; the impacts of upstream sediment supply (e.g., landslides, surface erosion); and the existing level of disturbance along the watercourse.

A five-point rating system was used for watercourse sensitivity, including very low (e.g., generally undisturbed bedrock channel), low (e.g., generally undisturbed boulder/cobble dominated channel), moderate (e.g., generally undisturbed gravel dominated channel), high (e.g., generally undisturbed fine-grained alluvial channel), and very high (e.g., highly disturbed fine-grained alluvial channel). Watercourses that are highly disturbed and unstable over a substantial portion of their length would typically move up one or more sensitivity ratings compared to similar watercourses in an undisturbed state. For unchannelized natural watercourses, the surface roughness (e.g., stones, large wood) and abundance of reinforcing materials (e.g., vegetation roots) were considered in evaluating sensitivity.

4.2.1.2 Likelihood of a peak flow impacting elements at risk – structures

A five-point rating system (very low, low, moderate, high, and very high) was used for the likelihood of a peak flow impacting structures (i.e., sensitivity of structures), and was focused on drainage crossings and buildings (residential, agricultural) (where present). Several factors were considered, including the (1) proximity of the structure to the watercourse (qualitative judgment accounting for the size of the watercourse, among other factors), (2) type of structure and design elements impacting the vulnerability to being obstructed and/or otherwise impacted, (3) flow capacity of the structure (based on visual inspection), (4) overall condition of the structure (e.g., damage, installation/placement), and (5) location of the structure of interest relative to the distribution of runoff generating areas (e.g., downstream from forest cover disturbance).

The assessment of the sensitivity of structures focused on the most at-risk structures (based on frequency and type of use, proximity to the watercourse, size/power of watercourse) in the drainage unit for the purpose of identifying the overall level of concern for the drainage. Notwithstanding this overview level approach, specific structures of concern and recommendations for mitigation are summarized in Appendix 2.

4.2.1.3 Likelihood of a significant peak flow increase

The likelihood of a significant peak flow increase in a drainage unit related to spring freshet runoff was assigned a rating based on the forest cover condition and/or other mitigating factors within a drainage (e.g., attenuation in lakes and wetlands, topographic variability) (rationale for assigned ratings is provided in Section 6). A five-point rating system (very low, low, moderate, high, and very high) was used. It was evaluated relative to the runoff conditions that would have existed with the forest cover in an undisturbed state.

Determining the likelihood of a significant peak flow increase relied heavily on analyzing the distribution of ECA (calculation methods outlined in Section 4.2.2). For any drainage unit or portion of a drainage unit (e.g., high elevation), ECA levels were considered very low (<20%), low (20-30%), moderate (30-40%), high (40-50%), or very high (>50%).

4.2.2 ECA analysis

The methods for the ECA calculations followed the basic approach of the BC Watershed Assessment Procedure (WAP) Guidebook [*BC Ministry of Forests*, 1999], with the following exceptions:

- The hydrologic recovery curve published by *Winkler and Boon* [2015] was implemented for estimating the rate of ECA recovery;
- Regenerating stands averaging 20 m tall or more were excluded from contributing to ECA, to account for the corresponding high rates of evapotranspiration and snowpack shading;
- Road right-of-way was included as a contribution to ECA, assuming a mean denuded width of 12 m for roads and 6 m for trails; and
- For stands with at least 40% of the standing trees dead due to forest pests, the standing dead trees were assumed to contribute to ECA at a rate of 50% of the mortality level, based on research indicating snowpack accumulation and melt rates for attacked stands are intermediary between healthy stands and clearcuts [*Boon*, 2007; *Winkler and Boon*, 2010; *Winkler et al.*, 2012]. Stand mortality levels less than 40% were excluded from contributing to ECAs [*Spittlehouse*, 2007; *Moore et al.*, 2008; cited in *Winkler et al.*, 2010a; *Goeking & Tarboton*, 2020].

Tree heights for regenerating stands (e.g., previously harvested) were extracted from the 2023 Provincial Vegetation Resource Inventory (VRI) dataset. Corrections were made to the estimated tree heights and spatial coverage wherever errors were noted in field observations or satellite imagery (e.g., regenerating tree heights, cleared private land).

Catchment level ECAs (e.g., entire watershed), high elevation ECAs (area above the H40 elevation in the watershed), and middle elevation ECAs (area between the H40 and H70 elevations in the watershed) were calculated for each study watershed. The ECA for a given landscape class (e.g., high elevation) was calculated as the total area of forest cover disturbance (adjusted for hydrologic recovery and/or partial retention) within the area of the landscape class divided by the actual area of the landscape class (expressed as a percentage). The H40 and H70 elevations were defined at the catchment level for each watershed (see Table 1 and current condition map in Appendix 5 for more details). The high elevation and middle elevation ECAs were calculated for all study watersheds (i.e., pre-programmed for efficiency), but were given little or no consideration for Basin F because of its small size and limited elevation relief.

Table 1. H40 and H70 elevations for the study watersheds.

Drainage unit	[1]H70 elevation (m)	[1]H40 elevation (m)
Basin A	812	909
Basin B	684	794
Basin C	707	817
Basin D	598	647
Basin E	642	769
Basin F	690	697

1. Defined separately for each drainage unit.

5 Elements at risk

5.1 Sensitivity of natural watercourses

This section summarizes the current condition of natural watercourses (e.g., stream channels, NCDs, unchannelized drainages) in the study watersheds based on the field review, and their sensitivity to potential mobilization of the substrates. It focuses on the mainstem watercourse in each watershed, consistent with the scope outlined in the introduction (Section 1) and terms of reference (Section 2). The ratings for the sensitivity of natural watercourses relate to the likelihood of peak flows mobilizing substrates (e.g., disturbance to channel morphology, downward scour, sediment transport). Field photos are provided in Appendix 1, and the corresponding site locations are indicated on the current condition map in Appendix 5.

5.1.1 Basins A-D & F

Very few defined stream channels (i.e., contiguous channel of recurrently mobilized alluvium) were identified in the field within or immediately downstream from the study watersheds. The main exception is the lower reaches of Basin E where an alluvial channel was somewhat defined (discussed in Section 5.1.2). For Basins A through D and F, the watercourses are typically comprised of broad swales or NCDs that were mostly dry during the field review. There was evidence of historical surface flow in the upper reaches (Photo 1; Appendix 1), and historical surface flow was reported by a local resident for locations near the watershed POIs (e.g., between Sites 7 and 11) [*Sorensen*, 2024]. Moreover, multiple alluvial fans were identified slightly downstream from the POIs near Salmon River Road (Photo 2), indicating a history of sediments being mobilized by surface flow.

At locations inspected within the middle and/or upper reaches of the natural watercourses, the ground surface is generally brushy with an abundance of woody debris in contact with the ground, creating surface roughness (Photo 3). In the lower reaches, the ground surface is generally well vegetated with brush, grass, and/or weedy vegetation (e.g., Photo 2). Notwithstanding the stability generated by the vegetation and debris, the mean gradient along the mainstem watercourses in these watersheds is typically 20-30% [*Google Earth*, 2025]. Basin F is an exception with a mean gradient of ~15% in the upper reaches, and ~5% in the lower reaches. At these slope gradients, an increase in surface runoff caused by forest development could generate excessive scouring of the ground surface, and transport eroded sediment downstream.

The overall sensitivity to potential mobilization of substrates along the natural watercourse is considered moderate for Basins A through D and F. This rating balances (1) the generally intact condition of the watercourses, (2) the stability generated by vegetation and debris, and (3) the potential erosion forces associated with the slope gradients. This sensitivity limits the capacity of the watersheds to accommodate increased surface runoff.

5.1.2 Basin E

The conditions in the middle and upper reaches of Basin E are similar to those described in Section 5.1.1 for the other study watersheds (i.e., broad swales or NCDs, dry, well vegetated, abundant woody debris) (Photo 3). Slightly downstream from the watershed POI (Site 8), a defined channel was identifiable in the field, but was mostly vegetated with grass and/or weedy vegetation (Photo 4). A resident on the property at Site 8 indicated that the stream flows in the middle reaches for part of the year. Access was not granted to review the middle reaches; however, it is inferred that a defined channel likely exists, though the specific condition of the channel is uncertain.

The upper half of the watershed has a mean gradient along the mainstem watercourse in the range of 20-25%, and the lower half has a mean gradient around 10%. Increased surface runoff from forest development could generate substantial scour and sediment transport, particularly in the middle and upper reaches.

The overall sensitivity to potential mobilization of substrates along the natural watercourse is considered moderate for Basin E, for the same reasons discussed in Section 5.1.1.

5.2 Sensitivity of structures

Table 2 summarizes the overall sensitivity of structures along the mainstem watercourses in the study watersheds, consistent with the scope outlined in the introduction (Section 1) and terms of reference (Section 2). The sensitivity ratings relate to the likelihood of an extreme peak flow (e.g., 100 year event) severely impacting drainage crossings (e.g., overtopped, undermined) and/or buildings (residential, agricultural) (e.g., undermined, inundated) (where present). The ratings are based on visual inspections completed during the overview level field review, as well as a review of satellite imagery [*Bing Aerial*, 2025; *Google Earth*, 2025]. It is assumed that extreme peak flows could mobilize coarse sediment and debris; however, the sensitivity ratings do not account for potential impacts from terrain instability (e.g., direct impact from a debris flow). A terrain risk assessment would need to be completed by a terrain specialist to evaluate the capacity for structures to accommodate terrain instability.

The assessment of structures did not involve detailed inspection of every structure along a watercourse that could be impacted. It focused on the most at-risk structures (based on frequency and type of use, proximity to the watercourse, size/power of the watercourse) in each drainage unit for the purpose of identifying the drainages of greatest concern. Notwithstanding this overview level approach, specific structures of concern and recommendations for mitigation are summarized in Appendix 2.

Table 2. Likelihood of impacting the most at-risk structures during an extreme peak flow event along the mainstem watercourses in the study watersheds. Specific structures of concern and recommendations for mitigation are summarized in Appendix 2.

Drainage unit	Sensitivity of structures	Rationale
Basin A	High	Broad alluvial fan with a residence in close proximity (<5 m) to the watercourse at the POI (Photo 5) [*Google Earth*, 2025]. No cross-drain (e.g., culvert) downstream from the POI at Salmon River Road (~270 m), combined with a shallow drainage ditch along the upslope side of the road (Photo 6). These concerns generate flood safety hazards at multiple points downstream from the study watershed.
Basin B	High	No cross-drain downstream from the POI at Salmon River Road (~115 m), combined with a shallow drainage ditch along the upslope side of the road, generating a flood safety hazard (Photo 7).
Basin C	High	The only cross-drain along Salmon River Road between Sites 8 and 11 is at Site 7 (culvert) (Photo 8), which is near Basin C; however, the culvert is not in a location where it will capture flow from Basins C, D, or E. This situation presents a flood safety hazard.
Basin D	High	No cross-drain downstream from the POI at Salmon River Road (~225 m), generating a flood safety hazard.
Basin E	High	No cross-drain downstream from the POI at Salmon River Road (~215 m), generating a flood safety hazard.
Basin F	Moderate	Potential sensitivity of a shallow groundwater well located within a wetland area near Site 23 (Photo 9).

5.2.1 Structures requiring monitoring or remediation

Table A2 (Appendix 2) summarizes structures in the study watersheds identified as requiring monitoring or remediation for existing or potential runoff impacts. Priority ratings and suggested actions for remediation are provided; however, follow-up site assessments (by the authority responsible for each structure) are needed to finalize a suitable course of action. The priority ratings are based on qualitative judgment of the condition of the structures from visual inspection, the potential for elevated peak flows (e.g., high spring freshet runoff from elevated ECAs), and the overall risk to the public and/or environment (locally or downstream). It was assumed that all drainage structures (e.g., culverts) in the

study watersheds receive routine monitoring as set forth by relevant regulations. On this basis, only structures of elevated concern are identified in Table A2.

6 Likelihood of a significant peak flow increase under the current condition

The ratings for the likelihood of a significant peak flow increase are summarized in Section 7.1.6 for the current watershed condition (see current condition map in Appendix 5 for distribution of forest cover disturbance).

6.1 Basin D

The likelihood of a significant peak flow increase is considered low for Basin D. Compared to an undisturbed forest cover condition, catchment runoff has likely been increased slightly during the peak flow period due to increased snowpack accumulation and lower evapotranspiration rates associated with forest cover disturbance on private land. The catchment level ECA is borderline between low and moderate, the high elevation ECA is very low, and the middle elevation ECA is moderate (see Table 3 and current condition map in Appendix 5). Combining the middle and high elevations, the ECA is low at 24% (based on data in Table 3).

The catchment is northerly facing. Forest cover disturbance on north-facing terrain typically does not generate a substantial change in snowmelt timing [*Ellis*, 2011; *Ellis et al.*, 2011; *Ellis et al.*, 2013; *Jost et al.*, 2007; *Smith*, 2011; *Smith et al.*, 2014; *Smith et al.*, 2024; *Toews and Gluns*, 1986]; thus, the existing forest cover disturbance is a low concern for increased synchronization of runoff between the middle and high elevations during the peak flow period [*Ellis*, 2011; *Ellis et al.*, 2011; *Ellis et al.*, 2013; *Green and Alila*, 2012; *Smith*, 2011; *Smith et al.*, 2014; *Winkler et al.*, 2010a; *Winkler et al.*, 2010b]. However, for these same reasons, the potential for desynchronization of snowmelt timing (e.g., from forest cover disturbance in the middle and low elevations) is also limited. The somewhat low elevation relief in the watershed (~276 m) also limits the potential for desynchronization (snowmelt timing would not vary substantially based on elevation differences). Moreover, the potential for attenuation of runoff in the watershed is considered low based on the distribution of terrain, and the lack of lakes and/or wetlands. Considering all factors, a low likelihood rating is warranted by the moderate ECA in the middle elevation.

6.2 Basin E

The likelihood of a significant peak flow increase is considered very low for Basin E. Compared to an undisturbed forest cover condition, change in catchment runoff during the peak flow period has likely been negligible with respect to potential impacts from forest cover disturbance. The catchment level ECA is low, the high elevation ECA is negligible (<5%), and the middle elevation ECA is borderline between low and very low (see Table 3 and current condition map in Appendix 5). Combining the middle and high elevations, the ECA is very low at 10%. The potential for runoff attenuation is considered low for the catchment based on the distribution of terrain, and the lack of lakes and/or wetlands. Considering all factors, a very low likelihood rating is warranted by the negligible ECA in the high elevation combined with the low / very low ECA in the middle elevation.

6.3 Basins A-C & F

The likelihood of a significant peak flow increase is considered very low for Basins A through C and F. Compared to an undisturbed forest cover condition, changes in catchment runoff during the peak flow period have likely been negligible. The catchment level ECAs range from 5% to 10%, and the high elevation ECAs are negligible (<5%). Combining the middle and high elevations, the ECAs are under 6%. The potential for runoff attenuation is considered low for these catchments based on the distribution of terrain, and the lack of lakes and/or wetlands. Considering all factors, the very low likelihood ratings are warranted by the very low ECAs.

Table 3. Current ECAs (Jan 1/25) for the study watersheds, accounting for existing disturbance, including stand mortality (see Section 4.2.2 for more details).

Drainage unit	Gross area (ha)	ECA (%)		
		[1]Catchment	[2]High elevation	[3]Middle elevation
Basin A	104	4.5	4.1	2.8
Basin B	27	6.8	3.4	0.6
Basin C	46	10.1	3.4	0.0
Basin D	33	29.5	14.8	35.1
Basin E	269	24.9	3.0	20.5
Basin F	6	6.0	3.7	8.1

1. Calculated for the entire drainage unit.
2. Calculated for the portion of the drainage unit above the H40 elevation. See Section 4.2.2 and Table 1 for details.
3. Calculated for the portion of the drainage unit between the H40 and H70 elevations.

7 Partial risk

As outlined in Section 4.2.1, partial risk was defined as the likelihood of a hydrologic disturbance (e.g., elevated peak runoff, decreased low flow, road surface erosion, landslide, or instability due to riparian disturbance) generating a material adverse impact on the stability of the natural watercourse, runoff volume, or the integrity of structures within a drainage unit, or on water quality at the outlet of a drainage unit (e.g., POI).

7.1 Current condition

The partial risk ratings for the current watershed condition are summarized in Section 7.1.6. As outlined in Section 4.2.1, partial risk under the current condition represents the severity of hydrologic impacts at the current level of landscape disturbance, and the likelihood of ongoing impacts associated with this landscape disturbance.

7.1.1 Peak flow

The peak flow risk ratings were generated based on a risk matrix (Figure 3) combining the likelihood of a peak flow impacting elements at risk along a watercourse (i.e., sensitivity) (Section 5) and the estimated likelihood of a significant peak flow increase (Section 6). Sensitivity was evaluated separately for the natural watercourse (e.g., stream channel, NCD, unchannelized drainage) and structures. These factors combined to generate two separate peak flow risk ratings for each study watershed under the current watershed condition (one rating for risk to the natural watercourse, and one rating for risk to structures).

Under the current watershed condition, Basin D has a moderate peak flow risk rating for structures, and a low risk rating for the natural watercourse. Basins A-C and E have low peak flow risk ratings for structures, and very low risk ratings for the natural watercourses. Basin F has very low risk ratings for structures and the natural watercourse.

Recommendations are provided in Section 11 for addressing peak flow risks in the watersheds.

7.1.2 Low flow

The current low flow risk is considered low for Basin E, and very low for all other drainage units. To-date, decreases in seasonal low flows caused by historical forest cover disturbance and any associated impacts on water supply are likely low (e.g., compared to negligible) for Basin E, and negligible for all other drainage units.

It is important to bear in mind that the low flow risk rating for the current watershed condition represents the likelihood that the distribution of historical forest cover disturbance (combining all sources of natural and human related disturbance) is causing low flows to be reduced currently compared to the drainage in an undisturbed forest cover condition. **The low flow risk rating is not a reflection of the severity of naturally occurring low flows. Rather, it reflects the current distribution of regenerating stands in the stem exclusion stage following historical stand replacing disturbance (e.g., clearcutting, severe wildfire) (hereafter referred to as *immature stands*), and/or advanced regeneration that has been released following non-stand replacing disturbance (e.g., selection harvesting, insect mortality)**.

Stand replacing forest cover disturbance does not typically cause an immediate reduction in seasonal low flows [*Pike & Scherer*, 2003; *Winkler et al.*, 2015; *Winkler et al.*, 2017; *Coble et al.*, 2020]. Rather, stands in early stages of regeneration have the potential to increase low flows due to low rates of evapotranspiration and elevated snowpack accumulation. However, it is possible that low flows can decrease (compared to undisturbed conditions) once a large portion of a catchment becomes established with immature stands having closed canopies, rigorous growth, and, thus, elevated rates of evapotranspiration (e.g., 30-50 years after disturbance). Low flows can also decrease following non-stand replacing disturbance [*Coble et al.*, 2020]. For catchments with high elevation relief, the high elevation areas are particularly important as source areas for low flows due to greater snowpack accumulation and later melt.

Partial cutting (e.g., small patch clearcuts, selection harvesting) has occurred on private land throughout the lower and/or middle elevations of Basins C through E, and limited portions of the lower elevation in Basins A and B. Stand regeneration appears to be limited currently within most of the harvested areas [*Google Earth*, 2025], and has likely resulted in excess runoff within the harvested areas. However, a large stand in the middle of Basin E (southwest of Site 24) appears to have been harvested several years ago and has reestablished at a high density. This stand is likely using more water than the original (i.e., pre-disturbance) stand through elevated rates of evapotranspiration. It is possible that this stand is reducing runoff locally, but likely has limited influence at the watershed scale because of being located in the middle elevation (the high elevation is more influential).

The overall amount of stand replacing forest cover disturbance (combining all existing sources of natural and human related disturbance, but not accounting for hydrologic recovery) is very high (>50%) for Basin D; high (40-50%) for Basin E; low (20-30%) for Basins B, C, and F; and very low (<20%) for Basin A (Table 4). Low flow concerns could develop in the long-term once existing harvested stands reach a state of closed canopy (e.g., 30-50 years after disturbance) , particularly for Basins D and E. Notwithstanding these concerns, the long-term impact on

seasonal low flows is somewhat uncertain due to unknown long-term disturbance patterns (e.g., forest development, wildfire, forest pests). These findings account for forest cover disturbance only, and do not account for other potential long-term impacts on low flows (e.g., climate change).

Table 4. Current level (Jan 1/25) of stand replacing forest cover disturbance combining all historical impacts. **These values are not ECAs, and do not account for hydrologic recovery**. They are utilized for evaluating the overall level of forest cover disturbance in the study watersheds, for assessing potential (current and/or future) impacts on low flows.

Drainage unit	Gross area (ha)	Forest cover disturbance (%)	
		[1]Catchment	[2]High elevation
Basin A	104	13.8	11.2
Basin B	27	25.3	3.4
Basin C	46	27.4	3.9
Basin D	33	77.2	46.8
Basin E	269	40.9	3.0
Basin F	6	24.8	18.0

1. Calculated for the entire drainage unit.
2. Calculated for the portion of the drainage unit above the H40 elevation. See Section 4.2.2 and Table 1 for details.

7.1.3 Surface erosion

The current surface erosion risk is considered low for Basins C and E, and very low for all other drainage units. The rating levels generally correspond to the extent and severity of ongoing surface erosion as identified during the field review (Appendix 3). The primary sediment issue identified in the field is road related surface erosion, primarily along the main forest road within the AOI (between Sites 14 and 20) (Photo 10). Notwithstanding the discontiguous surface flow in the study watersheds, surface erosion in the study area likely results in sediment being transported downstream during periods of elevated runoff. However, impacts to streams are likely limited, as most mainstem watercourses in the study area are unchannelized or NCDs (Sections 1 and 5.1).

Notwithstanding, accumulated runoff along road surfaces is a concern in the study area. Soils in the study area are generally sand and silt dominated, and well drained (Section 3.1). The erodibility of soils was found during the field review to be typically moderate. Improved drainage management (e.g., more frequent water bars and cross-drains) is required to reduce road related surface erosion.

7.1.4 Landslides

The current landslide risks are considered very low for all drainage units. No terrain stability related concerns were identified in the field or on satellite imagery [*Bing Aerial*, 2025; *Google Earth*, 2025]. It appears unlikely that landslides have impacted watercourses in the study area.

7.1.5 Riparian function

The current riparian function risk is considered moderate for Basin E, and very low for all other drainage units. The moderate rating is associated with forest clearing on private land in the middle and lower reaches of Basin E where there is likely a defined channel (Section 5.1.2). The riparian clearing likely provides ready access to streams for livestock. Riparian related impacts likely do not exist in the other study watersheds, as most mainstem watercourses are unchannelized or NCDs (Section 5.1.1).

7.1.6 Ratings

The partial risk ratings for the current watershed condition are summarized in Tables 5 and 6.

Table 5. Partial risk ratings for the current watershed condition related to peak flows.

Drainage unit	Likelihood of peak flow increase	[1]Sensitivity		Partial risk of peak flows	
		Watercourse	Structures	Watercourse	Structures
Basin A	Very low	Moderate	High	Very low	Low
Basin B	Very low	Moderate	High	Very low	Low
Basin C	Very low	Moderate	High	Very low	Low
Basin D	Low	Moderate	High	Low	Moderate
Basin E	Very low	Moderate	High	Very low	Low
Basin F	Very low	Moderate	Moderate	Very low	Very low

1. The sensitivity rating for the natural watercourse and/or structures limits the overall capacity of the watershed as a whole to accommodate disturbance events, including elevated peak runoff related to forest cover disturbance.

Table 6. Partial risk ratings for the current watershed condition related to low flows, surface erosion, landslides, and riparian function.

Drainage unit	Partial risk			
	[1]Low flow	Surface erosion	Landslide	Riparian function
Basin A	Very low	Very low	Very low	Very low
Basin B	Very low	Very low	Very low	Very low
Basin C	Very low	Low	Very low	Very low
Basin D	Very low	Very low	Very low	Very low
Basin E	Low	Low	Very low	Moderate
Basin F	Very low	Very low	Very low	Very low

1. The low flow risk ratings are not a reflection of the severity of naturally occurring low flows. Rather, they reflect the distribution of immature stands and/or release of advanced regeneration, and potential impacts on low flows.

7.2 Future forest development

BCTS did not provide specific proposed cutblocks or roads for review (e.g., mapping shapefiles); thus, it was not possible to complete a risk analysis for planned forest development. However, the sections below provide a discussion of risk factors to consider for forest development planning in the study watersheds, and associated recommendations are provided in Section 11.

7.2.1 Peak flow

The sensitivity of structures is high for Basins A through E, and moderate for Basin F (Section 5.2). The high sensitivity ratings are related primarily to insufficient drainage structures across Salmon River Road, downstream from the study watersheds, but also the close proximity of a residence to the mainstem watercourse in Basin A. A local resident reported that runoff flowed over Salmon River Road historically during periods of elevated runoff [*Sorensen*, 2024]. The timing and magnitude of this historical runoff is uncertain; however, its occurrence highlights that there is an associated risk with materially increasing runoff from the study watersheds through forest cover disturbance. Moreover, redirecting runoff from one study watershed to another along the forest road network could also increase these risks.

The potential consequences of peak flow impacts require careful consideration with forest development planning. Increased runoff from forest development could lead to uncontained flow or channel avulsions downstream from the study

watersheds during unusually wet periods (e.g., an extreme rain-on-snow event). These events could cause damage to agricultural fields, flood impacts to residential and/or agricultural structures, undermining and/or overtopping of Salmon River Road or private roads, and associated impacts to public safety.

Further to the peak flow risks discussed above, this overview assessment focused on the scale of the study watersheds. It is important to also consider the potential for peak flow impacts within smaller tributary drainages, for managing localized ECAs, drainage along roads and trails, and the flow capacity of drainage structures. Recommendations are provided in Section 11 for forest development planning in the study watersheds.

7.2.2 Low flow

The potential for future forest development to exacerbate seasonal low flows requires careful consideration with respect to any dependence of local residents on surface water supply (e.g., livestock watering in Basin E) or on runoff contributions to groundwater supply. In this respect, low flow in this assessment refers to the rate of runoff during the summer drought season, whether the runoff is above (surface) or below the ground surface (sub-surface) . The rate of below ground runoff is also a potential concern for maintaining regional groundwater levels (discussed further in Section 9).

It is important to consider the near-term and long-term distribution of immature stands and/or release of advanced regeneration, and the associated effects on localized runoff. For instance, selection harvesting (single tree selection or similar) can cause a near-term decrease in low flows by releasing advanced regeneration. Widespread clearcutting can increase low flows in the short-term, but decrease low flows in the long-term (e.g., 30-50 years after disturbance) once existing and future forest cover disturbance reaches a state of closed canopy, rigorous growth, and, thus, elevated rates of evapotranspiration.

On these bases, it is important to maintain a range of forest age classes across the study watersheds (e.g., a mix of clearings and regenerating, immature, and mature stands). Maintaining variable age classes can help mitigate the long-term potential for a catchment to become dominated by immature trees with high evapotranspiration rates that can decrease seasonal low flows. Maintaining a range of stand structures (e.g., through commercial thinning) can also help mitigate potential impacts on low flows. It is also important to manage the amount of shallow groundwater intercepted along roads and trails, as shallow groundwater is often an important source for streamflow further downslope, and can be an important contribution to regional groundwater (i.e., aquifer storage).

Additional discussion is provided in Sections 7.1.2 and 9 regarding the impacts of forest cover disturbance on low flows and groundwater. Recommendations are provided in Section 11 for forest development planning in the study watersheds.

7.2.3 Surface erosion

Generally, as the amount of development in a drainage increases, the potential for soil to be eroded and delivered to the drainage network also increases. The length of in-block roads and trails typically increases with increasing cutblock area, particularly for partial cutting. The potential for sediment delivery to the drainage network is increased substantially for development (roads, trails, cutblocks) in close proximity to a watercourse, particularly wherever the development is on terrain with elevated surface erosion potential (influenced by soil texture, slope gradient, and surface roughness). Roads and trails with long, continuous grades that are oriented downslope toward the drainage network are generally of greatest concern, as there is a greater potential for surface runoff to accumulate and deliver eroded sediment to the drainage network.

Roads and trails near watercourses and/or on terrain that is prone to surface erosion require careful drainage management to minimize the accumulation of surface runoff. Provided best management practices are utilized with future road construction, harvesting, and post-harvest maintenance and deactivation operations to minimize surface erosion and sediment delivery, and to maintain natural drainage patterns, the potential for additional hydrologic disturbance related to surface erosion can be limited in the study watersheds.

Recommendations are provided in Section 11 for addressing surface erosion risks.

7.2.4 Landslides

Terrain hazard mapping was not available for the study area. A map of slope gradient and soil texture is provided in Appendix 6. The primary concern for any future development would be proposed roads or cutblocks on or above moderately steep (40-60%) and/or steep (>60%) terrain, or above deeply incised drainages. The amount of area mapped in the study area as moderately steep or steep is very limited, with no areas mapped as steep within the AOI. Notwithstanding, this mapping should not be considered a replacement for terrain hazard mapping or assessment by a terrain specialist. For instance, this mapping is derived from a digital elevation model (DEM) at a 10 m grid resolution. It is possible that localized slope gradients can exceed the values indicated on the map in Appendix 6, and that small scale incised drainages can be masked by the grid resolution of the DEM.

In any case, it is important for BCTS to be cognizant of the potential for timber harvest and/or road construction to alter drainage patterns and increase runoff to

hazardous terrain downslope, and the corresponding potential to cause slope instability. Moreover, careful management of windthrow potential in riparian buffers and adjacent stands, particularly within incised drainages, is important for limiting the associated risk of slope instability. With respect to these risks, this assessment is considered an overview hydrologic assessment and does not mitigate the need for BCTS to exercise a high level of due diligence with determining when and where to engage a terrain specialist for reviewing development plans and any terrain concerns identified in the field during layout processes.

Recommendations are provided in Section 11 for addressing landslide related risks.

7.2.5 Riparian function

Riparian function risk relates to the likelihood of future forest development incrementally increasing stream channel impacts related to riparian management. The extent of defined stream channels in the study area is limited (Sections 1 and 5.1). In this respect, the potential for future BCTS development to impact stream channels is also limited. Notwithstanding, it is important to protect any wet areas and NCDs identified during field layout processes from disturbance by harvesting equipment. Another concern would be the proximity of future development to incised drainages with respect to potential windthrow along gully sidewalls.

Provided best management practices [*Tschaplinski and Pike*, 2010] are utilized with future road construction and harvesting operations to maintain properly functioning riparian areas and channel stability, and to protect wet areas and incised drainages, the potential for riparian management practices to directly cause disturbance can be limited. Recommendations are provided in Section 11 to ensure adequate riparian protection along natural watercourses and incised drainages.

8 Climate change

Climate change is predicted to cause several changes to weather patterns in the region that will impact the hydrology of the study watershed. By the 2050s, precipitation in the North Okanagan region is predicted to increase by 3.1% annually and 16.4% in the winter, and decrease by 0.9% in the spring (median values) [*PCIC*, 2025]. For those same periods, air temperature is predicted to increase by 2.5-2.9°C. Further to these changes, 1 in 100 year precipitation intensities for the 2040-2070 period are predicted to increase by 28% compared to historical values (1986-2005 period) for the highest elevation in the study watershed (Mount Swanson) (Appendix 4) [*Simonovic et al.*, 2015]. These meteorological changes could lead to several changes in the hydrology of the study watersheds, including but not limited to [*Smith et al.*, 2024]:

- lower winter snowpack accumulation because of warmer winter air temperatures;
- earlier spring freshet because of warmer spring air temperatures;
- lower mean spring freshet peak flows because of lower snowmelt volumes;
- higher extreme spring freshet peak flows because of higher spring rainfall intensities;
- lower summer, fall, and/or winter low flows because of earlier spring snowmelt and higher evapotranspiration rates during the growing season;
- higher frequencies of stand replacing wildfires, which could increase the potential for flash flooding associated with water repellent soils;
- higher rates of natural stand mortality related to insect attack and disease, which could exacerbate impacts on peak flows and/or low flows; and
- higher frequencies of terrain instability and surface erosion because of higher rainfall intensities and/or higher wildfire frequencies.

These changes could increase risks to the study watersheds with respect to flooding, stream dewatering, and/or sedimentation. The potential consequences of increased flooding include channel instability and/or scour along natural watercourses, degraded water quality, damage to local infrastructure (e.g., stream crossings, residential structures), and/or impacts to public safety. An increased frequency and/or persistence of drought could increase water supply constraints. Increased rates of sedimentation could impact the quality of the water supply.

For BCTS, adapting to an increased potential for sediment production requires carefully managing terrain stability and drainage of surface flow on roads and trails (Sections 7.2.3 and 7.2.4). Adapting to the potential impacts of climate change on spring freshet peak flows involves ensuring drainage structures (i.e., ditch-lines, culverts) are properly functioning and adequately sized to provide capacity for increasing extreme peak flow events and associated increased mobility of sediment/debris. Implementing climate change adaptation measures is most important for structures involving a long time horizon (e.g., in place more than 5-10 years), and structures involving high consequence scenarios (e.g., public safety, private property). It is also important to bear in mind that existing streamflow records used for developing design flows likely span multiple past decades and, thus, likely do not properly account for non-stationarity in peak flows related to recent climate change impacts on weather patterns (i.e., existing datasets are backward looking and, thus, under-represent the current hydrometeorological regime).

Based on a comparison of meteorological changes predicted for the study watersheds to results from runoff modelling for the Penticton Creek Watershed in southern BC [*Smith et al.*, 2024], crossing structures of concern should be up-sized to accommodate peak flow increases of ~25% or more related to climate change

uncertainty. For corrugated culverts, this increased flow capacity can typically be achieved by up-sizing culverts by one standard size (e.g., up-sizing a 500 mm CMP by one standard size to 600 mm). These capacity increases are additional to the sizing deemed adequate based on historical flows and the conditions of the catchment draining to the crossing (e.g., drainage area, topography, vegetation type), and are additional to any up-sizing that would normally be considered for other reasons (e.g., public safety, ECAs, soil disturbance, sediment and debris movement under historical runoff conditions).

9 Groundwater concerns

A review of government data showed that five groundwater wells exist in Basin E, with all of them being deep wells exceeding 120 m [*iMapBC*, 2025] (see groundwater map in Appendix 7). Numerous other wells are in close proximity to or directly downslope from the study watersheds (e.g., Sites 23, 27) (Photo 9). In addition, multiple groundwater dugouts were identified during the field review that are utilized for water supply (e.g., livestock watering) (e.g., Sites 25, 26) (Photo 11). Multiple additional dugouts are identifiable on satellite imagery within the study watersheds (e.g., Basin E) [*Google Earth*, 2025]. These data indicate there is substantial groundwater activity in and around the study area that requires careful consideration with planning future forest development.

The groundwater sources discussed above involve both deep and shallow aquifers. The shallow aquifers are unconfined (i.e., no impermeable layer residing above the aquifer). The deep aquifers include both confined (i.e., artesian; layers of impermeable material reside both above and below the aquifer) and unconfined types (Section 3.1) (Appendix 7). In either case, confined and unconfined aquifers would both be replenished periodically (at least annually) by surface water inputs in overlying and/or upslope recharge areas.

The distribution of recharge areas for the confined aquifers is uncertain, as it depends on the location of permeable seems, cracks, and/or fissures that would allow water to percolate into the aquifers. The recharge areas could be located inside and/or outside the delineated study area, as these permeable features can be oriented laterally and deliver source water from a distance. Detailed hydrogeological mapping is beyond the limits of the author's area of professional practice, and requires involvement by a hydrogeologist.

With respect to the recharge areas for unconfined aquifers, Aquifer 1157 (Hullcar Perched – inferred to be unconfined) extends into Basin E; thus, water (rainfall and snowmelt) infiltrating into soils within Basin E would recharge Aquifer 1157 (Appendix 7). Aquifer 103 (Hullcar Unconfined) is located directly downslope from Basins A through E. Surface water and shallow groundwater (infiltrating into the soil and flowing through the sub-surface) flowing downslope from these

watersheds would recharge Aquifer 103. Basin F is more distant from the mapped unconfined aquifers; however, a shallow groundwater well was observed in this watershed (Photo 9). It is inferred that a local unconfined aquifer (e.g., perched aquifer) exists in this study watershed. In any case, any significant changes to the volume of runoff (surface and/or sub-surface) in an upslope recharge area located within the study area could impact delivery of groundwater to one or multiple unconfined aquifers.

With respect to protecting the quantity of groundwater supply, the primary concerns would be decreasing runoff yield within groundwater recharge areas (i.e., low flows; Section 7.2.2), or intercepting shallow groundwater along roads and trails. Any increase in runoff yield (i.e., peak flows; Section 7.2.1) would either have a negligible effect, or would increase groundwater supply, depending on the distribution of the forest development relative to the recharge areas.

It is important to carefully manage near-term and long-term impacts on seasonal low flows and, thus, groundwater supply with future development. It is also important to manage the amount of shallow groundwater intercepted along roads and trails. Additional discussion on this topic is provided in Section 7.2.2. Recommendations are provided in Section 11 for forest development planning in the study watersheds, with respect to managing impacts on low flows and minimizing interception of shallow groundwater.

10 Summary of key findings

10.1 Sensitivity of natural watercourses

- Few defined stream channels were identified within or immediately downstream from the study watersheds, with the exception of the middle and lower reaches of Basin E.
- The watercourses are typically comprised of broad swales or NCDs that were mostly dry during the field review. However, there was evidence of historical surface flow in the upper reaches, and historical surface flow was reported by a local resident for locations near the watershed POIs.
- Multiple alluvial fans were identified slightly downstream from the POIs near Salmon River Road, indicating a history of sediments being mobilized by surface flow.

- Along the natural watercourses, the ground surface is generally brushy, grass, and/or weedy, with an abundance of woody debris in contact with the ground.
- Based on the slope gradients, an increase in surface runoff caused by forest development could generate excessive scouring of the ground surface, and transport eroded sediment downstream.

10.2 Sensitivity of structures

- Table 2 summarizes sensitivity ratings for structures at the watershed scale. Appendix 2 summarizes specific structures requiring monitoring or remediation for existing or potential runoff impacts, along with priority ratings and suggested actions for remediation.
- The sensitivity of structures is considered high for Basins A through E, related to insufficient cross-drains along Salmon River Road, as well as a residence being located in close proximity (<5 m) to the watercourse in Basin A.
- The sensitivity of structures is considered moderate for Basin F.

10.3 Partial risk for current condition

- Under the current watershed condition, Basin D has a moderate peak flow risk rating for structures, and a low risk rating for the natural watercourse. Basins A through C and E have low peak flow risk ratings for structures, and very low risk ratings for the natural watercourses. Basin F has very low risk ratings for structures and the natural watercourse.
- The current low flow risk is considered low for Basin E, and very low for all other drainage units. To-date, decreases in seasonal low flows caused by historical forest cover disturbance and any associated impacts on water supply are likely low or negligible.
- Low flow concerns could develop in the long-term once existing harvested stands reach a state of closed canopy, particularly for Basins D and E. Maintaining a range of stand structures across the land-base could help mitigate potential impacts on seasonal low flows.
- The current surface erosion risk is considered low for Basins C and E, and very low for all other drainage units. The primary concern is surface erosion on forest roads.

- The current landslide risks are considered very low for all drainage units. No terrain stability related concerns were identified in the field or on satellite imagery.
- The current riparian function risk is considered moderate for Basin E, and very low for all other drainage units. The moderate rating is associated with forest clearing on private land in the middle and lower reaches of Basin E, which likely provides ready access to streams for livestock.

10.4 Partial risk for future forest development

- BCTS did not provide specific proposed cutblocks or roads for review; thus, it was not possible to complete a risk analysis for planned forest development.
- The occurrence of historical surface flow in the study watersheds highlights that there is an associated risk with materially increasing runoff from the study watersheds through forest cover disturbance. Moreover, redirecting runoff from one study watershed to another along the forest road network could also increase these risks.
- Increased runoff from forest development could lead to uncontained flow or channel avulsions downstream from the study watersheds during unusually wet periods. These events could cause damage to agricultural fields, flood impacts to residential and/or agricultural structures, undermining and/or overtopping of Salmon River Road or private roads, and associated impacts to public safety.
- The potential for future forest development to exacerbate seasonal low flows requires careful consideration with respect to any dependence of local residents on surface water supply or on runoff contributions to groundwater supply. The rate of below ground runoff is a potential concern for maintaining regional groundwater levels.
- Roads and trails near watercourses and/or on terrain that is prone to surface erosion require careful drainage management to minimize the accumulation of surface runoff.
- The amount of area mapped in the study area as moderately steep or steep is very limited, with no areas mapped as steep within the AOI. Notwithstanding, it is possible that localized slope gradients can exceed the values indicated on the map, and that small scale incised drainages can be masked by the relatively large grid resolution of the DEM.
- The extent of defined stream channels in the study area is limited; thus, the potential for future BCTS development to impact stream channels is also limited. Notwithstanding, it is important to protect any wet areas, NCDs, and incised drainages identified during field layout processes.

10.5 Climate change

- 1 in 100 year precipitation intensities for the 2040-2070 period are predicted to increase by 28% for the highest elevation in the study watershed (Mount Swanson).
- Meteorological changes could lead to several changes in the hydrology of the study watersheds, including higher extreme spring freshet peak flows, decreased low flows, and more frequent terrain instability and surface erosion.
- Climate change could increase risks to the study watersheds with respect to flooding, stream dewatering, and/or sedimentation.
- Adapting to the potential impacts of climate change on spring freshet peak flows includes ensuring drainage structures (i.e., culverts and bridges) are properly functioning and adequately sized to provide capacity for increasing extreme peak flow events and associated increased mobility of sediment/debris.
- Crossing structures of concern should be up-sized to accommodate peak flow increases of ~25% or more related to climate change uncertainty.

10.6 Groundwater concerns

- There is substantial groundwater activity in and around the study area that requires careful consideration with planning future forest development.
- The groundwater sources involve both confined and unconfined aquifers, which would both be replenished periodically (at least annually) by surface water inputs in overlying and/or upslope recharge areas.
- The recharge areas for confined aquifers could be located inside and/or outside the delineated study area.
- Any significant changes to the volume of runoff (surface and/or sub-surface) within the study area could impact delivery of groundwater to one or multiple unconfined aquifers.
- With respect to protecting the quantity of groundwater supply, the primary concerns would be decreasing runoff yield, or intercepting shallow groundwater along roads and trails.

11 Recommendations

11.1 Forestry issues

Consistent with the introduction (Section 1) and terms of reference for the assessment (Section 2), the following recommendations are provided as guidance to BCTS on how to minimize impacts from their operations in the study watersheds. The recommendations are based on the review of the current watershed condition. It is advisable to be proactive with implementing the recommendations for all areas of the study area (where appropriate).

1. The **remedial measures** identified in Tables A2 and A3 (Appendices 2 and 3) regarding concerns observed during the field review should be implemented to the extent they pertain to BCTS' authority.
2. The potential for increased **surface erosion, terrain instability, and riparian disturbance** require consideration with forest development planning in the study watersheds. Mitigation measures should be implemented on an as-needed basis to minimize the potential for sediment delivery to watercourses and/or risks to public safety, using recommendations below as a guide. Further, it should be noted that this assessment is considered an overview hydrologic assessment and does not mitigate the need for BCTS to exercise a high level of due diligence with determining when and where to engage terrain specialists for reviewing development plans and any terrain concerns identified in the field during layout processes. In particular, it is important to be cognizant of the potential for timber harvest and/or road construction to alter drainage patterns and increase runoff to **hazardous terrain downslope**, and the corresponding potential to cause terrain instability.
3. Under the current watershed condition, all study watersheds have a moderate rating for the sensitivity of natural watercourses, and Basins A through E have high ratings for the sensitivity of structures. There are **risks to water intakes, natural watercourses, public roads, residential and agricultural development, and public safety** that require careful consideration when determining the amount and distribution of harvest to complete. Carefully managing ECAs with long-term forest development planning and hydrologic recovery (i.e., forest regeneration) would help limit peak flow risks by limiting the likelihood of a significant peak flow increase. Table 7 summarizes **maximum ECAs** corresponding to **peak flow risk ratings of moderate or less** (assuming no change in the sensitivity of watercourses and/or structures) (hereafter referred to as the *moderate risk condition*). The maximum ECAs in Table 7 account for the distribution of topography (e.g., slope gradient, slope aspect, elevation) and soils, and the potential for runoff attenuation (e.g., low gradient terrain).

Table 7. Current ECAs for the study watersheds, and maximum ECAs corresponding to peak flow risk ratings of moderate or less (i.e., moderate risk condition) (assuming no change in the sensitivity of watercourses and/or structures).

Drainage unit	Current condition					Moderate risk condition				
	Partial risk of peak flows		Current ECA (%)			Partial risk of peak flows		Maximum ECA (%)		
	Watercourse	Structures	[1]Catchment	[2]High elevation	[3]Middle & high elevations (combined)	Watercourse	Structures	[1,4]Catchment	[2,4]High elevation	[3,4]Middle & high elevations (combined)
Basin A	Very low	Low	4.5	4.1	2.8	Low	Moderate	NA	22.0	26.0
Basin B	Very low	Low	6.8	3.4	0.6	Low	Moderate	NA	22.0	26.0
Basin C	Very low	Low	10.1	3.4	0.0	Low	Moderate	NA	22.0	26.0
Basin D	Low	Moderate	29.5	14.8	35.1	Low	Moderate	NA	25.0	30.0
Basin E	Very low	Low	24.9	3.0	20.5	Low	Moderate	NA	22.0	26.0
Basin F	Very low	Very low	6.0	3.7	8.1	Moderate	Moderate	35.0	NA	NA

1. Calculated for the entire drainage unit.
2. Calculated for the portion of the drainage unit above the H40 elevation (defined separately for each drainage unit). See Section 4.2.2 and Table 1 for details.
3. Calculated for the portion of the drainage unit above the H70 elevation (defined separately for each drainage unit). See Section 4.2.2 and Table 1 for details.
4. ECAs required to maintain ratings for the **likelihood of a significant peak flow increase** of **low** for Basins A through E; and **moderate** for Basin F. These likelihood ratings combine (using the partial risk matrix outlined in Figure 3) with the sensitivity ratings outlined in Section 5 (natural watercourses and structures) to generate the peak flow risk ratings outlined in Table 5 for the moderate risk condition.

4. The following clarifying points are provided to assist with **implementing Recommendation 3**.
    a. The ECA limits for the moderate risk condition are provided based on BCTS having a moderate risk tolerance [*Lau & Langston*, 2025].
    b. The ECAs specified in Table 7 should be evaluated independently for each study watershed in terms of limiting forest development to stay within the moderate risk condition. For each watershed, the most constraining condition should supersede with regards to location (e.g., ECA for high elevation versus middle and high elevations combined).
    c. To the greatest extent practicable, ECAs should be well distributed among tributary drainages.
    d. It is important to bear in mind that any change in the sensitivity of the natural watercourses and/or structures could also result in a change to the peak flow risk ratings (up or down). For this reason, the assessment of peak flow risk for the study watersheds should be updated at least every five years if additional harvesting is proposed in the future.
    e. It is acknowledged that runoff contribution to the peak flow from the middle elevation is typically less than that from the high elevation. On this basis, the ECA limits for Basins A through E are slightly higher for the middle and high elevations combined, compared to the ECA limits for strictly the high elevation. This difference allows for a slightly higher level of forest cover disturbance in the middle elevation.
    f. To assist BCTS with forest development planning, Table A8 (Appendix 8) provides the maximum forest harvest available (clearcut equivalent) in the study watersheds without exceeding the maximum ECAs specified in Table 7 for the moderate risk condition. These harvest areas can be increased for partial cutting in proportion to the amount of basal area retention.
5. It is important to avoid any **migration of accumulated runoff between study watersheds**. A large relative increase in flow within a particular drainage could impact the integrity of the watercourse and any downstream water intakes or structures, and generate flow over Salmon River Road. Similarly, a large relative decrease in flow could impact the availability of water supply. Cross-drains along BCTS roads and trails should be located strategically to avoid flow migration between watersheds. In this respect, consideration should be given to installing a cross-drain (e.g., culvert) at each location where a BCTS road or trail crosses a study watershed boundary on a downslope grade (see current condition map in Appendix 5 for drainage delineations).

6. To minimize the potential impacts of forest development on **aquifer levels**, the following strategies should be implemented to minimize the amount of **groundwater intercepted by roads and trails**.
    a. Minimize the depth of roads cuts by avoiding steep topography with road routing/alignment.
    b. Out-slope roads and construct cross-drains / water bars at a high frequency to readily disperse intercepted groundwater and accumulated surface flow to the forest floor (for re-interception into the soil).
    c. As soon as practicable following development, fully rehabilitate/re-contour road sections that intercept groundwater during the snow-free period.
    d. To the extent it is not practicable to fully rehabilitate/re-contour roads (e.g., a permanent mainline road), groundwater interception can be managed using the practices outlined in Recommendation 6b, provided they are implemented to a high standard (i.e., best management practices) with the initial construction and post-construction maintenance/monitoring.
7. The following **best management practices** should be considered to ensure **high flows and mobile sediment/debris** can be properly conveyed by cross-drains, to minimize the potential for crossing failure, redirected and/or uncontained flow, and associated impacts on **terrain stability**. They are particularly applicable to drainages with elevated ECAs (current or future), including tributary drainages.
    a. To the greatest extent practicable, deactivate roads as soon as possible following development and prior to the subsequent peak flow period, including removing drainage structures and constructing cross-ditches and water bars. Problematic road sections should be given a higher priority, including roads that accumulate large amounts of runoff and drainage crossings with elevated upstream ECAs. Consider fully rehabilitating roads with downslope terrain having high or very high terrain hazards (where present).
    b. Ensure drainage structures (e.g., culverts) are properly functioning and adequately sized to provide capacity for peak flows and mobile sediment/debris. Any drainage structures that appear to be operating near capacity, or are damaged or otherwise functionally compromised, should be repaired or upgraded.
    c. Maintain natural drainage patterns and minimize the concentration of runoff on the soil surface.

d. Ensure cross-drains are draining into natural drainages/draws. Elsewhere, surface flows should be highly dispersed with a higher than normal frequency of cross-drains to account for increased runoff rates.

e. Routine field inspections and maintenance of ditches, road surfaces, and drainage structures should be implemented to account for potential increases in runoff and movement of sediment/debris. It is particularly important to complete inspections and maintenance in areas of elevated concern prior to major runoff events, including prior to spring freshet (e.g., during the prior fall for high elevation areas).

8. The following **best management practices** should be considered with road construction, harvesting, and post-harvest maintenance and deactivation operations in all areas of the study watersheds, particularly areas with relatively steep terrain, steep road sections, and/or close proximity to natural watercourses. They are intended to minimize the potential for **surface erosion and peak flow** related hydrologic disturbance by limiting soil disturbance, the amount of exposed soil, and concentration of runoff on the soil surface.

   a. Minimize the amount of constructed road.

   b. Deactivate or fully rehabilitate temporary roads as soon as possible following development.

   c. Maintain natural drainage patterns.

   d. Construct frequent cross-drains and water bars of adequate size to minimize flow accumulation and to disperse intercepted runoff to the forest floor. This is particularly important for roads oriented downslope, including in-block trails.

   e. Carefully plan and design road routes and alignment to minimize the quantity of drainage crossings and limit the length of ditch-line connected directly to the drainage network.

   f. For road sections that are connected directly to the drainage network, limit the ditches from extending continuously (i.e., without a cross-drain) beyond the adjacent gully sidewall.

   g. Construct sediment sumps where ditches connect directly to streams (this practice should not replace good road planning and design);

   h. Grass seed exposed soil along roadsides.

   i. Place coarse aggregate on road surfaces at stream crossings to prevent surface erosion and delivery of sediment to streams, and to avoid rutting along the tire tracks.

j. Limit site preparation in areas with minimal downslope breaks in terrain and/or surface roughness that would trap mobilized sediment.

k. Avoid road construction and harvesting activities when soils are sufficiently wet to cause excessive rutting of landings, roads, and/or skid trails during logging operations.

9. Careful attention should be given to implementing **best management practices** [*Tschaplinski and Pike*, 2010] with **riparian buffers, operational setbacks, and crossing design** (including skid-trail crossings) to minimize the potential impacts of road construction and harvesting operations on riparian function and the stability of natural watercourses. These practices should include careful windthrow management, particularly near any **incised drainages** due to the potential for elevated terrain sensitivity. Wherever elevated terrain sensitivity exists, brush species, advanced regeneration, non-merchantable conifers, and non-commercial species should be retained to the extent practicable (except where doing so increases the terrain stability concern). The primary objectives are to:

   a. avoid terrain instability;

   b. minimize soil disturbance near or in the watercourses;

   c. avoid depositing logging related debris in streams;

   d. retain vegetation along the banks for maintaining bank stability; and

   e. maintain a long-term supply of large wood to streams for regulating sediment transport and reducing flow velocities.

10. Consider **up-sizing the flow capacity** of drainage crossing structures in the study watersheds by ~25% or more to accommodate uncertainty in peak flows related to **climate change**. Implementing this climate change adaptation measure is most important for structures involving a long time horizon (e.g., culverts or bridges in place more than 5-10 years), and structures involving high consequence scenarios (e.g., public safety, domestic water supply). For corrugated culverts, this increased flow capacity can typically be achieved by up-sizing culverts by one standard size (e.g., up-sizing a 500 mm CMP by one standard size to 600 mm). These capacity increases are additional to the sizing deemed adequate based on historical flows and the conditions of the catchment draining to the crossing (e.g., drainage area, topography, vegetation type), and are additional to any up-sizing that would normally be considered for other reasons (e.g., public safety, ECAs, soil disturbance, sediment and debris transport under historical runoff conditions) (see Recommendations 7 and 8).

11. **Forest development planning** should consider opportunities to **maintain a range of forest age classes** across the study watersheds (e.g., a mix of clearings and regenerating, immature, and mature stands). Maintaining variable age classes can help mitigate the near-term and long-term potential for a catchment to become dominated by immature trees with high evapotranspiration rates that can decrease **seasonal low flows and aquifer recharge**. Maintaining a range of stand structures (e.g., through commercial thinning) can also help mitigate potential impacts on low flows.

11.2 Non-forestry issues

The following recommendations are provided as guidance for improving the overall hydrologic condition of the study watersheds. They are not specific to BCTS' authority, beyond notifying external organizations of relevant concerns and recommendations.

12. For **remedial measures** identified in Tables A2 and A3 (Appendices 2 and 3) that do **not pertain to BCTS' authority**, BCTS staff should notify the appropriate organizations (e.g., municipal or provincial governments, forest licensees, first nations, private landowners, clubs/associations) of the need to implement mitigation measures.
13. **Additional cross-drains** should be installed along **Salmon River Road** to properly manage surface runoff from the study watersheds. Consideration should also be given to constructing a **deeper ditch** along the upslope side of the road.

If you require any additional information, please do not hesitate to contact the undersigned.

Sincerely,

Russell S Smith, PhD, RPF
Senior Hydrologist

REGISTERED PROFESSIONAL FORESTER
PROVINCE OF BRITISH COLUMBIA
RUSSELL S. SMITH
NO. 4019

RSS Dec 24/25

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Appendix 1

Field photos



Photo 1. Natural watercourse in the upper reaches of Basin A (Site 13). The drainage is likely an NCD; however, it appears that it experienced flow the prior spring freshet. The watercourse is brushy and intact.



Photo 2. Alluvial fan below swale watercourse downstream from Basin B (Site 10). There is no road culvert at this location along Salmon River Road.



Photo 3. Broad swale watercourse in the upper reaches of Basin E (Site 17). A defined channel was not identified; however, a culvert immediately downstream showed evidence of historical flow. The drainage is brushy with woody debris in close contact to the ground surface.



Photo 4. Drainage channel slightly downstream from Basin E (Site 8). The channel is grassy at this location, and intact.



Photo 5. Residence in close proximity (<5m) to the watercourse near the apex of a broad alluvial fan at the POI for Basin A (Site 11).



Photo 6. Shallow drainage ditch along the upslope side of Salmon River Road, slightly downstream from Basin A (Site 11) (same location as Photo 5). There is no cross-drain at this location.



Photo 7. Shallow drainage ditch along the upslope side of Salmon River Road, slightly downstream from Basin B (Site 10). There is no cross-drain at this location.



Photo 8. This culvert (lower right) is the only cross-drain between Sites 8 and 11 allowing flow under Salmon River Road (Site 7).



Photo 9. Shallow groundwater well located within a wetland area in Basin F (Site 23).



Photo 10. Moderate-severe surface erosion from excess accumulation of flow on the running surface of the forest road (Site 20).



Photo 11. Shallow groundwater dugout that appears to be used for livestock watering (Site 25).



Photo 12. Culvert inlet ~50% obstructed with debris in upper reaches of Basin E (Site 17) (same location as Photo 3). Culvert overflow could be redirected eastward along the forest road.

Appendix 2

Summary of structures requiring monitoring or remediation

Table A2. Structures requiring monitoring or remediation for existing or potential runoff impacts as identified during the field review. The priority rating reflects the urgency for remediation to avoid future hydrologic disturbance and/or risk to public safety.

Drainage unit	Site	Drainage issue	Priority	Suggested remediation
Basin A	11	Broad alluvial fan with residence close to watercourse (<5m); flood safety hazard (Photo 5).	Very high	Manage ECAs to limit peak flow increase and, thus, potential for overbank flow / channel avulsion.
Basin E	17	Culvert inlet ~50% obstructed with debris; culvert overflow could be redirected eastward along forest road (Photo 12).	High	Remove debris.

Appendix 3

Summary of existing surface erosion & landslide disturbances

Table A3. Surface erosion and landslide related disturbances identified during the field review. The priority rating reflects the urgency for remediation to avoid future hydrologic disturbance and/or risk to public safety.

Drainage unit	Site	Type and/or severity of disturbance	Priority	Suggested remediation
Basin C	14	Upper extent of road surface erosion between Sites 14 and 20, ranging in severity from moderate to moderate-severe.	High	Construct water bars and/or additional cross-drains.
Basin E	20	Moderate-severe road surface erosion (Photo 10)	High	Construct water bars and/or additional cross-drains.

Appendix 4

Summary of precipitation intensity-duration-frequency

Table A4. Summary of historical and projected future (2040-2070 period) precipitation intensity-duration-frequency (IDF) values for the highest elevation in the study watershed (Mount Swanson).

Historical precipitation IDF (mm)

Duration	T: 2 years	T: 5 years	T: 10 years	T: 20 years	T: 25 years	T: 50 years	T: 100 years
5 min	3.1	4.7	6.1	7.9	8.5	10.8	13.7
10 min	4.3	6.5	8.5	11.1	12.0	15.4	19.7
15 min	5.0	7.5	9.7	12.6	13.5	17.4	22.2
30 min	6.4	9.5	12.4	16.2	17.4	22.7	29.7
1 h	8.8	13.1	16.7	21.0	22.4	27.6	33.8
2 h	11.8	16.3	19.9	23.9	25.2	29.9	35.2
6 h	16.3	21.1	24.6	28.6	29.8	34.2	39.0
12 h	19.4	24.8	28.6	32.5	33.7	37.6	41.7
24 h	22.1	28.4	32.9	37.8	39.3	44.4	49.9

Projected future precipitation IDF (mm)

Duration	T: 2 years	T: 5 years	T: 10 years	T: 20 years	T: 25 years	T: 50 years	T: 100 years
5 min	3.4	5.2	6.9	9.2	10.0	13.1	17.1
10 min	4.7	7.2	9.6	12.9	14.1	18.6	24.5
15 min	5.5	8.3	10.9	14.7	15.9	21.0	27.7
30 min	7.1	10.5	13.9	18.9	20.5	27.5	37.0
1 h	9.7	14.6	18.9	24.5	26.4	33.5	42.1
2 h	12.9	18.0	22.4	27.9	29.7	36.2	43.8
6 h	17.9	23.3	27.7	33.3	35.1	41.4	48.6
12 h	21.3	27.5	32.2	37.9	39.6	45.5	51.9
24 h	24.3	31.4	37.1	44.0	46.2	53.7	62.1

Ratio of projected future to historical

Duration	T: 2 years	T: 5 years	T: 10 years	T: 20 years	T: 25 years	T: 50 years	T: 100 years
5 min	1.10	1.11	1.13	1.16	1.18	1.21	1.24
10 min	1.10	1.11	1.13	1.16	1.18	1.21	1.24
15 min	1.10	1.11	1.13	1.17	1.18	1.21	1.25
30 min	1.10	1.11	1.13	1.16	1.18	1.21	1.24
1 h	1.10	1.11	1.13	1.16	1.18	1.21	1.25
2 h	1.10	1.11	1.13	1.16	1.18	1.21	1.24
6 h	1.10	1.11	1.13	1.16	1.18	1.21	1.24
12 h	1.10	1.11	1.13	1.16	1.18	1.21	1.24
24 h	1.10	1.11	1.13	1.16	1.18	1.21	1.25

RCP8.5, 2040-2070 period, GEV distribution, CMIP6, CanDCS-M6, ensemble of all models
https://www.idf-cc-uwo.ca/home

Appendix 5

Current condition map for the study area

1475000
1476000
1477000
1478000
631000
630000
629000
628000
627000

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27

Basin A
Basin B
Basin C
Basin D
Basin E
Basin F

909 m.a.s.l
812 m.a.s.l
817 m.a.s.l
769 m.a.s.l
647 m.a.s.l
598 m.a.s.l
707 m.a.s.l
684 m.a.s.l
642 m.a.s.l
690 m.a.s.l

Rose Swanson Basins
2024 Current Condition

- Field Site
- POI
- Contour (100 meter)
- Contour (20 meter)
- Paved Road
- Minor / Resource Road
- H40
- H70
- Stream (Order 1)
- Stream (Order > 1)
- Lake
- Wetland
- Private Land
- Watershed
- BCTS Area of Interest
- Splatsin te Secwépemc Woodlot

ECA Recovery
- 0-10%
- 10-30%
- 30-50%
- 50-70%
- 70-90%
- >90%

0 100 200 300 400 500 600
Meters
Scale: 1:5,000

Map Produced by: ECOSCAPE
Map Produced for: WATERSMITH
N

Date: 2025-10-17

Appendix 6

Map of slope gradient & soil texture for the study area

1475000
1476000
1477000
1478000
631000
630000
629000
628000
627000

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

Basin A
Basin B
Basin C
Basin D
Basin E
Basin F

598 m.a.s.l
642 m.a.s.l
647 m.a.s.l
684 m.a.s.l
707 m.a.s.l
769 m.a.s.l
812 m.a.s.l
817 m.a.s.l
909 m.a.s.l
690 m.a.s.l

Rose Swanson Basins
Slope Gradient & Soil Texture

- Field Site
- POI
- Contour (100 meter)
- Contour (20 meter)
- Paved Road
- Minor / Resource Road
- H40
- H70
- Stream (Order 1)
- Stream (Order > 1)
- Lake
- Wetland
- Private Land
- Watershed
- BCTS Area of Interest
- Splatsin te Secwépemc Woodlot

Slope Gradient (Percent)
- 0-20%
- 20-40%
- 40-60%
- > 60%

Soil Texture
- Sandy Loam
- Silt Loam
- Loam

0 100 200 300 400 500 600
Meters
Scale: 1:5,000

Map Produced by: ECOSCAPE
Map Produced for: WATERSMITH
N

Date: 2025-10-15

Appendix 7

Map of local aquifers & water supplies

Rose Swanson Basins
Local Aquifers & Water Supplies

- Field Site
- POI
- Water Licence

Groundwater Well
Finished Well Depth (m)
- <30
- 30-60
- 60-90
- 90-120
- >120
- Not Recorded

- Paved Road
- Minor / Resource Road
- BCTS Area of Interest
- Watershed

Aquifer (ID - Name)
- 102 - Hullcar Confined Aquifer
- 103 - Hullcar Unconfined Aquifer
- 355 - Aquifer (inferred to be confined)
- 1157 - Hullcar Perched Aquifer (inferred to be unconfined)

0 100 200 300 400 500 600
Meters
Scale: 1:5,000

Map Produced by: ECOSCAPE Environmental Consultants Ltd.
Map Produced for: WATERSMITH
N

Date: 2025-10-20

Basin A
Basin B
Basin C
Basin D
Basin E
Basin F

1475000 1476000 1477000 1478000
631000 630000 629000 628000 627000

Appendix 8

Maximum harvest available under moderate risk condition

Table A8. Maximum forest harvest available for the study watersheds without exceeding the maximum ECAs specified for the moderate risk condition (see Recommendation 3 in Section 11.1). These values were calculated using the difference between the current condition ECA and the maximum ECA under the moderate risk condition, as specified in Table 7 (i.e., future forest development would comprise a subtraction from these values). With utilizing these values for forest planning, it is important for BCTS to give careful consideration to Recommendation 4b regarding location.

Drainage unit	Gross area (ha)	[1]Maximum available harvest (ha)		
		[2]Catchment	[3]High elevation	[4]Middle & high elevations (combined)
Basin A	104	NA	7.5	16.5
Basin B	27	NA	2.0	4.6
Basin C	46	NA	3.4	7.7
Basin D	33	NA	1.3	1.5
Basin E	269	NA	20.5	29.3
Basin F	6	1.8	NA	NA

1. Clear-cut equivalent. Can be increased for partial cutting in proportion to the amount of basal area retention.
2. Calculated for the entire drainage unit.
3. Calculated for the portion of the drainage unit above the H40 elevation (defined separately for each drainage unit). See Section 4.2.2 and Table 1 for details.
4. Calculated for the portion of the drainage unit above the H70 elevation (including the area above the H40 elevation) (defined separately for each drainage unit). See Section 4.2.2 and Table 1 for details.