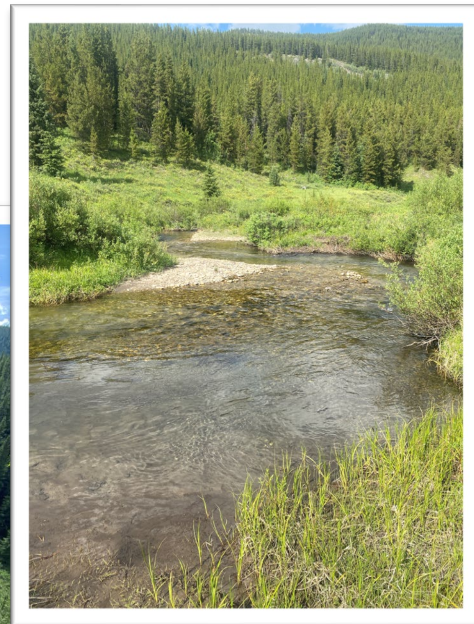
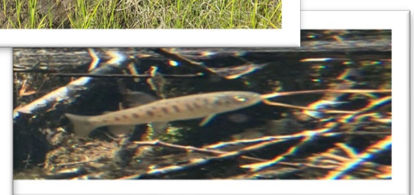
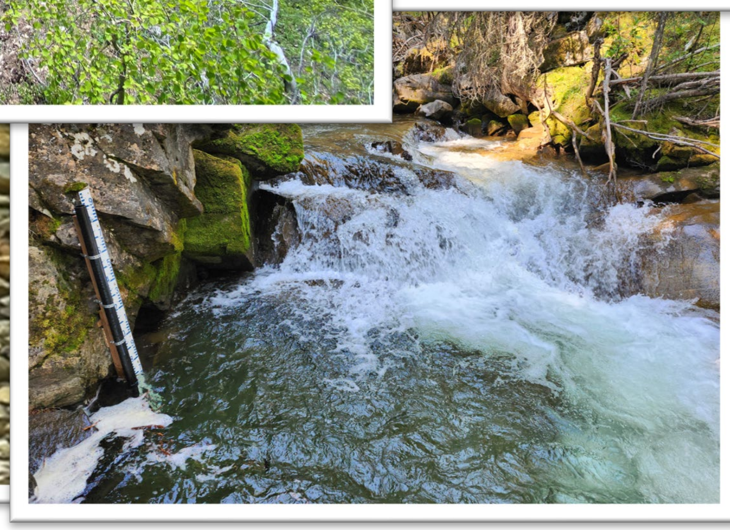
Loomis Creek Eco-hydrology Phase 1 Study: 2024-2025







May 27, 2025 Fintegrate file #: 2025-CPAWS-01

Prepared for:
Canadian Parks and Wilderness Society
Southern Alberta Chapter, 105 12 Ave SE Suite 310, Calgary, Alberta, T2G 1A1

Prepared by:
Matt Coombs, M.Sc., P.Biol., Fintegrate Fisheries & Watershed Consulting Ltd.
PO Box 473, Crowsnest Pass, Alberta, T0K 0C0
With contributions from:
Kim Green, PhD, P.Geo., Apex Geoscience Consultants Ltd.
Joshua Killeen, M.Sc., Canadian Parks and Wilderness Society

About

The Canadian Parks and Wilderness Society (CPAWS) Southern Alberta Chapter is a non-profit conservation organization working since 1967 to promote thriving, healthy, and diverse lands and waters in Alberta. We have long been engaged in land-use planning and sustainable forest management with a focus on promoting science-driven solutions that address cumulative effects and achieve sustainable ecosystem-based management.

Matt Coombs has been operating as Fintegrate Fisheries & Watershed Consulting Ltd. (Fintegrate) since 2021 working on projects for industry, governments, and First Nations. Fintegrate specializes in work on native fish species, many of which are listed as species at risk or species of special concern. Linkages are found between fish distribution and habitat use, broader watershed and hydrologic processes, and development of land and water resources. Fintegrate helps clients meet project-specific objectives while navigating applicable provincial and federal legislation protecting fish and fish habitat.

Kim Green works as a watershed geoscientist with Apex Geoscience Consultants Ltd. based in Nelson BC. Kim has been investigating watersheds for the past 30 years throughout western Canada. Apex is dedicated to the goal of sustainable resource management and provides a diversity of hydrological and geotechnical services including consulting for the natural resource sectors, private individuals, First Nations, Provincial government and Not-for-Profit organizations.

Online Map Compendium

An Online Map compendium accompanies this report and provides photographs, videos, and additional details for sites visited throughout the Project area.

Acknowledgements

We thank Paul Saso (Saso Consulting) for his work on the project, and Dave Mayhood (Freshwater Research Ltd.) and Lorne Fitch for their support in project conceptualization and review. We would also like to thank several volunteers for assistance with field work.

We thank Solinst, Fathom Scientific, and a generous donor for equipment donations toward the project. In addition, we thank Trout Unlimited and Alberta Conservation Association for further equipment donations.

Finally, a particular thank you goes to all those members of the public who generously supported this project through donations, and the Bow River Trout Foundation for matching donations from Foundation members. Without this support, this project would not have been possible.

Suggested Citation

Coombs, M., Green, K., & Killeen, J. (2025). Loomis Creek Eco-hydrology Phase 1 Study: 2024-2025. Prepared for Canadian Parks & Wilderness Society Southern Alberta Chapter.

Table of Contents

List of Figures

List of Tables

List of Photos

1 Executive summary

Canadian Parks and Wilderness Society (CPAWS) conducted an eco-hydrological field assessment of a recently approved clearcut logging plan in the upper Highwood River watershed. An earlier desktop-based hydrologic assessment and partial risk analysis of the same logging plan conducted for Alberta Forestry and Parks found the logging will increase mean annual and peak flows by approximately 10% and result in earlier, more rapid spring freshets. It recommended a field investigation of current channel morphology, riparian conditions, disturbance history, and vulnerability of bull trout (*Salvelinus confluentus*) critical habitat. CPAWS did this to demonstrate the level of detailed assessment required in watersheds where streams and riparian areas are legally designated as critical habitat.

Planned roads, water crossings, and clearcuts were found within as little as 10 m upslope and upstream of the most sensitive critical habitat in the watershed where bull trout spawn, eggs incubate over the winter, and juveniles rear. Logging will directly damage or destroy critical habitat, and the plan does not follow all the requirements of the provincial Operating Ground Rules (OGRs) or the federal *Species at Risk Act* (SARA) recovery strategy.

The field assessment confirmed for the first time that Loomis Creek is occupied by a resident bull trout population that is isolated from the Highwood River by log jams. With steeper stream gradients in the headwaters and lower reaches, the population relies heavily (if not entirely) on the only reach with a fully alluvial channel morphology. This mid reach of Loomis Creek where the stream gradient is lower was the only reach where bull trout spawning and young of the year (YOY) rearing were observed. Habitat quality is high because low-velocity flows meander through a broad beaver meadow floodplain over a stream bed of mobile gravel. The riffle-pool channel morphology contains back eddies, side channels, oxbows, and beaver ponds. Measurements of stream flow, electrical conductivity, and temperature suggest there is an influx of alluvial groundwater here.

At 36 sites surveyed, the size of the subwatershed area above tree line and the predominant slope aspect are reflected in trends of increasing channel cross-sectional area (m^2) and mobile bedload grainsize (cm) with increasing upstream drainage area (km^2). Heavier snowpacks and more rapid snow melt in clearcut areas will increase mean annual and peak flows and result in earlier, more rapid freshets. Existing signs of bank erosion, incisement, bedload movement, and channel aggregation and degradation on tributaries effected by historical logging indicate that the effects from the planned logging will be even greater due to a much larger area being clearcut. The mid reach of Loomis Creek is most at risk, with a bedload that is already entirely mobile under the current flow regime before any hydrologic alteration from new logging occurs. Loss of critical habitat is likely where stream meanders are cutoff in high flows and spawning gravel is swept downstream.

Historical wildfire and logging in the Loomis Creek watershed did not affect the most hydrologically reactive headwaters, but the planned clearcuts, disproportionately on south facing slopes, will. The earlier desktop-based hydrologic assessment showed hydrologic recovery of the forest has been slow, and loss of critical habitat due to higher flows on Loomis Creek and its tributaries could reduce or stop bull trout spawning and rearing for 50 years or more. This threatens the sustainability of the Loomis Creek bull trout population.

2 Introduction

In 2023, CPAWS learned of the upcoming clearcut logging of 12.5 km^2 by West Fraser Mills Ltd. (West Fraser Cochrane, WFC) within the Highwood River and Loomis Creek watersheds near Highwood Junction, Alberta. The area is part of the multi-use Kananaskis Country, adjacent to Don Getty Wildland Provincial Park. The logging plan, described as the Highwood River Annual Operating Plan (hereafter referred to as 'the AOP'), involves constructing roads over watercourses that are legally designated as critical habitat for bull trout under the federal *Species at Risk Act* (SARA). Riparian areas designated as critical habitat will also be impacted, as well as groundwater recharge and seepage sites and other features, functions, and attributes that bull trout rely on for survival and reproduction.

A desktop-based watershed assessment and partial risk analysis conducted for Alberta Forestry and Parks found considerable change in the flow regime of Loomis Creek is likely, if the planned logging proceeds, resulting in potentially harmful flood events (Chernos et al. 2024). This is due to an increase in Equivalent Clearcut Area (ECA) leading to earlier and higher spring and summer peak flows relative to current conditions. The desktop analysis suggested that future fieldwork could be completed to better inform an understanding of the level of risk that the likely hydrologic changes pose. Gathering a current understanding of channel morphology, riparian conditions and disturbance history, and the vulnerability of the aquatic habitat in the watershed was recommended to assess whether the anticipated degree of hydrologic alteration poses an acceptable level of risk to bull trout critical habitat. A field-based assessment by a hydrologist and a fisheries biologist to evaluate the potential effects of the proposed logging on critical habitat was therefore conducted.

2.1 Terms of reference for Loomis Creek study

In June 2024, CPAWS retained Matthew Coombs, M.Sc., P.Biol., Fintegrate Fisheries & Watershed Consulting Ltd. (Fintegrate), Kim Green, PhD, P.Geo. (Apex Geoscience Consultants Ltd.), and Paul Saso (hydrology technician, Saso Consulting), to conduct an eco-hydrological assessment of the Loomis Creek watershed. This team was tasked with conducting a field-based assessment of bull trout distribution and habitat use as well as stream channel morphology, riparian forest condition, historical disturbance from forest fire and logging, stream discharge, electrical conductivity and water temperature, erosion, turbidity, and total suspended solids. This project is the first phase in providing a comprehensive field-based assessment of forest hydrology, fish distribution and habitat use in the Loomis Creek watershed in the context of an approved logging plan. The study is the first field-based watershed and hydrologic assessment of Loomis Creek and the first time the distribution of bull trout and their spawning activity have been assessed in the watershed. It will provide a pre-disturbance benchmark, which otherwise would not be available, allowing the effects of clearcut logging to be adequately assessed over time. Phase 1 goals were to:

1. Investigate fish distribution and fish habitat values.
2. Identify risks of the logging plan to watershed integrity and fish and fish habitat.

3. Demonstrate the level of detailed assessment required to effectively document pre-disturbance conditions of native trout critical habitat and habitat use and evaluate the risks associated with industrial clearcut logging in watersheds with native trout.

2.2 Values at risk in Loomis Creek

2.2.1 Fish habitat

The Highwood River and Loomis Creek are habitat for bull trout. Within the larger Bow River basin, the Highwood is one of only three population units where bull trout population status is not assessed as "very low" (Government of Alberta 2023). The upper Highwood watershed is the principal spawning area for bull trout in the Highwood River system (Eisler and Popowich 2010) and the Highwood River supports a strong hybrid population of rainbow trout (*Oncorhynchus mykiss*) and westslope cutthroat trout (*O. lewisi*).

Bull trout are considered an indicator of watershed health and integrity (Fraley and Shepard 1989, Isaak et al. 2009, ASRD & ACA 2009, Howell and Sankovich 2012, Government of Alberta 2023, Kaeding and Mogen 2023), although the species can persist in some heavily altered watersheds if basic habitat requirements are met (e.g., Line Creek and the Elk River; see Hagen and Decker 2011, Robinson et al. 2018). Bull trout depend on cold, clean, complex, and connected habitats (D'Angelo and Muhlfeld 2013), as are found in the watersheds of the Eastern Slopes. The health of bull trout and other native trout populations, and the presence of fish habitat in forested watersheds necessary to support these populations, are also linked to resilient and reliable water sources for Albertans.

Bull trout require high water quality throughout most of the year, including low water temperatures, high dissolved oxygen, and low total suspended solids (TSS). Habitat complexity is necessary to support spawning, rearing, feeding, and overwintering and habitat connectivity is necessary to allow for migration to spawning habitats and movement among isolated populations. Bull trout spawn in streams where groundwater upwelling contributes significantly to flows, with redds constructed in localized zones where transitional bedforms result in localized hyporheic downwelling and high intra-gravel flow rates (Baxter and Hauer 2000). These conditions allow eggs to incubate over the winter without freezing and keep alluvial substrate and the incubating eggs clean. Geologic, forest hydrologic, and fluvial geomorphological processes combine to create bull trout spawning habitat, so the presence of spawning populations indicates that these processes have not been altered to the point of becoming disconnected and not being able to sustain bull trout. This makes the species an effective indicator of watershed health.

Declines in abundance and distribution for native trout species have been recognized provincially and federally, leading to Threatened designations for bull trout (*Salvelinus confluentus*) and westslope cutthroat trout, and an *Endangered* designation for Athabasca rainbow trout in Alberta under the *Species at Risk Act* (SARA). Recovery strategies (Fisheries and Oceans Canada 2019, 2020a, 2020b) have since defined critical habitat for these species and legal protection has been enacted through Critical Habitat Orders, making destruction of critical habitat, which includes riparian areas, illegal. However, the definitions of critical habitat have been challenged as ineffective (Fluker and Mayhood 2020) and the legal protections that are in place have suffered from a notable lack of enforcement (CPAWS 2025).

Cumulative effects of industrial and recreational activities on watershed processes as well as historical stocking (leading to hybridization) and replacement with non-native trout species and livestock grazing (leading to erosion and sedimentation), are recognized as the primary causes of native trout decline in Alberta (e.g., Government of Alberta 2023). Logging operations can negatively affect trout populations through changes to the watershed hydrologic processes they rely on, as well as through damage and destruction of habitat, and erosion and sedimentation via access roads and crossings. Access roads are a major source of fine sediment entering streams (Al-Chokhachy et al. 2016), particularly affecting smaller headwaters streams that are considered minor watercourses and receive less protection. These smaller watercourses receive the lowest level of protection in Alberta's Operating Ground Rules (OGRs; Government of Alberta 2024) but make up 70-80% of total channel length of river networks (Wohl 2017) and are especially sensitive to disturbance (Buttle et al. 2012). Provincial regulations (Government of Alberta 2024) also do not align with definitions of critical habitat provided in the federal recovery strategies for seasonal watercourses (Fisheries and Oceans Canada 2019, 2020a, 2020b).

2.2.2 Water supply

The Rocky Mountain headwaters provide the majority of Alberta's water supplies (e.g. >75% of South Saskatchewan water supplies originate in the Rocky Mountain headwaters), as well as supplying water across the prairie provinces (Government of Alberta 2014). The hydrologic and ecological integrity of these headwaters is therefore of vital importance to Albertans. They are also crucial for biodiversity, particularly for Alberta's threatened native trout species.

Hydrological impacts resulting from forestry operations in snow-dominated watersheds in the region pose risks. Recognized impacts include increasing frequency and magnitude of bankfull or greater peak flows, earlier onset peak flows, and earlier onset and longer lasting low flows (Green and Alila 2012, Winkler et al. 2017, Pham and Alila 2024). Access roads and logged areas can also become sources for geohazards such as landslides and debris flows as well as increase erosion and sedimentation (Hancock and Wlodarczyk 2025).

The Highwood River poses significant flood risks to downstream communities such as High River, as evidenced by the impact of the 2013 floods (Pomeroy et al. 2016). Regional land-use planning led by the provincial government has identified watershed management and headwaters protection as the "*highest priority*" for forests in the region (Government of Alberta 2014). A desktop watershed assessment for the Loomis Creek and upper Highwood River watersheds, commissioned by Alberta Forestry and Parks, found that there is a "*high likelihood of hydrologic alteration in Loomis Creek, particularly for peak flows*" associated with the planned logging, with potential for climate change to compound hydrologic effects of forest removal (Chernos et al. 2024).

Another desktop risk assessment of the planned logging in the Loomis Creek watershed and adjacent areas along the Highwood River applied BC Forest Service's Interior Level 1 Watershed Assessment Procedure (Mayhood and Killeen 2024). It found 75% of subwatersheds in the area were at high risk of alteration. While current forest hydrology modelling methods were not used and it was assumed historical logging roads were eroding at the same rate as new roads, which turned out to be inaccurate based on current field observations, it still highlighted the increased risk of erosion resulting from the interaction of increased peak flows with increased road and stream crossing density. The assessment predicts an increase in stream temperature and identifies many of the same issues with the logging plan that are highlighted by the current field observations.

3 Study Area

3.1 Physiography

The study area is the Loomis Creek watershed in the Upper Highwood region of Kananaskis Country, Alberta, part of the Bow River drainage. Kananaskis Country is a multi-use area composed of a mosaic of protected areas and areas available for resource development. The upper Highwood River watershed drains an area east of the Continental Divide, with the Elk River immediately to the West of the divide in British Columbia (BC), which is part of the Columbia River watershed and drains to the Pacific Ocean.

The Loomis Creek watershed is characterized by high relief, extending from 1679 m at the mouth near the Highwood River to 2850 m on the summit of Bishop Peak. The upper portion of the watershed is within the Don Getty Wildland Provincial Park, with the remainder within the B12 Forest Management Unit, which is part of WFC's Forest Management Agreement and managed under their 2021 Forest Management Plan (Spray Lake Sawmills 2021). The focus of Phase 1 of the Project was the Loomis Creek subwatershed above the confluence with Highwood River, which drains a 31.3 km^2 area bordering the Continental Divide.

The upper Highwood River and Loomis Creek watersheds lie within the Rocky Mountain Natural Region of Alberta and include alpine and subalpine ecological natural subregions. The Rocky Mountain Natural Region is known for cool summers and high annual precipitation, particularly in the winter, and highly variable climates that characterize each subregion (Downing and Pettapiece 2006). The Alpine Natural Subregion includes all areas above tree line and is characterized by extreme slopes and sudden aspect changes, cold summers, short growing seasons, and high snowfall.

The upper Highwood River watershed experiences a substantial east-west precipitation gradient with higher precipitation along the Continental Divide on the western margin of the study area. Considerably drier conditions exist further east that receive approximately half as much precipitation and contribute little to overall runoff.

The combined effects of the elevation and precipitation gradients in the upper Highwood River and Loomis Creek watershed determine the hydrological behavior in terms of the timing and volume of runoff and frequency and magnitude of peak flows. Differences in hydrological behavior of subwatersheds within the Loomis Creek subwatershed can be observed as differences in channel morphology which records the history of disturbance events in these channels.

Local physiography, climate, and geology of the Loomis Creek and upper Highwood River watersheds are further described in Chernos et al. 2024 and Mayhood and Killeen 2024.

3.2 Vegetative cover

The Loomis Creek watershed is primarily forested except for those areas above tree line (~2300 m) and limited open areas at lower elevations (**Figure 1**).

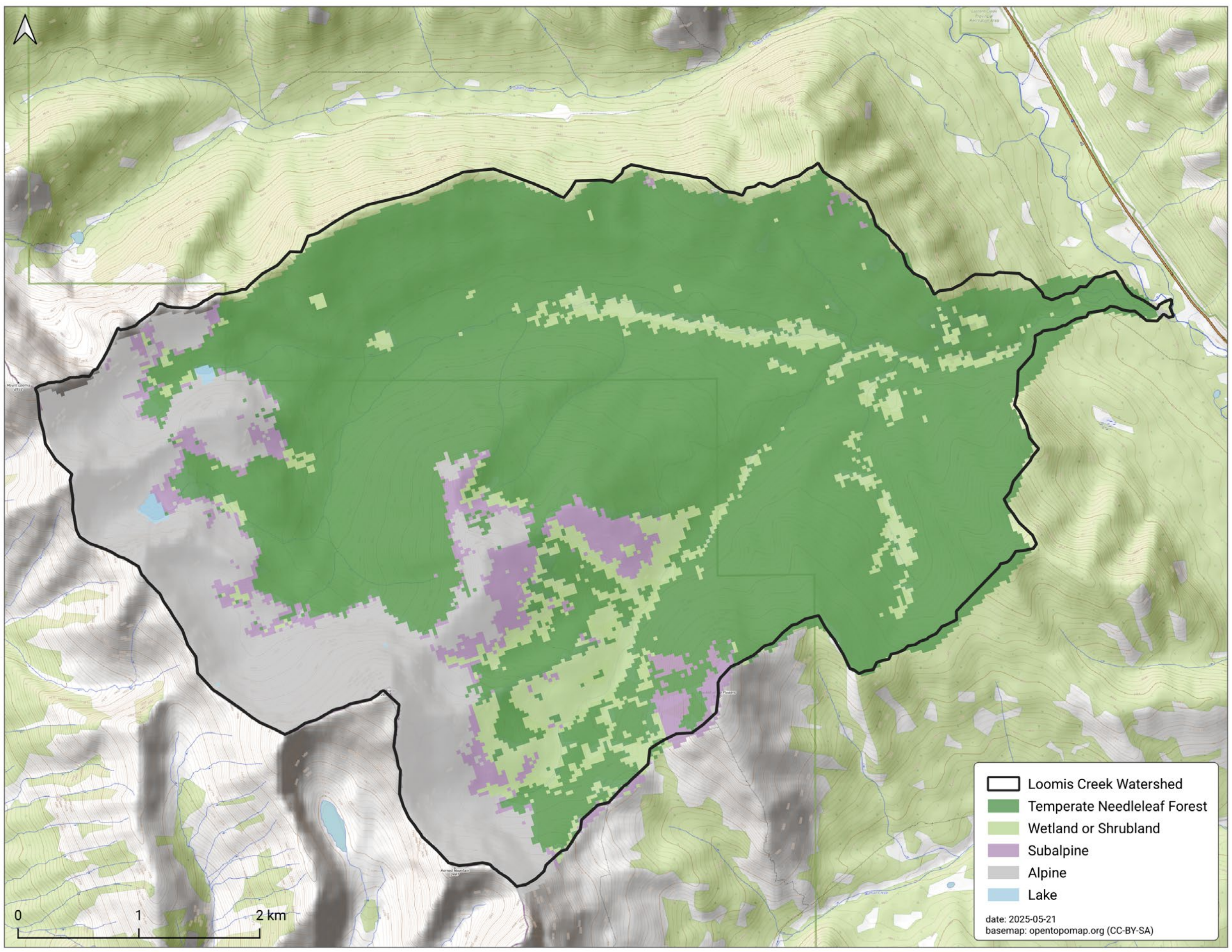


Figure 1. Land cover in the Loomis Creek watershed.

Vegetation varies with elevation, with most of the watershed dominated by coniferous forests, while open lower elevation areas are covered with willow and bog birch plant communities. Trembling aspen (*Populus tremuloides*) and individual balsam poplar (*P. balsamifera*) trees are notably absent from much of the Loomis Creek watershed, having been replaced by encroaching coniferous forest following decades of forest regeneration since the last wildfire in 1936. Lodgepole pine (*Pinus contorta*) and white spruce (*Picea glauca*) dominate the subalpine with Engelmann-white spruce hybrid complex (*Picea* *engelmannii X P. glauca*) and Engelmann spruce occurring alone at higher elevations, as well as subalpine fir (*Abies lascarpa*) and subalpine larch (*Larix lyallii*). Endangered whitebark pine (*Pinus albicaulis*), listed under SARA, has been reported from the area (Smith et al. 2008: Figure 1). Above tree line at higher elevations, vegetation is sparce and exposed rock dominates.

3.2.1 Beaver meadows and riparian vegetation

Most of the wetlands in the Loomis Creek watershed have been created by beavers, particularly at lower elevations along the floodplains of stream channels. These areas are referred to in this report as “beaver meadows”, although they also contain stream habitat and beaver ponds and dams in various stages of construction and decline. The beaver meadows have formed over centuries from prolonged flooding and retention of sediment and organic matter in beaver ponds that have been successively built, washed out, and rebuilt across the entire broad floodplain. The areas are flat, treeless, and characterized by rich, moist soil with dense woody shrubs and obligate herbaceous riparian vegetation. The largest beaver meadow in the watershed exists along the mainstem of Loomis Creek upstream of Bishop Creek (2.6 km in length, average width approximately 100 m). This area overlaps the shallowest gradient reach of Loomis Creek and supports the only area where bull trout were observed spawning in the watershed. All other beaver meadows are much smaller (200 m in length or less).

3.3 Historical forest disturbance

In 1936 a large portion of the upper Highwood River watershed upstream of Cataract Creek burned, including parts of the Loomis Creek watershed, but the headwaters of the Loomis Creek watershed did not burn. Aerial imagery shows that most of the forested areas in the Bishop Creek watershed burned, as well as areas in the lower portion of the Loomis Creek watershed along the Highwood River and areas north of Bishop Ridge (**Figure 2**).

Aerial imagery and field observations show that large spruce in the headwaters of the Loomis Creek watershed were logged sometime after 1949 but before 1969 and that the currently existing logging road was already built to a point just beyond the western limit of the beaver meadows on Loomis Creek by 1949. The road was extended into the headwaters by 1969 and is still used now as a recreational trail for hiking and equestrian users (non-motorized use only) as well as by ranchers that graze cattle in the watershed. All other spur roads in the watershed, including the road paralleling Bishop Creek, have become overgrown with alders and young trees, and while they are not yet mature forest, they are not eroding. All watercourse crossing structures (bridges and culverts) associated with these roads no longer exist and all these crossings are now fords.

Hydrologic recovery after logging depends on juvenile and mature forest stand height, canopy cover regeneration, and snow accumulation and ablation rates in clearcuts (Winkler et al. 2017). Chernos et al. (2024) estimated that the historically logged areas in the Loomis Creek watershed have a current estimated hydrologic recovery of 70-80%, and

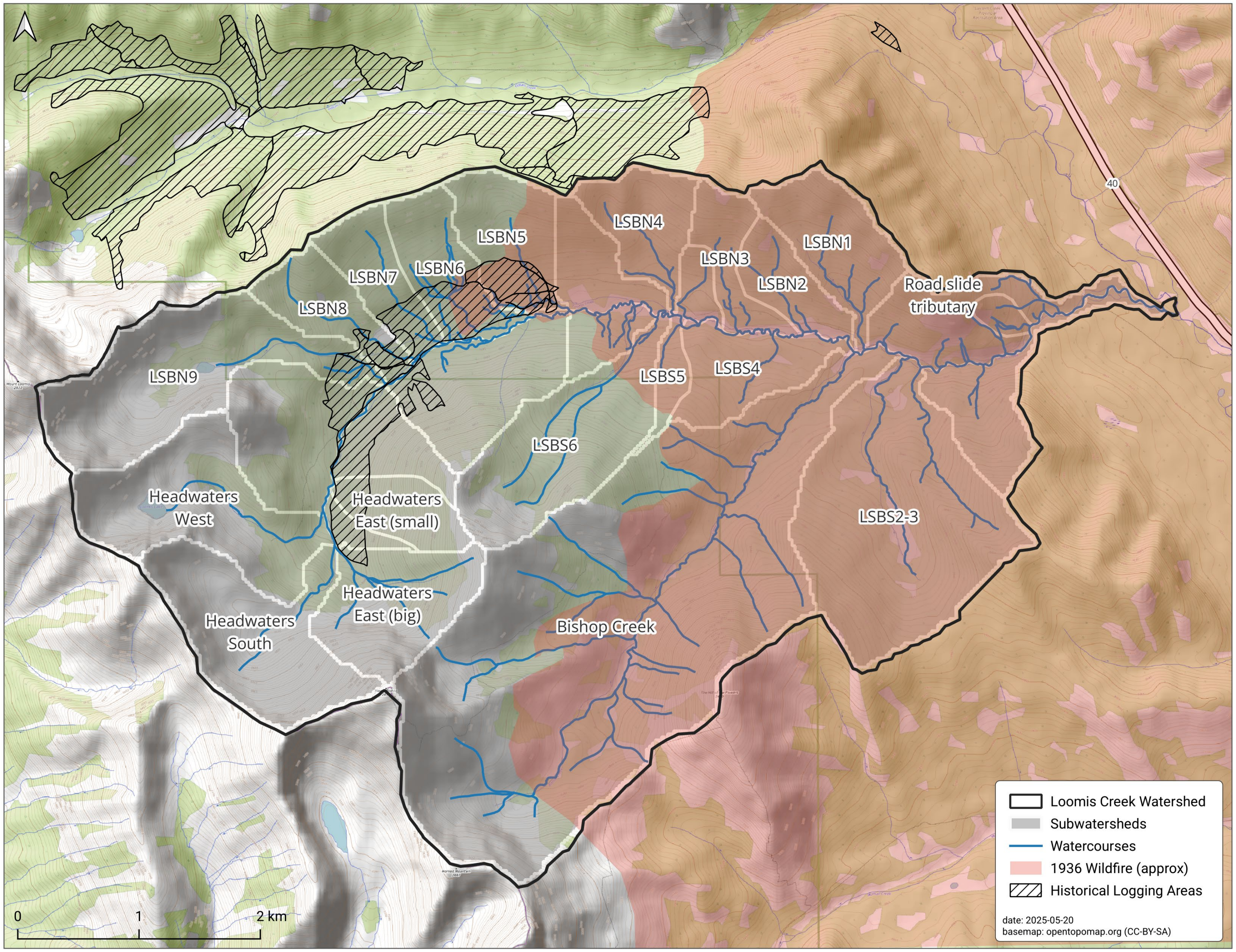


Figure 2. Historical logging and wildfire extent within the Loomis Creek watershed.

therefore there are still some lingering effects of logging on the hydrologic regime. This was based on years since harvest and a relationship developed for interior-BC forests (Winkler et al. 2017). Adjustments were made to make the relationship applicable to the Oldman River watershed using field and LiDAR-based analysis of forest height and canopy cover regeneration so that smaller mature stand heights and delayed hydrologic recovery in the Oldman River watershed were accounted for (Green et al. 2021). The adjusted relationship was deemed applicable to the Highwood River watershed as well, since it is also east of the Continental Divide and immediately north of the Oldman (Chernos et al. 2024).

3.4 Named Loomis Creek crossings

Locations where the historical logging road crosses Loomis Creek were named to be used as reference points. The first crossing closest to the Highwood River is referred to as "Blowout Crossing" (**Figure 3**). The Project refers to four other crossings as "Short Crossing", "Boulder Crossing", "Low Gradient Crossing", and "Cattle Crossing" (**Figure 3**).

3.5 Planned Logging

12.5 km^2 of forest removal is planned through clearcut logging by WFC, with 5.5 km^2 within the Loomis Creek watershed and the remainder along the Highwood River. Planned logging areas, water crossing locations, crossing structure types, and the location of streams were identified by WFC on an AOP map and are presented below (**Figure 4**).

4 Methods

4.1 Geospatial analysis

Geospatial analysis was conducted using QGIS (v3.40.1-Bratislava) and non-spatial analysis was conducted using R (v4.4.2) and Microsoft Excel. The WFC-produced stream layer used for AOP development was the stream network GIS layer used for the Project. This layer provides more accuracy than the provincial base map hydro layer, which DFO used to map the currently designated bull trout critical habitat in Alberta. It was also generally more accurate than the Alberta Wet Area Mapping (WAM) Predicted Stream Layers, which is a LiDAR-based product produced by the Government of Alberta. However, none of the three layers match the actual drainage network on the ground in all locations, so ground truthing is still necessary to ensure all water features are appropriately buffered. The Loomis Creek watershed boundary was provided by Alberta Forestry and Parks under the Open Government License.

4.1.1 Subwatershed Delineation

Subwatersheds throughout the Loomis Creek watershed and the elevation profile of the mainstem of Loomis Creek were delineated using the freely available 25m Alberta Provincial Digital Elevation Model (DEM), 10 m and Soil and Water Assessment Tool (SWAT) plugin, and WFC's stream layer.

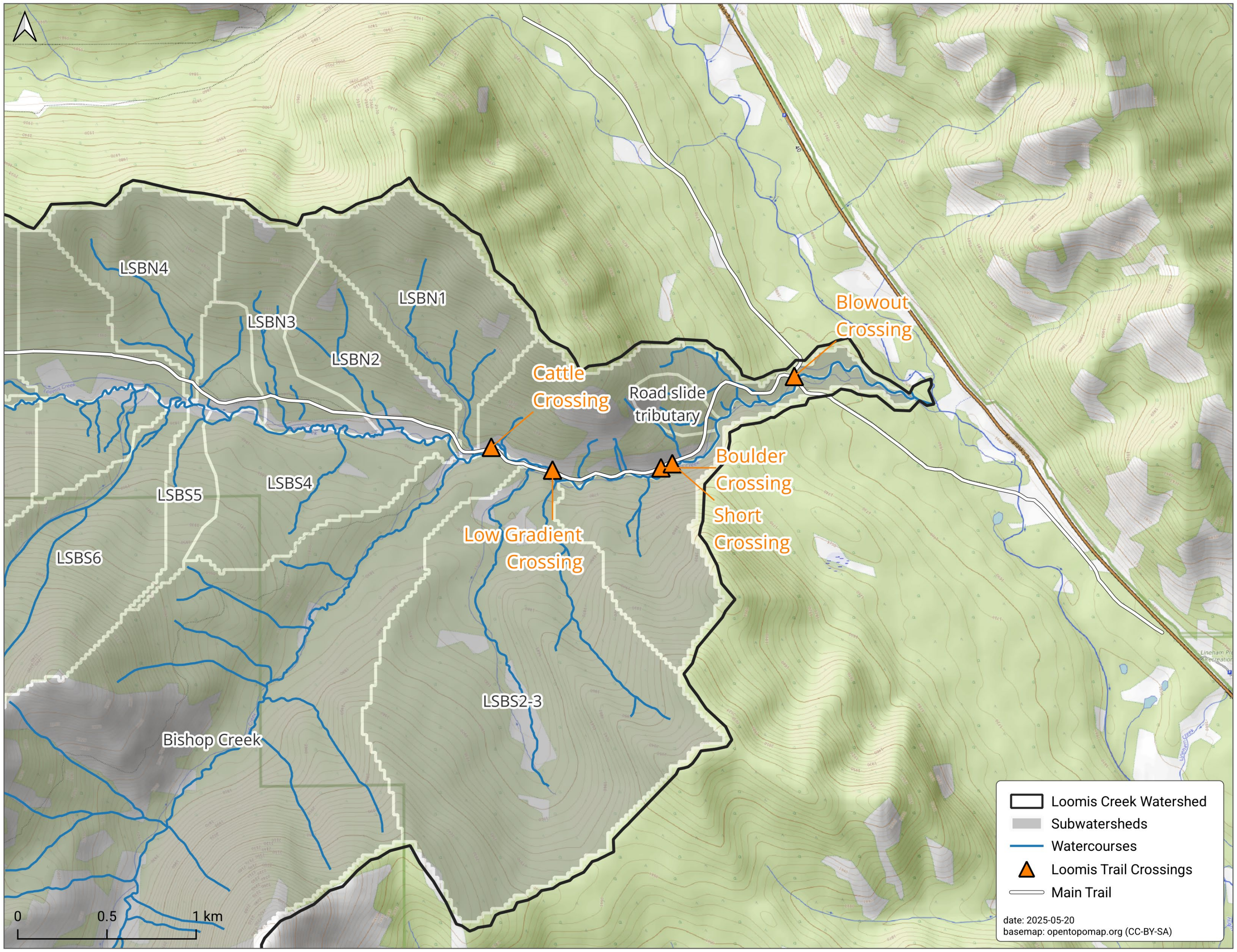


Figure 3. Where historical logging road (now a trail) crosses Loomis Creek.

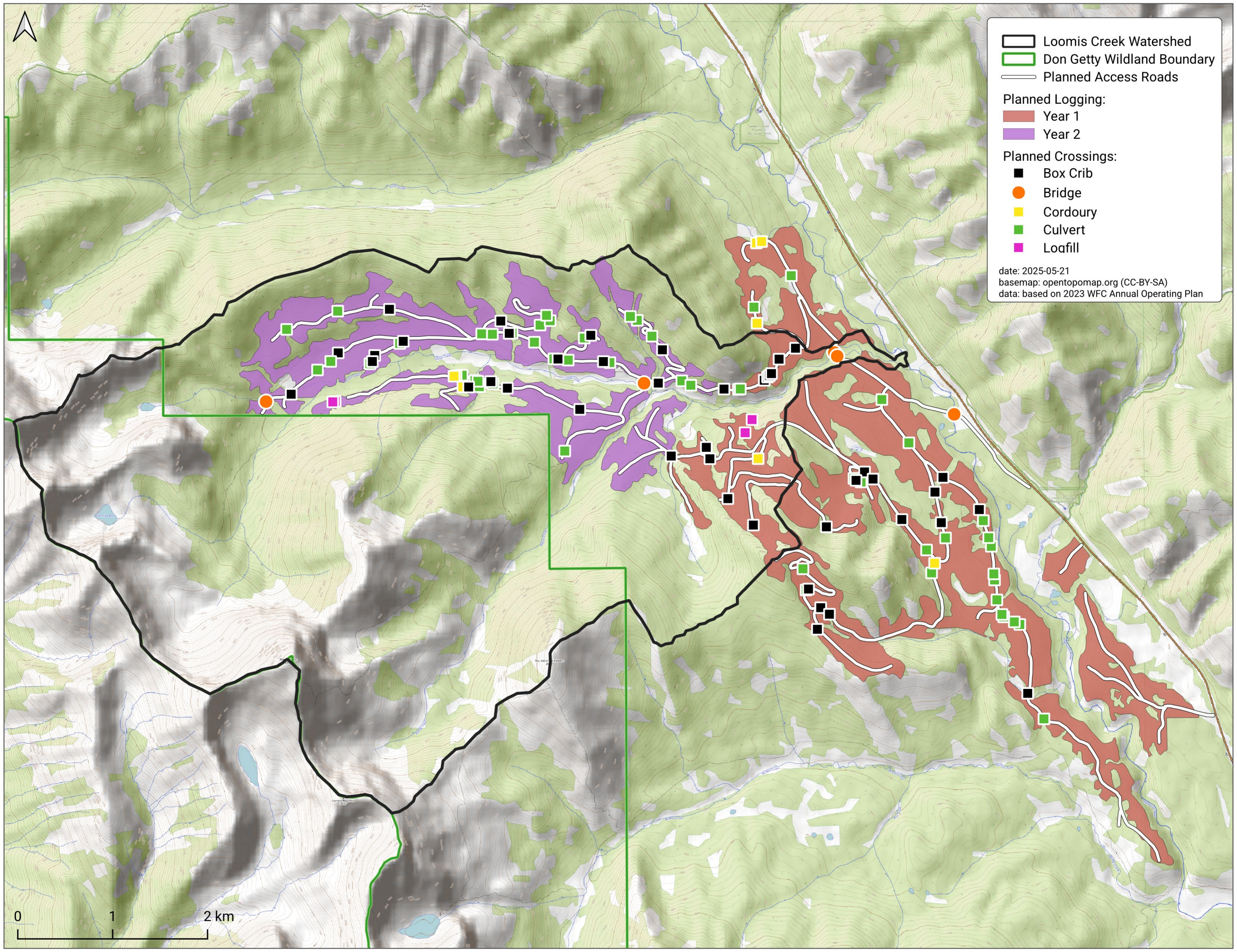


Figure 4. Logging plan in the Loomis Creek and upper Highwood River watersheds.

- Subwatershed areas were delineated upstream of 36 sites where channel morphology measurements were taken to assess how channel cross-sectional area and largest mobile substrate (D90, cm) increases with increasing upstream area.
- Subwatersheds were also delineated at the mainstem confluences to determine the total subwatershed area for each sub-basin, allowing the areal coverage of different slopes and slope aspects for the entire sub-basin and for planned clearcut areas to be mapped and quantified.
- The elevation of Loomis Creek was plotted relative to the distance from the Highwood River to document steeper channel gradients in the headwaters and in the canyon section downstream of Bishop Creek and shallower channel gradient in the mid reach of Loomis Creek.

4.2 Channel morphology investigation

In 2024 the Loomis Creek watershed was investigated in the field at 36 channel morphology sites during the low flow period between September 9-19. These channel morphological assessments were conducted starting in the headwaters of Loomis Creek, moving downstream throughout the watershed, and surveying the lower mainstem channel last. The cumulative effects of historical wildfire, logging, and flooding can be more easily discerned by taking this upstream to downstream approach.

Channel morphology sites were placed on each of the four headwater tributaries as well as throughout the watershed. Eleven sites were on the mainstem of Loomis Creek, two were on Bishop Creek upstream and downstream of the planned logging, and 23 sites were on tributaries to Loomis Creek. Each of the four headwater tributaries that form Loomis Creek had one channel morphology site surveyed. Of the 17 tributaries surveyed for channel morphology, 10 had just one site surveyed and seven had two sites surveyed.

Field assessment of channel morphology was conducted by Matt Coombs with assistance from volunteers, with site selection and assessment methods provided by Kim Green, PhD., P.Geo. Field data and photographs were recorded for each site using Avenza™. Data collected in the field included taking measurements of:

- bankfull channel width and average depth to estimate channel cross-sectional area
- channel gradient
- channel entrenchment
- approximate floodplain width
- average size of the largest mobile bedload (D90, cm)
- size distribution of all bedload (Wolman pebble counts, mm)

Data also included classifying channel type and recording written observations of:

- flow permanency and connectivity to Loomis Creek
- riparian vegetation and riparian–channel dynamics
- riparian forest stand characteristics
- bank condition

- beaver activity
- large woody debris (LWD) function and abundance
- past disturbance events (e.g., flood, wildfire, logging history, and avalanches)
- signs of an ongoing upstream sediment supply
- sediment deposits
- bedload movement

Where specific methods were used for taking some of the measurements and observations listed above, these are included below (**Appendix III**).

4.3 Hydrometric investigation

A stream flow staff gauge was established on Loomis Creek on July 24, 2024, by Paul Saso (Saso Consulting) together with Matt Coombs (Fintegrate). The gauge is located midway between the first road crossing of Loomis Creek and the Highwood River (**Figure 5**). Details describing how the gauging site was located are included below (**Appendix III**). Stream flow is being monitored at the site using a Solinst Levellogger5 installed on the staff gauge, calibrated with a Solinst barometric pressure logger on the adjacent streambank. These loggers are recording pressure and temperature continuously at 5-minute intervals and the data are then analysed using Solinst Levelogger 4.6.3 software.

Instantaneous flow measurements at the gauge site were taken concurrent with staff gauge readings to develop a stage-discharge curve using a Quick Instream Q(flow) & Uncertainty Analysis Calculator (QiQuac™), which is a serial datalogger designed for salt dilution flow measurements from Fathom Scientific. The QiQuac™ functions by first measuring background electrical conductivity and then monitoring changes in electrical conductivity after a known mass of salt (NaCl) is injected to the stream upstream of the monitoring point. This slug injection method works well in relatively steep mountain streams where using a conventional current metering device to measure velocity at precise cross-sectional measurements of the channel is difficult due to turbulence in the water surface and an uneven streambed consisting of cobbles and boulders of variable size (Sappa et al. 2015, Moore 2005). Measuring the rise and fall in stream electrical conductivity as a function of time at a point downstream from the injection point where complete mixing across the width of the channel has occurred is used to calculate flows.

Staff gauge readings were taken using a cell phone to record a video of the fluctuating surface of the water as it moved up and down on the staff gauge. Over a 30 second period the maximum and minimum water levels observed on the gauge were recorded and the reading was recorded as the midpoint between these levels.

Three instantaneous flow measurements at the staff gauge were taken with the QiQuac™ together with concurrent staff gauge readings on July 24, September 25, and October 26, 2024. These measurements were taken as stream discharge declined over the summer and fall. Additional measurements are advised throughout the spring, summer, and fall of 2025 to further develop and refine a stage-discharge relationship.

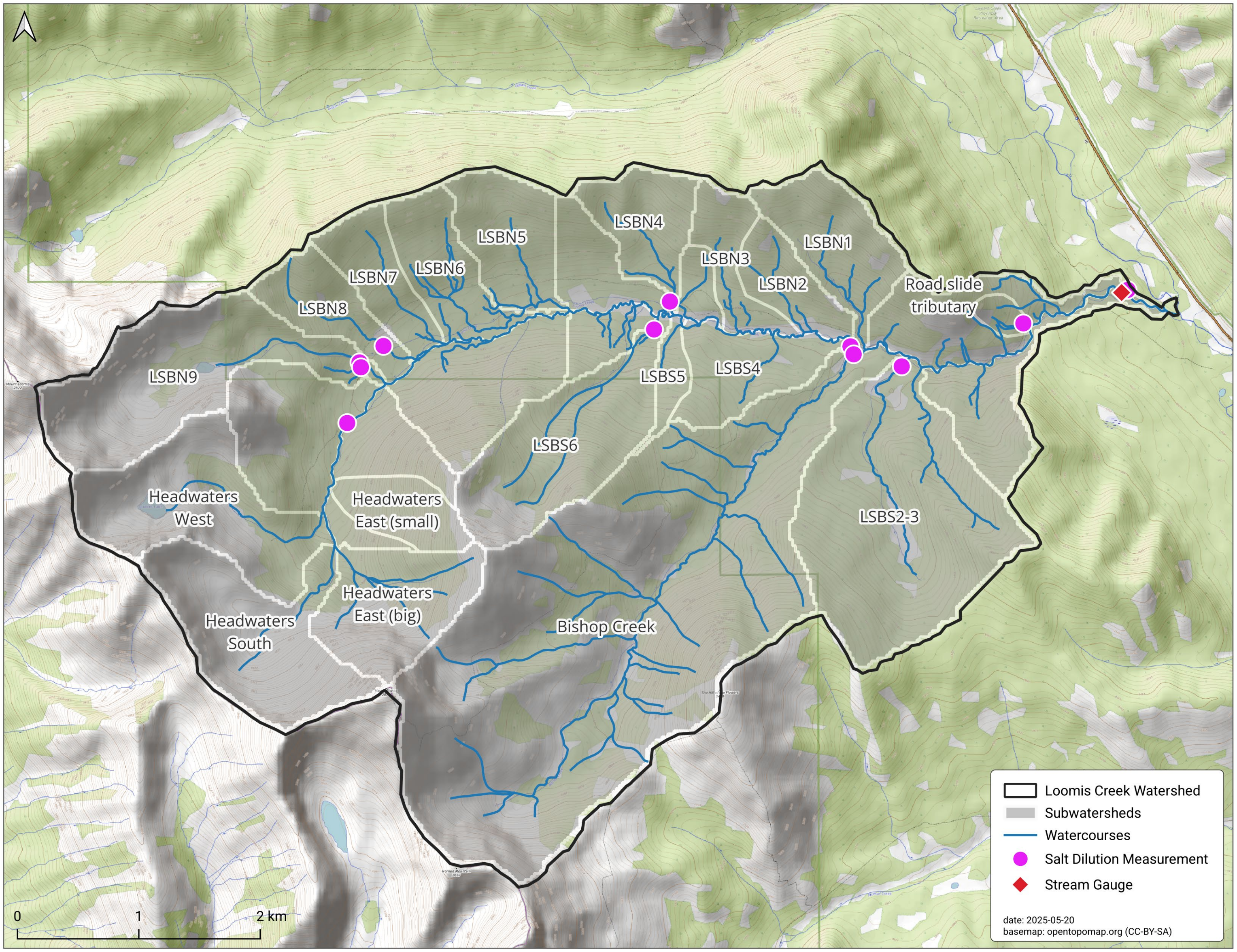


Figure 5. Loomis Creek staff gauge and locations of salt dilution flow measurements.

Synoptic instantaneous flow measurements were also performed throughout the Loomis Creek watershed to assess relative discharge from the different subwatersheds (**Figure 5**). These measurements were taken by performing instantaneous salt dilution measurements using the QiQuac™ on July 24-25, September 26, and October 26-27, 2024. On the mainstem of Loomis Creek these measurements were taken near the headwaters upstream of the planned logging as well as at a point immediately upstream of Bishop Creek (**Figure 5**). They were also taken near the mouths of eight tributaries to Loomis Creek, including Bishop Creek, five tributaries on the north side of Loomis Creek (Unnamed to LSBN9, LSBN9, LSBN8, LSBN4, Road Slide Tributary), and two other tributaries on the south side of Loomis Creek (LSBS2-3 and LSBS6; **Figure 5**). While measurements at all 11 sites were taken in July and September, 2024, in October, 2024, due to inclement weather, measurements were not taken at LSBN9, LSBN8, LSBN4, LSBS2-3, or LSBS6.

4.4 Stream electrical conductivity investigation

Background stream electrical conductivity on tributaries with flows that were large enough to monitor with the QiQuac™ was recorded during synoptic instantaneous flow measurements in July, September, and October 2024. The QiQuac™ was calibrated daily, and measurements were compensated to 25°C.

These measurements were taken at the same locations (**Figure 5**) and times described above in **Section 4.3**.

Stream electrical conductivity readings at each field survey site followed the methods used with the QiQuac™ instantaneous salt dilution flow measurements. The two probes were placed in the stream flow for a period of time until the conductivity and temperature values stabilized. The QiQuac™ data logger records the conductivity data automatically, including background values before salt is added. Two electrical conductivity probes were used, placed on the opposite banks of the stream, and providing two measurements at each site.

4.5 Stream temperature investigation

To assess how watershed processes are currently affecting temperature throughout the Loomis Creek watershed and start monitoring before any changes occur, if the planned logging proceeds, stream temperature is being monitored at 17 sites and air temperature is being monitored at two sites (**Figure 6, Appendix III**). Onset HOBO TidbiT MX2203 or MX2201 wireless temperature data loggers are being used to monitor temperature. All loggers are in the Loomis Creek watershed, except two in the Highwood River; one immediately upstream from Loomis Creek and at the downstream limit of the planned logging near the McPhail Creek confluence. Temperature loggers are installed in white PVC cases cabled to trees or staked with rebar into the stream substrate. Eight loggers were deployed on July 1, five were deployed on July 14, and six were deployed on July 16, 2024. The site IDs corresponding to the Online Map and installation and data download dates are included in **Appendix III Table III- 2**.

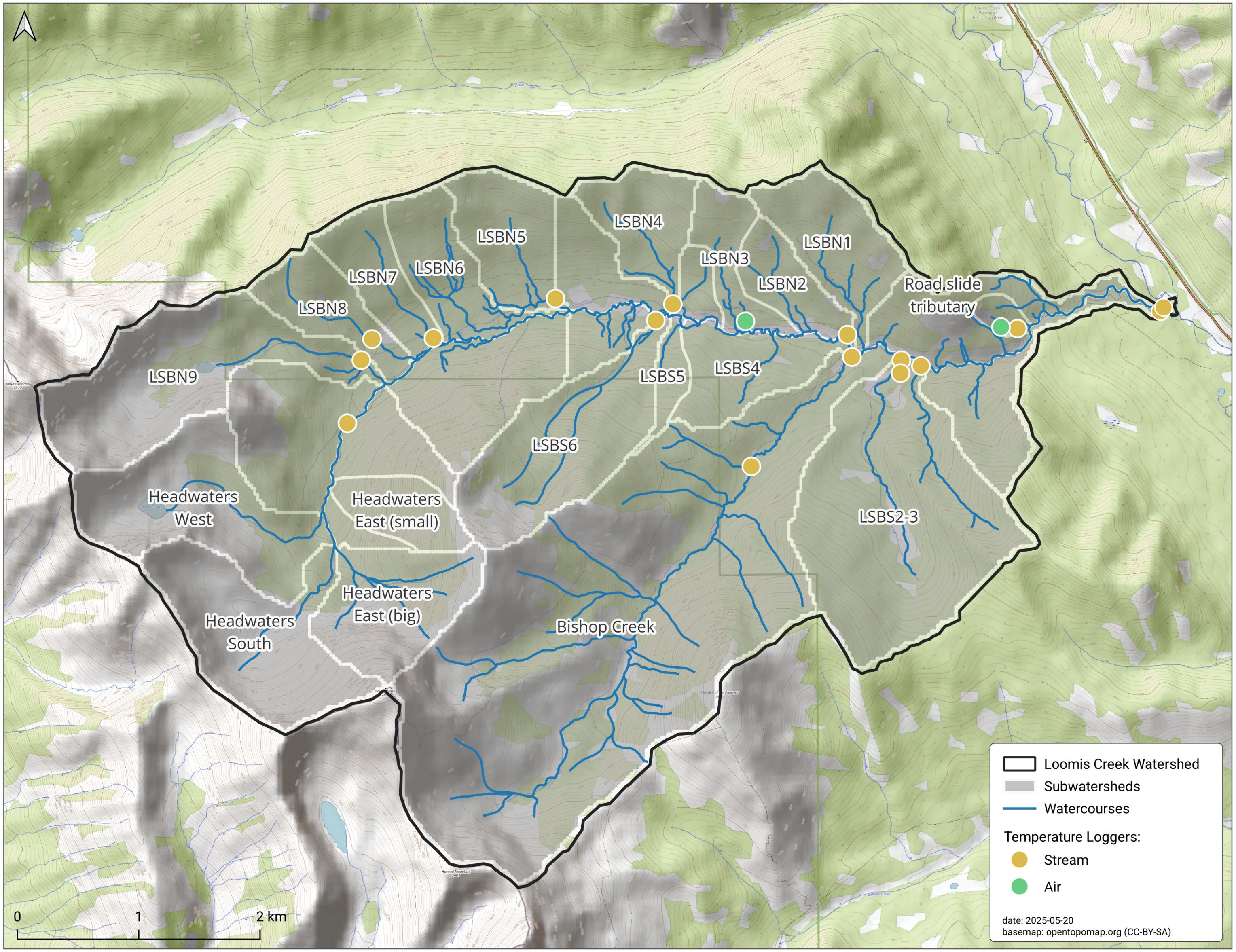


Figure 6. Stream and air temperature logger locations in the Loomis Creek watershed.

4.6 Total Suspended Sediment (TSS) sampling

On June 29, 2024, total suspended solids (TSS) samples (1 L samples per site) were collected from five sites at the confluences of select streams in the watershed. Samples were taken from the mouth of Loomis Creek and from the Highwood River immediately upstream from Loomis Creek. They were also taken from Loomis Creek immediately upstream from Bishop Creek and the mouth of Bishop Creek. A fifth sample was collected from the mouth of the LSBS2-3 tributary. On July 17, 2024, TSS samples were again collected (this time three 1 L samples per site) from only the mouth of Loomis Creek and the Highwood River immediately upstream. TSS samples were refrigerated and submitted to Bureau Veritas (ISO/IEC 17025 accredited) within 24 hours of collection for analysis following approved methods (See **Appendix III**, ***Section vii TSS analysis*** for details).

4.7 Fish habitat occupancy and use investigation

4.7.1 Assessment of bull trout distribution, spawning, and rearing

Habitat occupancy is a means to demonstrate importance of SARA critical habitat, so the Project assessed the bull trout distribution in the Loomis Creek watershed.

1. Fintegrate conducted an initial bull trout redd survey on the lower reach of Loomis Creek from the Blowout Crossing upstream to near Bishop Creek on September 13, 2023. On the same day, a bull trout redd survey was conducted by Fintegrate on the Highwood River between the confluences of Lineham and Loomis creek. Additional redd surveys in the area on the Highwood River were conducted by Dave Mayhood on September 22 and October 9, 2023.
2. On November 21, 2023, the environmental DNA (eDNA) method was used to assess the bull trout distribution on Loomis Creek at four sites along the reach where the 2023 bull trout redd survey was conducted.
3. In 2024, the eDNA method, redd surveys, and direct observations were used to assess the bull trout distribution further upstream on Loomis Creek. The eDNA samples were collected from the LSBS2-3 tributary near the mouth of Loomis Creek upstream from a section of steep gradient as well as from the mainstem of Loomis Creek halfway between Bishop Creek and the headwaters. Methods to collect and analyse the eDNA were reported previously (Coombs 2023). Locations where bull trout were observed on Loomis and Bishop creeks were also recorded and mapped. Bull trout redd surveys were also conducted in 2024 starting where the 2023 redd survey ended and continuing upstream. Bishop Creek was also surveyed for bull trout redds in 2024 from the confluence with Loomis Creek to a point adjacent to the upstream limit of the planned logging.

4.7.2 Assessment of evidence of brook trout

The 2024 eDNA sample from the mainstem of Loomis Creek was also tested for brook trout eDNA. Brook trout are a non-native species from eastern North America that have spread throughout all major watersheds in Alberta where bull trout occur. Brook trout can hybridize with bull trout, occupy the same habitat, and use the same resources (Warnock and

Rasmussen 2013). In some streams, brook trout have completely replaced bull trout, so the presence of this species is considered a potential threat to bull trout populations.

4.8 Logging plan investigation

During fieldwork for other aspects of the Project, logging plan layout issues relative to water features and bull trout critical habitat were identified. Only a small portion of the Loomis Creek watershed was visited, generally by a single observer. The presence of water features, mapped or unmapped, including perennial and intermittent stream channels, groundwater recharge and discharge points, wetlands, and beaver ponds and meadows, was recorded with photographs and GPS coordinates. Layout issues were identified based on the buffers prescribed in Section 2.17 (Aquatic and Riparian Area Protection) of the OGRs (Government of Alberta 2024) as well as the assumption that all mapped and unmapped water features are bull trout critical habitat and the SARA-required minimum 30 m riparian buffer applies.

A summary of the layout issues that were identified is presented below (see **Section 7**, **Appendix II**, and the Online Map).

4.9 General observations

Concurrent with the other field activities described above, the location and description of observations relevant to the eco-hydrological assessment were also recorded as part of general surveys in the Loomis Creek watershed using photos, GPS coordinates, and field notes. This was to document current conditions prior to disturbance if the planned clearcut logging happens. The following categories of observations were recorded and results are presented in the Online Map:

- historical fire, logging, and flood
- LWD
- erosion (human and natural causes), sedimentation, turbidity
- existing stream crossings
- planned logging stream crossings
- observations of stream channels and other water features
- cattle impacts
- fish barriers
- fish observations
- beaver sign
- beaver dams

5 Geospatial Analysis

5.1 Subwatershed delineation

Nineteen subwatersheds in the Loomis Creek watershed were delineated and labelled (**Figure 7**). An additional nine subwatershed areas were delineated but not labelled and considered “undefined” areas for which geospatial analysis was not conducted.

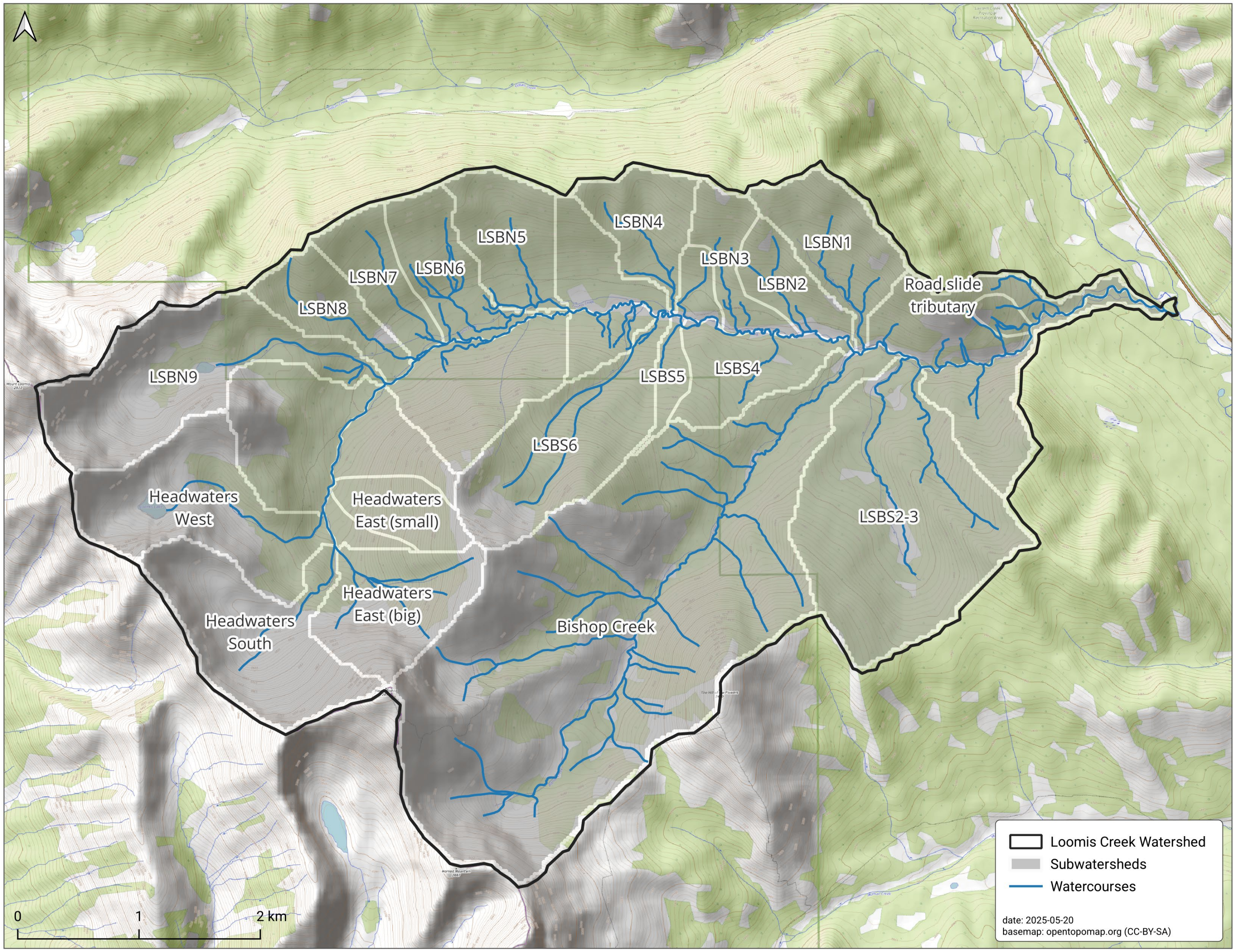


Figure 7. Labeled subwatersheds and tributaries in the Loomis Creek watershed.

Nine sub-basins on the North side of Loomis Creek were numbered LSBN1-9 (**Figure 7**). A tenth sub-basin and tributary were labelled “Road Slide Tributary” because it flows near a section of the historical logging road that slumped into Loomis Creek (**Figure 7**). Another tributary that flows into LSBN9 was labelled “LSBN9-unnamed” but was not associated with a separate sub-basin. Besides Bishop Creek, five sub-basins on the South side of Loomis Creek were numbered LSBS2-3, LSBS4, LSBS5, and LSBS6 (**Figure 7**). Despite stream channel mapping showing LSBS2 and LSBS3 flowing along separate channels into Loomis Creek, field verification showed that the channels converge before reaching Loomis Creek, so the combined drainage area was considered one sub-basin (LSBS2-3).

5.2 Subwatershed size

The sizes of the 19 named Loomis Creek subwatersheds and percent area of the entire watershed each covers is summarized below (**Table 1**). Of the 19 named subwatersheds in the larger Loomis Creek watershed, Bishop Creek is the largest, accounting for 25% of the entire area of the Loomis Creek watershed. The second and third largest subwatersheds drain the LSBS2-3 and LSBN9 tributaries and account for 9% and 6% of the entire area of the Loomis Creek watersheds, respectively. Three of the four headwater subwatersheds each account for approximately 5% of the entire area of the Loomis Creek watershed. The fourth headwater subwatershed is much smaller (**Table 1**). The area of the remaining subwatersheds is smaller and varies.

Table 1. Subwatershed size (km^2) and percent (%) of the area of Loomis Creek watershed.

Subwatershed	Area (km^2)	% of Loomis Creek watershed area
Bishop Creek	7.94	25.36
LSBS2-3	2.95	9.41
LSBN9	1.85	5.90
Headwaters West	1.61	5.16
Headwaters South	1.53	4.88
LSBS6	1.54	4.92
Headwaters East (big)	1.09	3.47
LSBN1	0.85	2.72
LSBN5	0.79	2.53
LSBN6	0.74	2.36
LSBS4	0.73	2.35
LSBN4	0.66	2.11
LSBN8	0.60	1.92
LSBN7	0.57	1.81
Headwaters East (small)	0.48	1.55
LSBN2	0.48	1.54
LSBN3	0.47	1.49
LSBS5	0.20	0.63
Road slide tributary	0.11	0.36

5.3 Predominant subwatershed slope

A map of the distribution of slopes in the Loomis Creek watershed is presented below (**Figure 8**). Steep slopes occur in alpine areas along the Continental Divide, while the valley bottom and some subwatersheds contain considerable low-gradient areas. Slopes remain less than 40% over 93% of the Loomis Creek watershed but exceed this along the continental divide (Elk Range) and along the outlying ridges east of the divide (Loomis and Bishop ridges) where slopes reach 80%. Only Bishop Creek, LSBN9, the three larger headwater basins, and LSBS6 subwatershed contain areas where slopes exceed 40%.

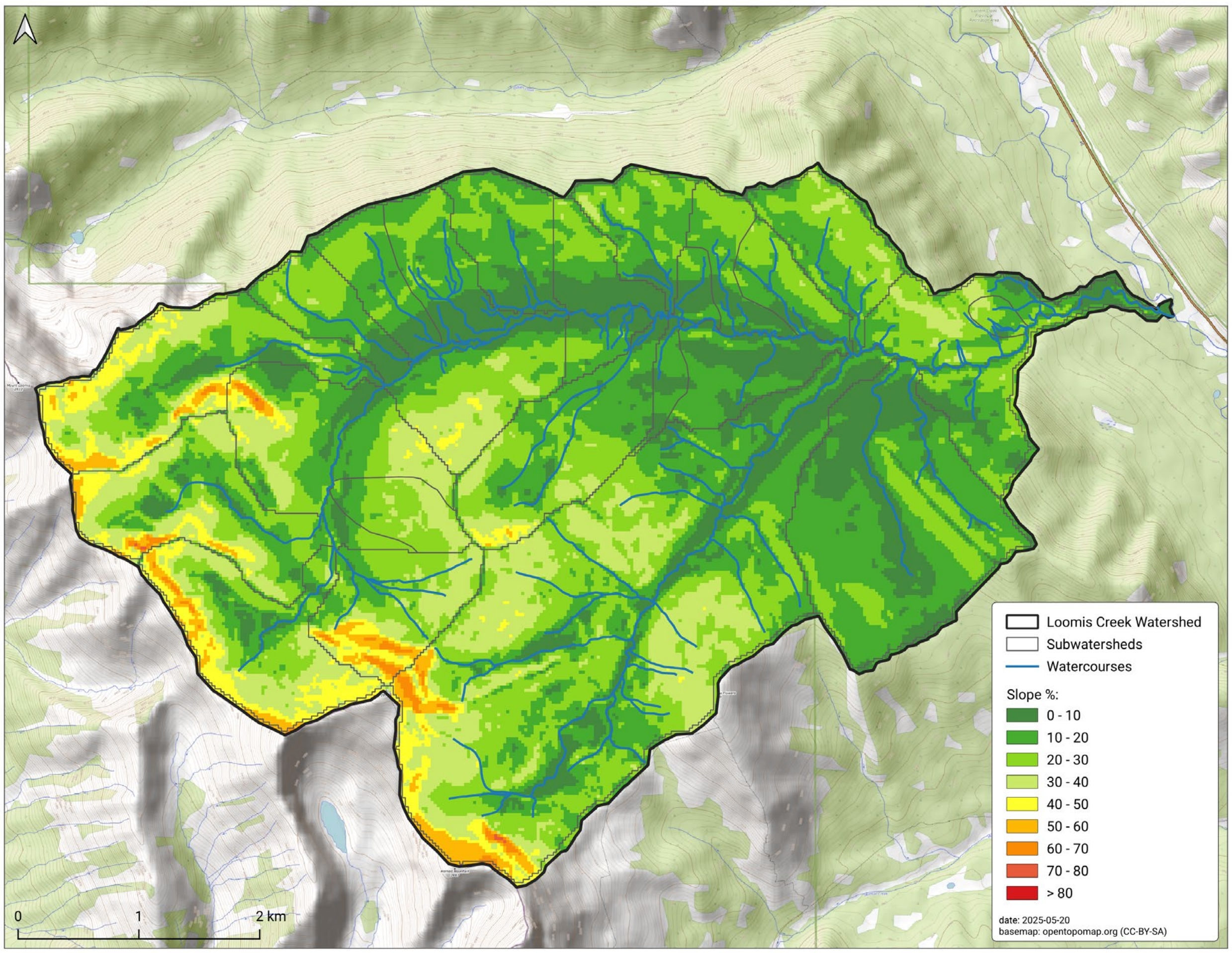


Figure 8. Slopes (%) throughout the Loomis Creek watershed.

5.4 Predominant subwatershed aspect

The Loomis Creek watershed has an east-west orientation, while tributaries generally include predominantly north and south aspects. Aspect (direction slopes face) is generally relatively well distributed in the Loomis Creek watershed (**Figure 9**, **Figure 10**).

Of the 19 named subwatersheds in the watershed, nine had predominantly south facing slope aspect and seven had predominantly north facing slope aspect (**Figure 11**).

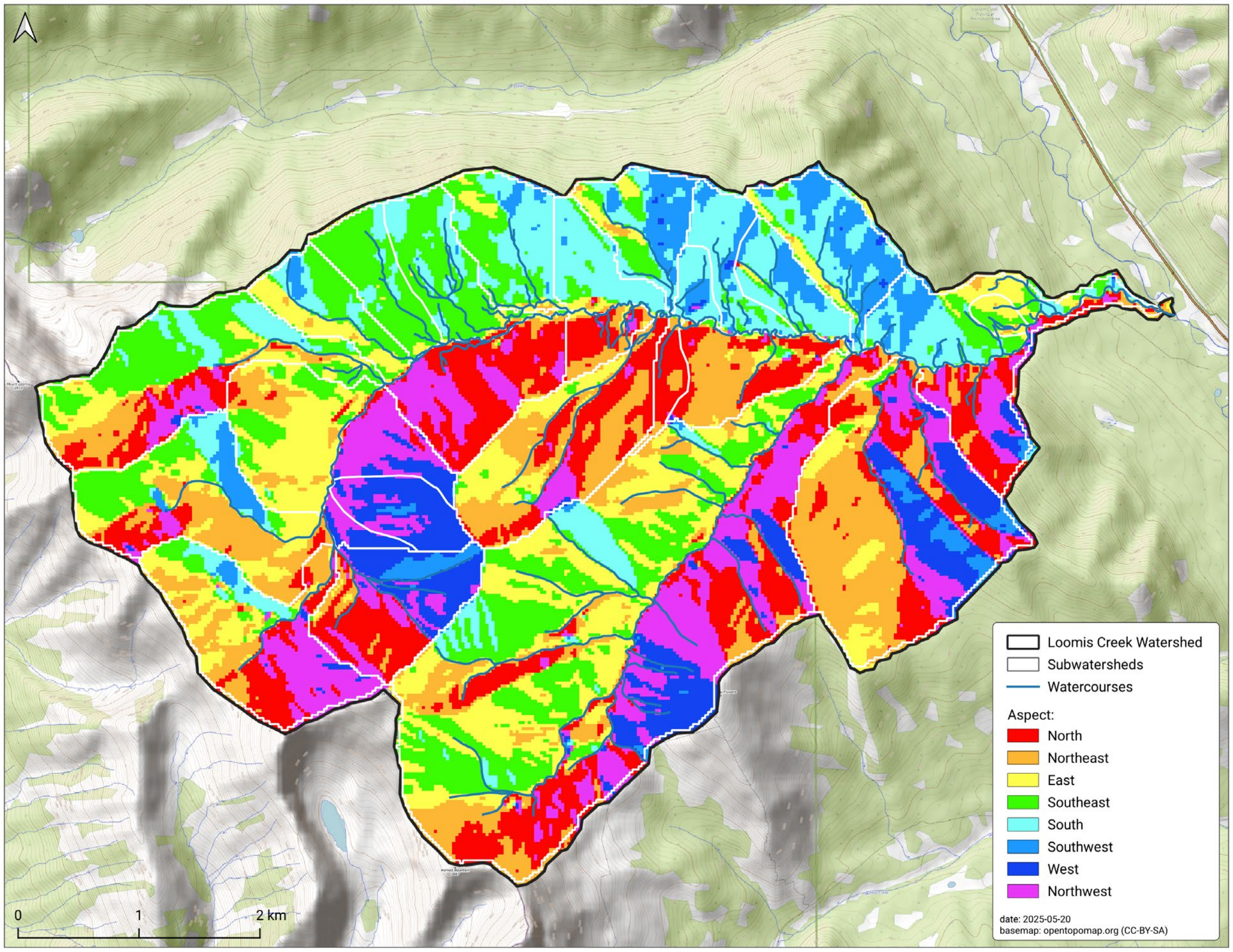


Figure 9. Slope aspect (direction slope facing) throughout the Loomis Creek watershed.

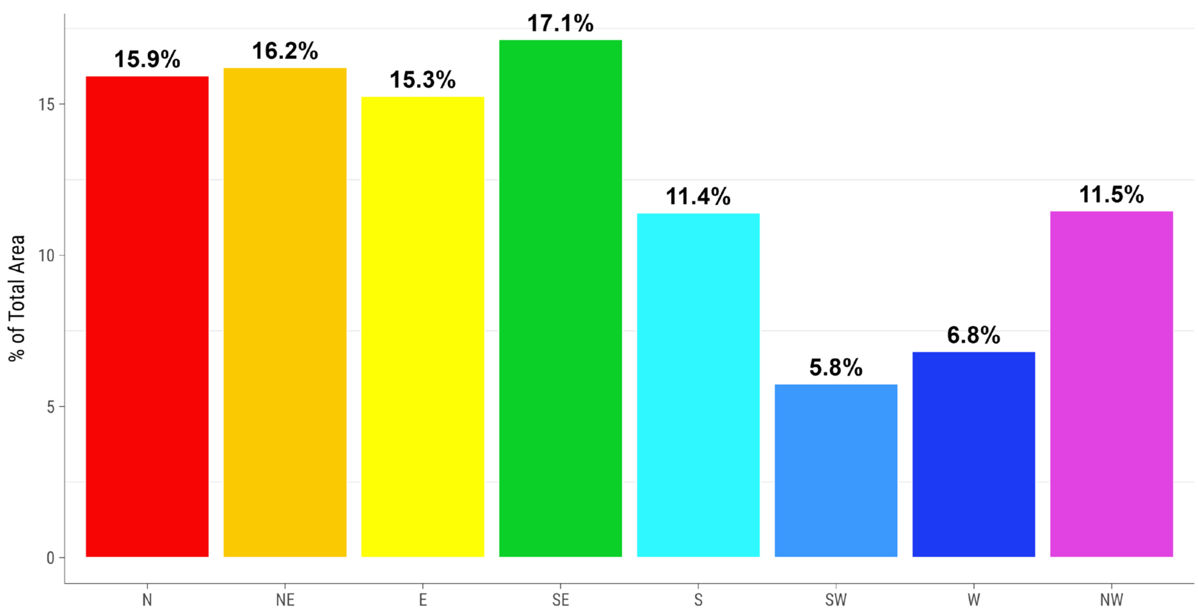


Figure 10. Slope aspect (direction slope facing) for the entire Loomis Creek watershed.

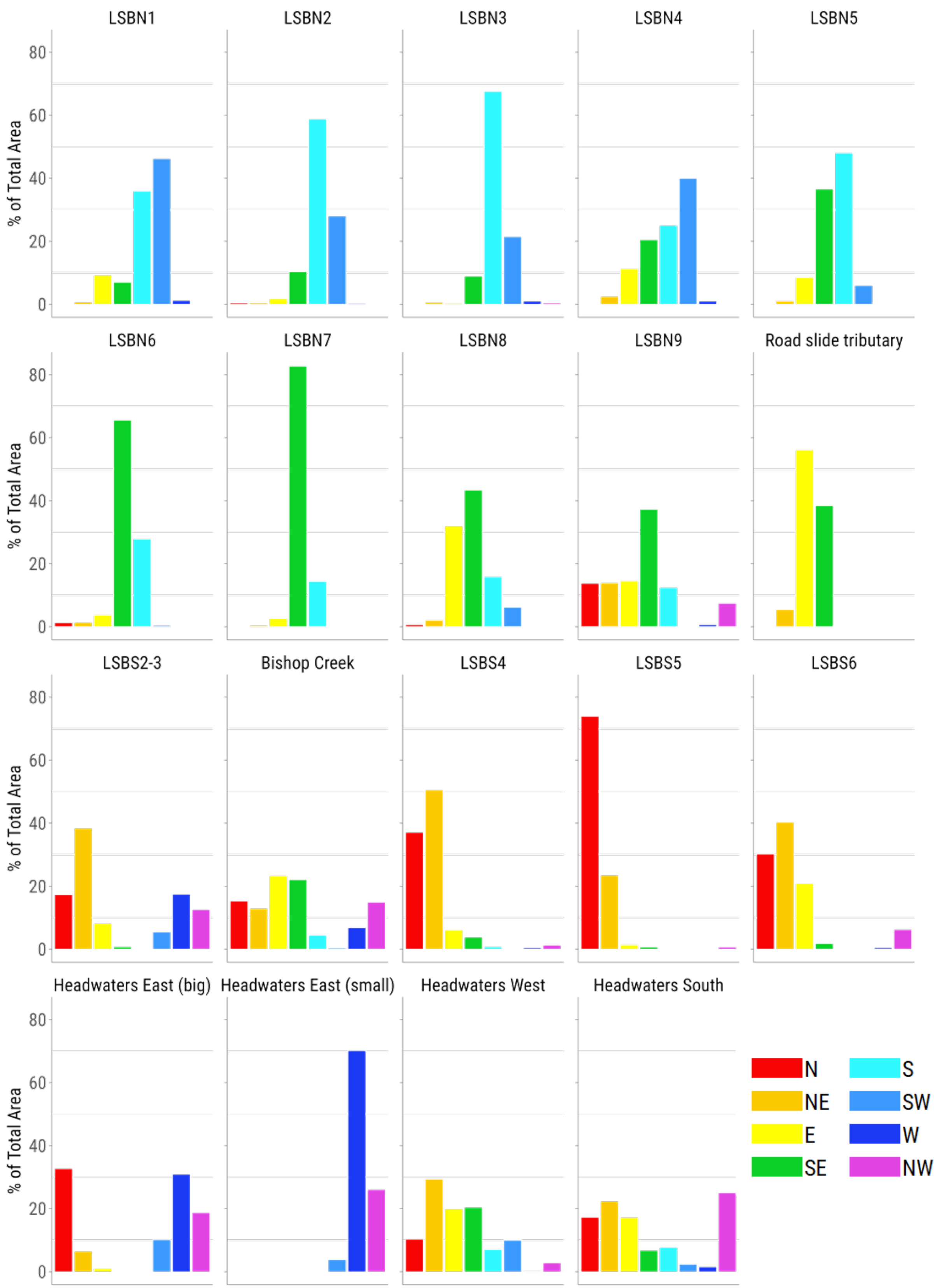


Figure 11. Cardinal directions slopes are facing in 19 Loomis Creek subwatersheds.

5.5 Loomis Creek channel gradient

Plotting the channel gradient of Loomis Creek from the Highwood River to the headwaters shows that it is just as steep at the mouth as it is upstream of the planned logging in the Don Getty Wildland Provincial Park (**Figure 12**). The first 3 km of the creek upstream from the Highwood River maintains a consistent steep gradient until the Low Gradient Crossing is reached. Channel gradient then gradually decreases from this point to a point roughly midway through the beaver meadows, before gradually increasing again and reaches the same gradient as the first 3 km of the creek. This point is near the confluence of LSBN8 & LSBN9 tributaries with Loomis Creek. Beyond this point the gradient of Loomis Creek increases steadily toward the Continental Divide. This lowest gradient reach of Loomis Creek is approximately 6 km long and encompasses the beaver meadow wetland habitat described above (**Section 3.2.1**).

6 Results

6.1 Existing and planned stream crossings

The historical logging road that parallels Loomis Creek is visible on the earliest available aerial imagery from 1949 and crosses the Highwood River at the same location where WFC built a bridge for the current logging plan in 2023. The route of the new planned road heads west, following the same route as the historical road, and crosses Loomis Creek at the Blowout Crossing approximately 1 km upstream from the Highwood River.

Significant channel avulsion has occurred at this first Loomis Creek crossing, washing out and embedding a concrete culvert, pieces of which are still visible embedded in the stream bed and on the stream bank (**Photo 1**). From this first crossing, the original logging road parallels Loomis Creek all the way to the headwaters, mostly staying on the North side of the creek. The historical logging road crosses Loomis Creek four more times upstream of the first crossing. All these crossings are downstream of the Bishop Creek confluence.

The logging plan includes new stream crossings over both Loomis and Bishop creeks near the confluence of these two streams.

The route for the new road is higher up on the North side of the valley. It crosses Loomis Creek only once with a bridge 250 m upstream of the Bishop Creek confluence (**Photo 2**). Although not shown on the AOP map, a stream crossing over Bishop Creek is also laid out approximately 450 m upstream from Loomis Creek.

A network of new roads is planned on the south side of Loomis Creek. These are connected to the Bishop Creek crossing and are accessed without crossing Loomis Creek from where the new and existing roads overlap just west of the bridge over the Highwood River.

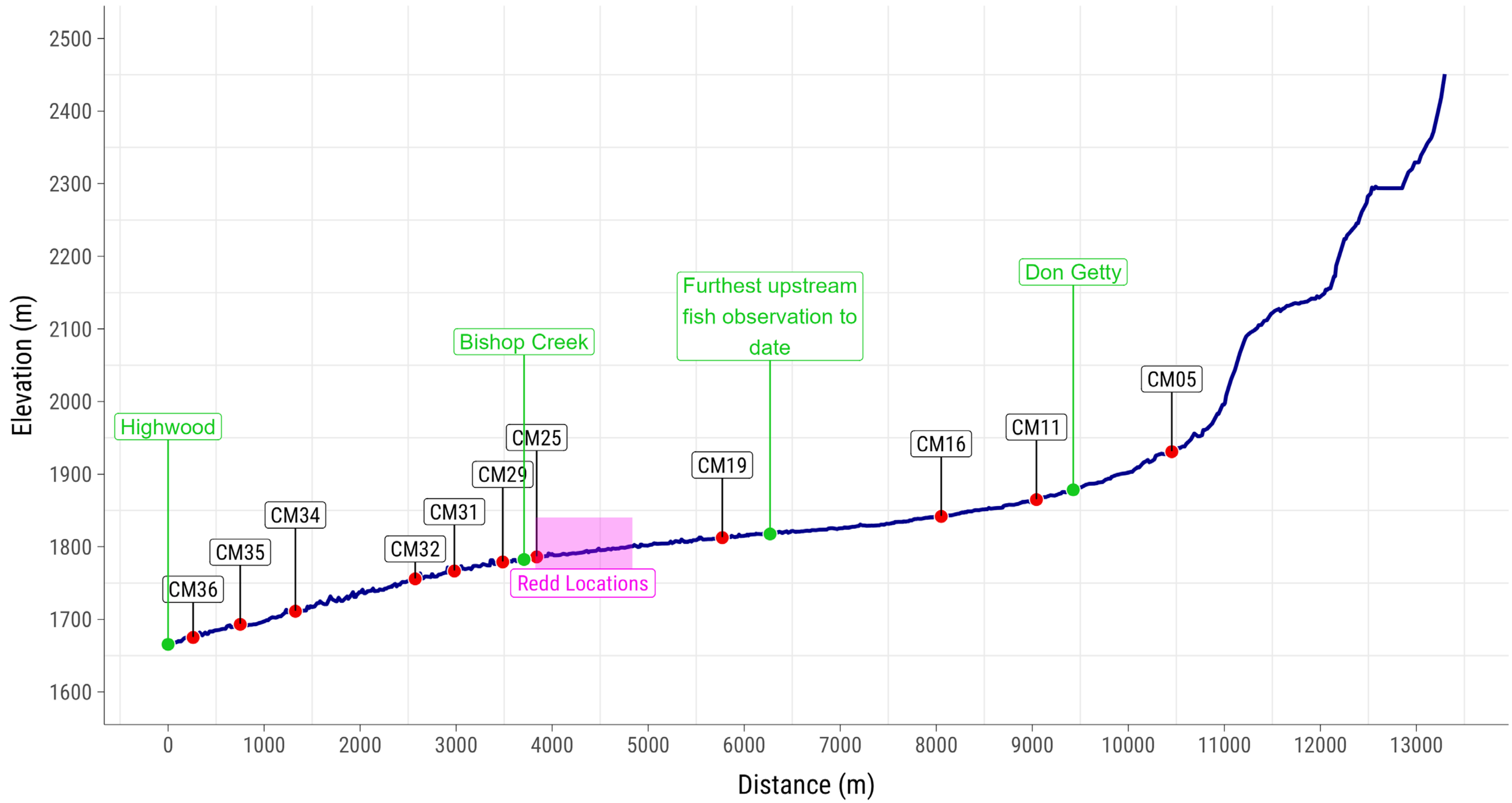


Figure 12. Loomis Creek channel gradient (mouth to headwaters) with channel morphology sites, landmarks, and bull trout redds.

Photo 1. Loomis Creek Blowout Crossing showing channel avulsion and pieces of a concrete culvert (*).

Photo 2. Planned Loomis Creek crossing site near the downstream limit of the beaver meadows and immediately upstream of where bull trout spawn.

6.2 Channel morphology

Channel morphology was investigated at 36 sites throughout the Loomis Creek watershed from September 9 - 19, 2024. Channel morphology summary descriptions for different parts of the watershed and related sub-basin characteristics are included here with more detailed reviews of the data collected included in **Appendix IV**.

Channel morphology is variable along stream channels and classification types assigned to sites were not always the same from one site to the next (**Figure 13**). The predominant channel morphology varies with stream gradient, channel confinement, sediment sources, and bedload material and general patterns observed are discussed below.

Channel morphology site IDs can be searched to see the location, photos of each site, and summaries of the data collected at each site using the Online Map for the Project. Photo examples of the eight channel morphology types are included below (**Photo 3**, **Photo 4**).

Summary tables of the following channel morphology data collected at each of the 36 channel morphology sites are included in **Appendix IV**:

1. site IDs, descriptions, channel morphology classifications (**Appendix IV, Table IV- 1**)
2. channel geometry, gradient, incisement, floodplain width, flood disturbance history (**Appendix IV, Table IV- 2**)
3. bedload movement and size, sediment supply, fine sediment deposits (**Appendix IV, Table IV- 3**)
4. bank condition, riparian disturbance, riparian stand characteristics, LWD abundance and function (**Appendix IV, Table IV- 4**)

6.2.1 Mainstem of Loomis Creek

The highest stream gradient on Loomis Creek is in the headwaters, where cascade boulder and step pool channel morphologies predominate (**Figure 12**, **Figure 13**). In a mid reach of the stream a riffle pool channel morphology predominates as the stream gradient drops to the lowest level anywhere on the mainstem (**Figure 12**, **Figure 13**). On the lowest portion of Loomis Creek channel gradient steepens again and cascade boulder and step pool channel morphologies again predominate (**Figure 12**, **Figure 13**).

Both the headwaters and lower reaches of Loomis Creek are confined by bedrock walls and steep valley escarpments with no floodplain in some sections or a narrow floodplain in others (**Photo 5**). Where a floodplain is present, the channel is incised from the 2013 event and Loomis Creek does not overtop the floodplain in typical 1-2 year highwater events.

In contrast, the mid reach of Loomis Creek flows through a broad floodplain that is forested upstream of the beaver meadows and unforested within the beaver meadows (**Photo 6**). The floodplain is also not overtopped in typical 1-2 year highwater events and was formed during the last glacial retreat. The beaver meadows have formed over centuries of beaver activity.

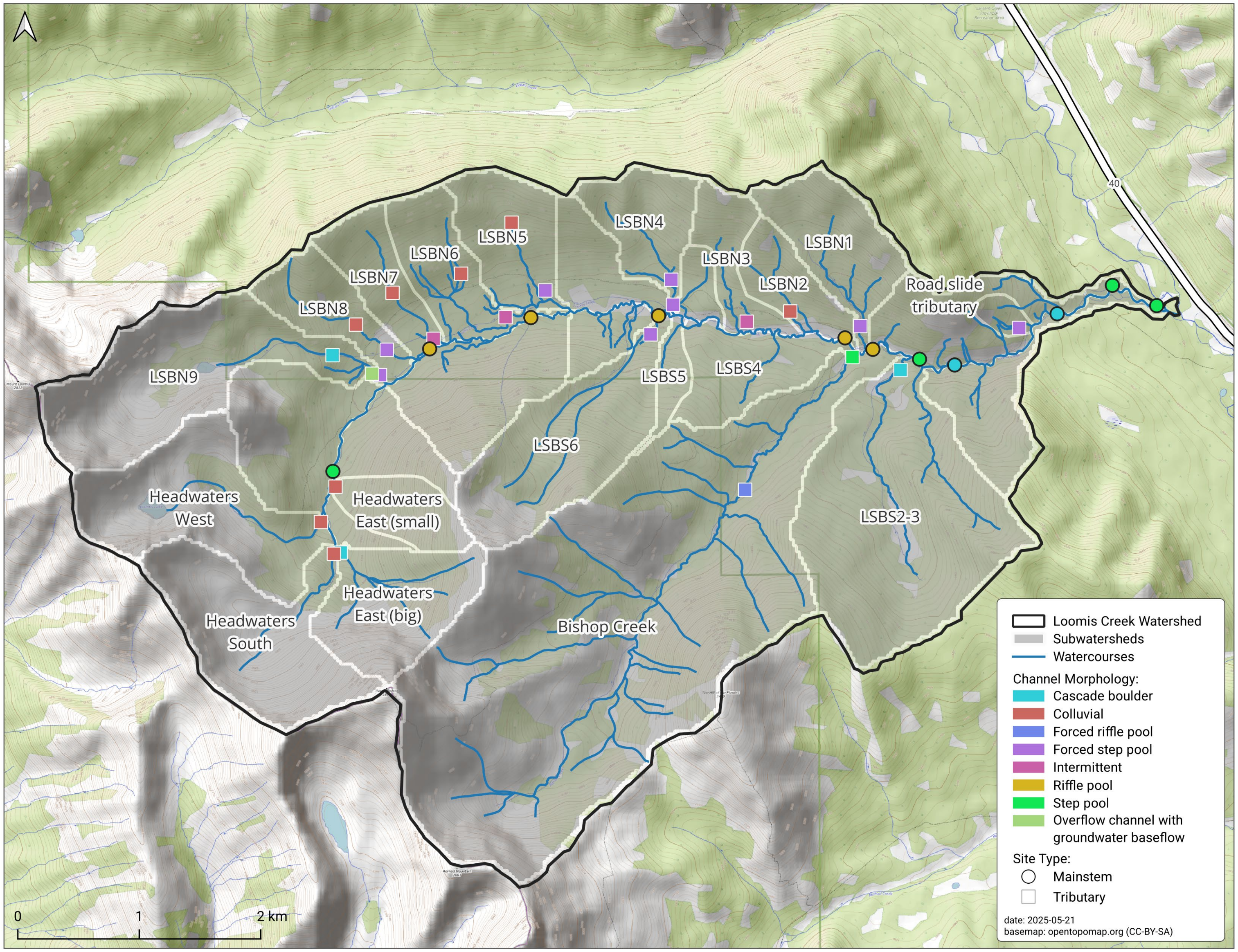


Figure 13. Channel morphology classifications of 36 sites assessed in the Loomis Creek watershed.

Photo 3. Morphology examples: colluvial (A: headwaters south), cascade boulder (B: LSBN9), forced riffle pool (C: Loomis mainstem), forced step pool (D: LSBN8).

Photo 4. Morphology examples: riffle pool (A: Loomis mainstem), step pool (B: Bishop at mouth), overflow channel (C: old LSBN9 channel), and intermittent (D: LSBN3).

Photo 5. Loomis Creek in headwaters (left) and lower reaches at Boulder Crossing (right), both showing high gradient, steep valley, lack of an active floodplain.

Photo 6. Low gradient, mid reach of Loomis Creek above (left) and within (right) the beaver meadows.

One large point source of ongoing sediment inputs to Loomis Creek was observed approximately 350 m downstream of Bishop Creek where a steep valley escarpment on the North bank is actively eroding and releasing substantial amounts of fine gravel, sand, and silt during rainfall events (**Photo 7**). It is not known whether the bank escarpment was destabilized by flooding triggered by hydrologic changes following historical fire or logging, but it is evident on 1949 areal imagery and is not associated with historical logging road construction. Fine sediment from the site resulted in a pulse of TSS that reached the Highwood River on July 17, 2024, while fine gravel from the eroding escarpment is building up in Loomis Creek immediately downstream of the site (**Photo 8**).

No other large point sources of sediment to Loomis Creek were observed by the Project. The largest cumulative source of sediment in the watershed is local bank erosion along the tributary and mainstem channels. There were no avalanche gullies in the headwaters resulting in sediment inputs, and while the historical logging road has washed out and slumped into Loomis Creek at a few locations, these sites are not significant ongoing sources of sediment. Descriptions of these sites are included in **Appendix IV**.

Historical logging of the riparian forest occurred in the headwaters of Loomis Creek but involved selective removal of large spruce. This may not have resulted in enough area of forest to be cleared to result in changes to snow accumulation, runoff, and discharge, because no effects on the mainstem channel of Loomis Creek are evident (e.g., incisement). LWD is abundant and being recruited into the channel in the headwaters.

The 2013 flood disturbance event is evident along the entire mainstem channel of Loomis Creek, while the 1995 event is less evident. Both flood events mobilized alluvium on the active floodplain, resulted in deposition of lateral bars, caused bank erosion, and mobilized LWD. Lateral bars from the 2013 event are still unvegetated in some areas.

In both the headwaters and lower reaches of Loomis Creek, LWD was mobilized by the 2013 flood event and swept downstream. Log jams are present in the headwaters (**Photo 9**), with some functioning to holdback water and sediment more than others. There are fewer log jams on the lower reaches of Loomis Creek, where the 2013 flood event pushed LWD onto the banks out of the active channel or swept it parallel to the channel (**Photo 9**). LWD is abundant upstream of the beaver meadows in the mid reach of Loomis Creek but absent within the beaver meadows due to the lack of riparian forest. Above the beaver meadows LWD remains suspended above the channel before rotting and collapsing into the channel. Stream gradient is too low throughout the mid reach to move LWD downstream.

6.2.2 Loomis Creek south side tributaries

Bishop Creek predominantly has a riffle pool morphology reflecting a consistently low channel gradient adjacent to the planned logging areas (**Photo 10**). However, the gradient is not as low as mid reach of Loomis Creek. There are some signs of the 2013 flood event, but flood disturbance is infrequent. There were no significant and ongoing sediment inputs. The Bishop Creek watershed historically burned, but there were no signs of wildfire within the riparian area.

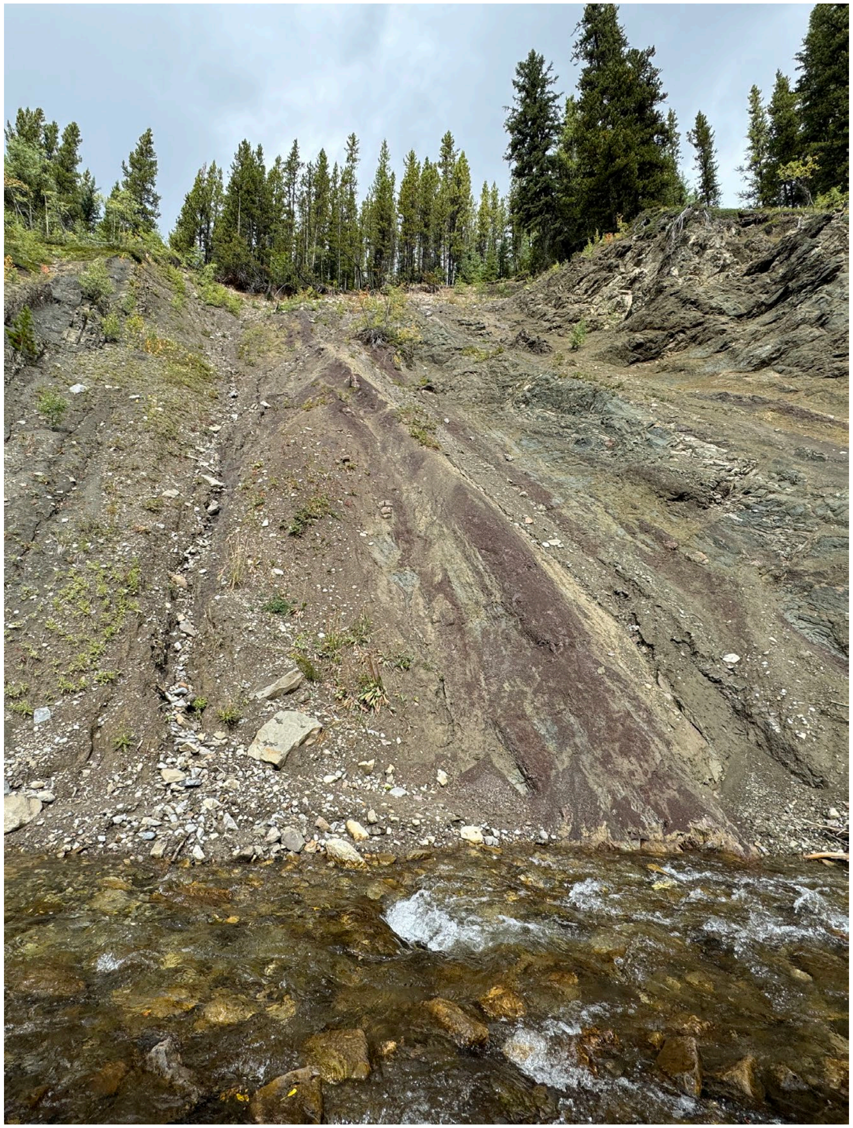


Photo 7. Actively eroding escarpment on Loomis Creek near Bishop Creek during July 17, 2024, rain event.

Photo 8. Turbidity in Loomis Creek from eroding bank escarpment at Boulder Crossing and discharging to the Highwood River; fine gravel from escarpment accumulating in Loomis Creek immediately downstream from escarpment.

Photo 9. LWD in Loomis Creek headwaters (left) and lower reaches (right).

Photo 10. Bishop Creek riffle-pool morphology common on the reach surveyed.

Although there was historical logging in the headwaters of Loomis Creek in the south side subwatersheds, there was no logging within any of the other south side subwatersheds (i.e., Bishop Creek, LSBS2-3, LSBS6), so the effects of historical logging were not assessed.

LSBS2-3 has a steeper channel gradient at the mouth near Loomis Creek with a cascade with boulders morphology, while higher upstream LSBS3 drains a low gradient wetland area and has a riffle pool morphology (**Photo 11**). Like Bishop Creek, there are no significant and ongoing sediment inputs to LSBS2-3 and no signs of historical wildfire. There are also no signs of flood disturbance on LSBS2-3. This subwatershed was never logged.

Part of the LSBS6 subwatershed burned in 1936. It is the steepest tributary on the south side of Loomis Creek, and a portion of the sub- watershed is above tree line. These factors may be why it shows signs of channel incisement and has a forced step pool channel morphology (**Photo 12**). There are no significant and recent signs of flood disturbance, channel forming flows, or sediment sources on LSBS6.

6.2.3 Loomis Creek north side tributaries

Channel morphology was assessed at sites above and below historical logging on LSBN5-9, but only at one site on LSBN1-4 and on the Road Slide Tributary.

Historical logging was more extensive on the North and the South side of Loomis Creek and appears to have started in the 1940s and expanded into the headwaters in the 1960s. The logging footprint overlaps LSBN5-9 subwatersheds. Historical wildfire in 1936 overlapped the Road Slide Tributary and LSBN1-6 subwatersheds, but did not burn the headwaters of Loomis Creek (**Figure 2**).

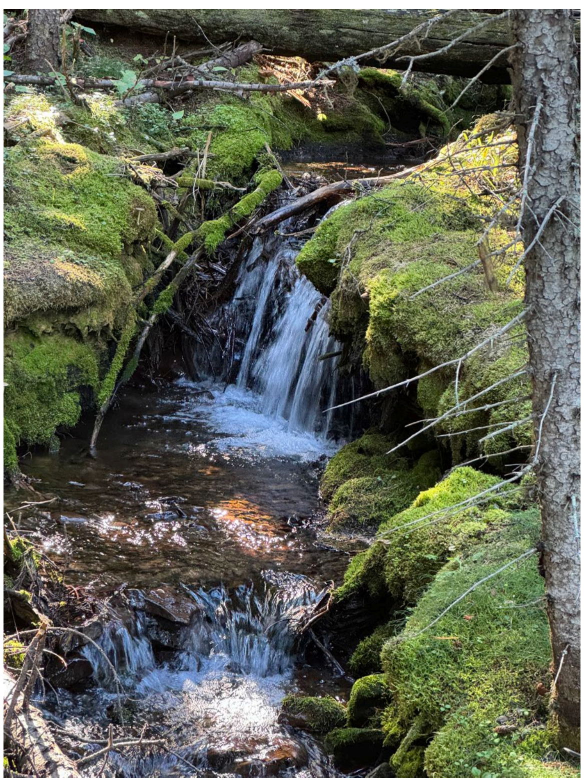
Where there were two channel morphology sites on a tributary, the upper site had a steeper gradient and generally had a colluvial channel form, while the lower sites generally had a forced step pool channel form, although some streams transitioned to subsurface flow and were classified as intermittent channels (**Figure 13**).

Signs of the effects of logging on channel morphology may be evident on LSBN9, where channel avulsion occurred within the logged area (**Photo 13**). LSBN5 and LSBN4 show some channel incisement, which may be because of historical logging, wildfire, or both (**Photo 14)**. Where historical logging removed riparian forest stands on these tributaries, LWD is now notably absent from stream channels, contributing to the channel incisement.

The LSBN9 sub-basin is nearly three times bigger than any of the other sub-basins on the north side of Loomis Creek (**Table 1**), has a large area above tree line (**Figure 7**), and a large proportion of the area has a south facing aspect (**Figure 11**). The LSBN9 stream channel reflects high peak flows at the site downstream of some of the historically logged area near Loomis Creek; with the channel bed being mostly mobile material at this point (**Photo 13**).

LSBN8 and LSBN5 sub-basins are smaller than LSBN9 and do not have areas above tree line. The site downstream of some of the historical logging on LSBN8 shows substantial bedload movement in some locations (Online Map Site ID: CM09). The site downstream of most of the historical logging on LSBN5 shows channel incisement (**Photo 14**).

Photo 11. LSBS2-3 cascade with boulders (left); upstream LSBS3 riffle pool (right).



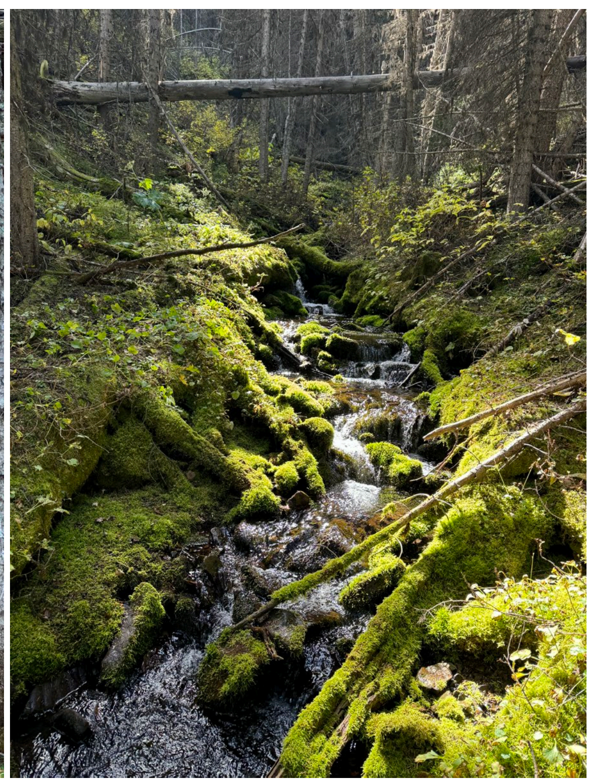


Photo 12. LSBS6 forced step pool incised channel within historical wildfire area.

Photo 13. LSBN9 new channel (July vs. September, left), old channel (bottom right), avulsion (middle and top right).

Photo 14. Channel incisement on LSBN4 (top) and LSBN5 (bottom) within and downstream of areas historically logged.

6.2.4 Loomis Creek headwater tributaries

The headwater tributaries to Loomis Creek are steep colluvial or bedrock channels that lack floodplains because they are in deeply incised valleys. Some are associated with alpine avalanche basins, but none were producing substantial, ongoing inputs of LWD or sediment. While historical logging has occurred in some of the subwatersheds, there were no signs of this within the immediate riparian area of any of the headwater tributary sites.

6.3 Hydraulic geometry

An increasing trend between bankfull flow channel cross-sectional area (m^2) to upstream watershed area (km^2) was observed for the 36 channel morphology sites (**Figure 14**). Channel cross-sectional area was used as a surrogate measure of annual average discharge, and larger upstream drainage areas were associated with larger channels. However, there was considerable variability in this pattern. Different categories of sites were considered when looking at this variability, and sites with smaller cross-sectional areas (m^2) and upstream watershed areas (km^2) were examined separately (**Figure 15**).

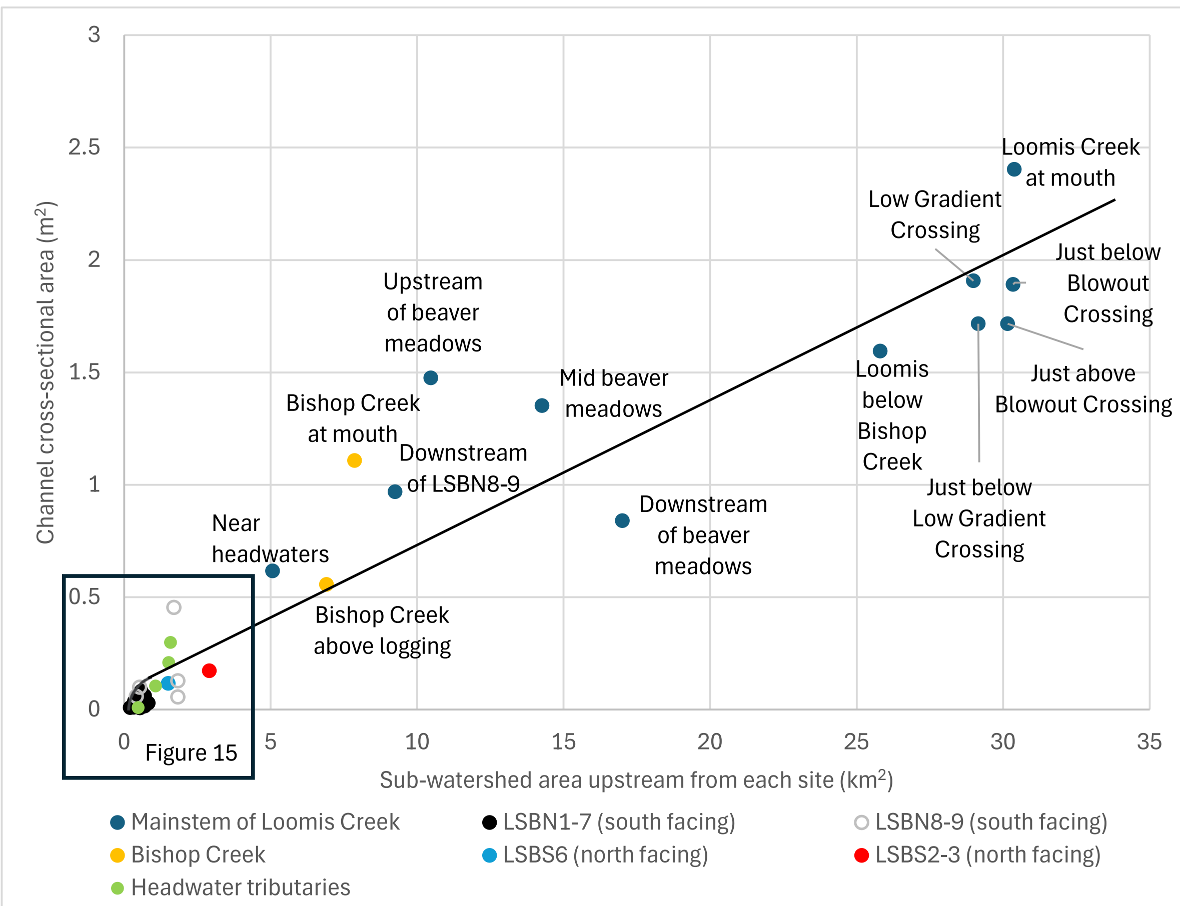


Figure 14. Plot of channel cross-sectional area (m^2) to upstream subwatershed area (km^2) for 36 mainstem and tributary sites in the Loomis Creek watershed; trendline for

discussion purposes only and becomes non-linear at the point where subwatersheds are too small to generate enough runoff to create a channel.

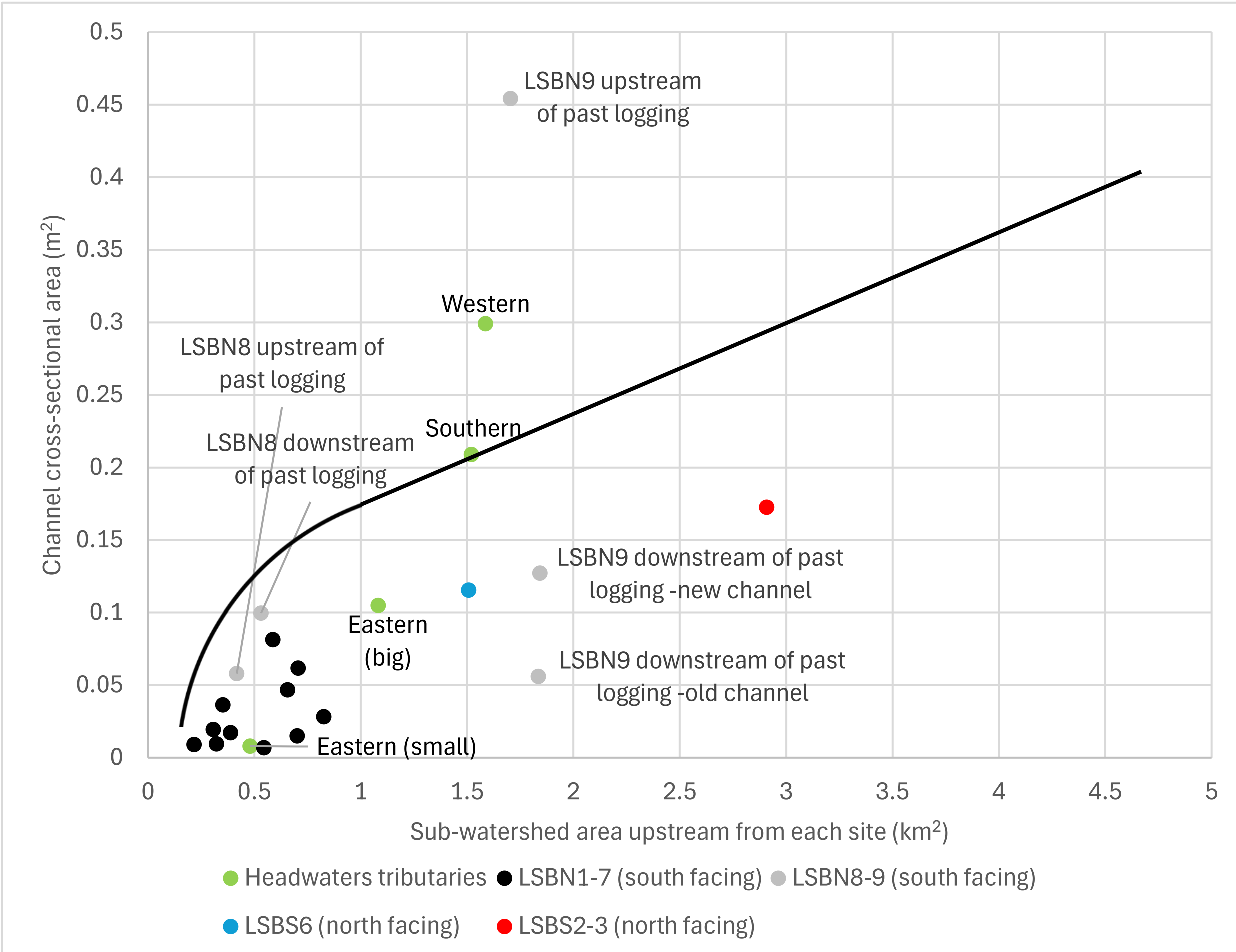


Figure 15. Plot of channel cross-sectional area (m²) to upstream watershed area (km²) for 23 tributary sites in the Loomis Creek watershed (excluding Bishop Creek); trendline for discussion purposes only and becomes non-linear at the point where subwatersheds are too small to generate enough runoff to create a channel.

6.3.1 *Loomis Creek mainstem*

The plot (**Figure 14**) of cross-sectional area (m²) to upstream watershed area (km²) for the Loomis Creek mainstem sites shows:

- The cross-sectional area (m²) of four mainstream sites from the midpoint of the beaver meadows (Online Map Site ID: CM19) upstream to near the headwaters (Online Map Site ID: CM05) is greater than the trendline predicts.
- At the site at the downstream limit of the beaver meadows (Online Map Site ID: CM25), the cross-sectional area (m²) was less than the trendline predicts.
- Five channel morphology sites downstream of the Bishop Creek confluence have cross-sectional areas (m²) close to, but slightly less than, a the trendline predicts.

- The cross-sectional area (m^2) of Loomis Creek at the mouth is higher than the trendline predicts.

6.3.2 South side tributaries of Loomis Creek

The plot (**Figure 15**) of cross-sectional area (m^2) to upstream watershed area (km^2) for south side tributaries of Loomis Creek shows:

- The upper site on Bishop Creek is consistent with a cross-sectional area (m^2) to upstream watershed area (km^2) trendline.
- Cross-sectional area of Bishop Creek at the mouth was greater than the trendline.
- Channel cross-sectional areas (m^2) of the sites on LSBS2-3 and LSBS6 are less than the trendline.

6.3.3 North side tributaries of Loomis Creek

The plot (**Figure 15**) of cross-sectional area (m^2) to upstream watershed area (km^2) for north side tributaries of Loomis Creek shows:

- Channel cross-sectional area of eight of the tributaries that flow into Loomis Creek from the north (LSBN1-8) is lower than predicted by a linear trendline. Of these tributaries, LSBN8 has the highest flow, largest channel area, and plots closest to the trendline.
- Channel cross-sectional area of the LSBN9 tributary is larger than predicted by the trendline upstream of the historical logging (Online Map Site ID: CM08), but smaller than predicted within the area historically logged (Online Map Site ID: CM06). In September 2024 the channel was dry within the area that was historically logged (Online Map Site ID: CM06), and by the end of October 2024 it had dried up at a point even further upstream. This suggests that LSBN9 transitions from a gaining to a losing stream, and this may occur between Online Map Site ID CM08 and CM06.

The watershed area for the Road Slide Tributary was unknown because it was too small to delineate using the DEM. Therefore, this tributary was not assessed in terms of cross-sectional area (m^2) and upstream watershed area (km^2).

6.3.4 Loomis Creek headwater tributaries

The plot (**Figure 15**) of cross-sectional area (m^2) to upstream watershed area (km^2) for the four headwater tributaries shows:

- Channel cross-sectional area of two of the four headwater tributaries is larger than predicted by a linear trendline (Headwaters West and Headwaters South). These two tributaries have subwatersheds that border the continental divide, have the largest area above tree line, and likely accumulate the largest snowpack (**Figure 7**).
- Channel cross-sectional area of the other two headwater tributaries is smaller than the trendline. The subwatersheds of these two tributaries do not border the continental divide (Headwaters East, big and small; **Figure 7**). Headwaters East (big) has a predominantly north facing aspect (**Figure 11**), while Headwaters East (small)

is smaller than all the other headwater subwatersheds and does not have any area above tree line that would accumulate a higher snowpack.

6.4 Size of the mobile bedload (D90)

Like the positive trend observed with cross-sectional area (m^2), an alluvial channel can move larger bedload material as the upstream watershed area (km^2) increases. An increasing trend between the average size of the largest mobile bedload (D90, cm) at sites and the upstream watershed area (km^2) at those sites was observed for 11 sites on the mainstem of Loomis Creek, two sites on Bishop Creek, and 14 sites on other alluvial tributaries (LSBN9, LSBN8, LSBS6, LSBN1, LSBS2-3, LSBN5; **Figure 16**).

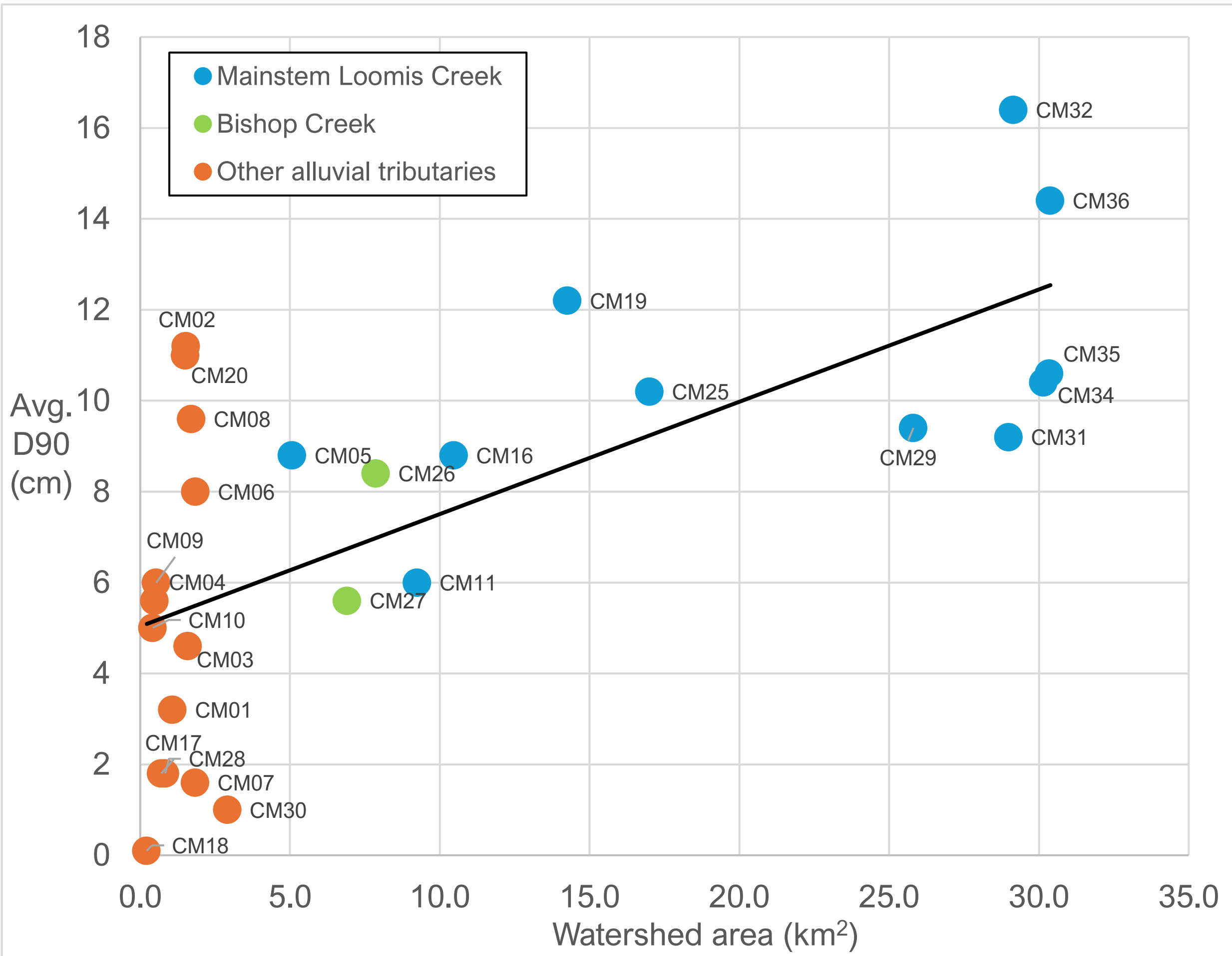


Figure 16. Plot of the average largest mobile bedload (D90, cm) to upstream watershed area (km^2) for 11 sites on Loomis Creek, 2 sites on Bishop Creek, and 14 sites on other alluvial tributaries; labels are channel morphology and Online Map Site IDs; trendline for discussion purposes only.

There is a lot of variability around the D90 (cm) to upstream watershed area (km^2) trendline (**Figure 16**), particularly for sites with the largest and smallest watershed areas.

The four sites on the lower 2.5 km of Loomis Creek have similar upstream watershed areas (29.1-30.2 km^2, **Appendix IV Table IV- 2**), but the D90 (cm) varies from 10.4-16.4 cm (**Figure 16**). Inputs of larger colluvial material from localized bedrock escarpments were observed near the Online Map Site IDs CM32 and CM36, which may locally increase the D90.

There is even more variability in the D90 (cm) at the smallest subwatershed sizes, where 14 tributary sites with alluvial channels (excluding Bishop Creek) have values ranging from 0.1 to 11 cm at watershed areas ranging from 0.2 to 2.9 km^2 (**Figure 16**). Of these 14 sites, the tributaries where the D90 (cm) was much lower than the trendline are small and have low or intermittent flow. Although LSBS2-3 (Online Map Site ID: CM30) drains a larger subwatershed, it has a lot of wetland area and no alpine headwaters, so it does not produce large peak flows to move bedload as other headwater tributaries do. LSBN5 is an intermittent stream, with the headwater site (Online Map Site ID: CM18) having a small upstream area, so only silt and sand can be mobilized. There is no larger bedload material available to mobilize on LSBN5 near Loomis Creek (Online Map Site ID: CM17), only silt and sand. On LSBN9, Online Map Site ID CM07 is a site where the channel was abandoned from an earlier flood event, so the D90 no longer reflects the upstream area. The site on LSBN1 (Online Map Site ID: CM28) was near the mouth where this tributary goes subsurface, resulting in the mobile bedload being small. The D90 (cm) may have been larger further upstream on LSBN1.

Another subset of the 14 sites with small watershed areas had much higher D90 (cm) values above the trendline (**Figure 16**). These sites were all on tributaries draining subwatersheds with alpine headwaters that accumulate a larger snowpack that can melt quickly, resulting in higher peak flows that mobilize larger bedload material. Two of these sites were on LSBN9 (Online Map Site IDs: CM06 and CM08), which is a flashy tributary due to the large subwatershed area above tree line with a southeast facing aspect dominating (**Figure 11**). Two other sites were on LSBS6 and the southern tributary in the headwaters of Loomis Creek (Online Map Site IDs: CM20 and CM02, respectively). Even though these subwatersheds do not have dominate south facing aspects, they drain relatively large areas above tree line that accumulate snow that can melt quickly, resulting in large D90 values.

Sites on the remaining Loomis Creek tributaries were not on alluvial streams (Road Slide Tributary and LSBN2, LSBN3, LSBN4, LSBN6, and LSBN7). These streams appeared to have intermittent or perennial flow resulting more from groundwater discharge than from runoff. Therefore, the D90 (cm) was not assessed in terms of upstream watershed area (km^2).

6.5 Wolman pebble counts – channel bed grainsize distribution

The typical pattern of coarsening channel bed grainsize distribution when moving longitudinally from headwater to mouth was not observed on Loomis Creek (**Figure 17**) due to the mid reach containing the beaver meadows being lower gradient than the upper and lower reaches of the stream (**Figure 12**). However, the mouth of Loomis Creek did have a slightly coarser channel bed grainsize distribution than the headwaters (**Figure 17**, compare red versus blue bars). A comparison of channel bed grain size distribution for all seven sites on Loomis Creek from headwaters to mouth showed that the bedload in the steeper gradients of the headwaters and lower reaches was substantially coarser than the mid reaches (**Figure 17**, compare blue and red bars together versus green, yellow, and orange bars). In the mid reach of Loomis Creek, the entire bedload was mobile. The average D90 across three sites in the mid reach (Online Map Site IDs: CM16, CM25, CM31) was 9.4 cm, while the Wolman pebble counts at these sites showed 93-95% of the bedload was less than 96 mm in diameter (**Figure 17**). This is consistent with the meandering riffle pool morphology observed throughout the mid reach of Loomis Creek.

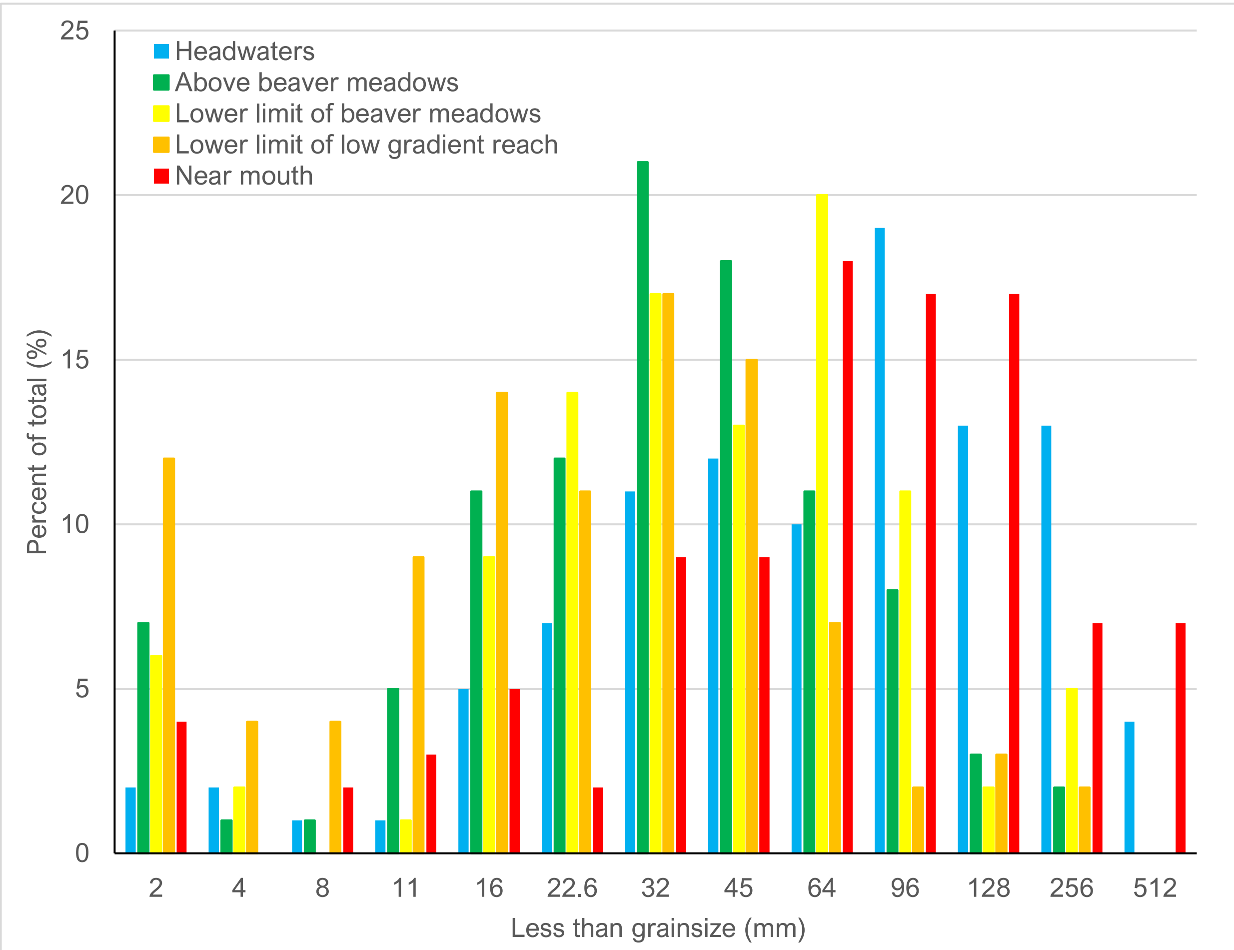


Figure 17. Streambed grain size distribution for five Loomis Creek mainstem sites.

The typical pattern of coarsening channel bed grainsize distribution when moving longitudinally from headwater to mouth was also not observed on Bishop Creek. There was very little difference in the channel bed grainsize distribution between the site upstream of the planned logging and the one at the mouth (**Figure 18**). The sites were only separated by 2.8 km, roughly half the length of Loomis Creek from the headwaters to the mouth (5.1 km). Channel gradient was relatively consistent along this reach of Bishop Creek.

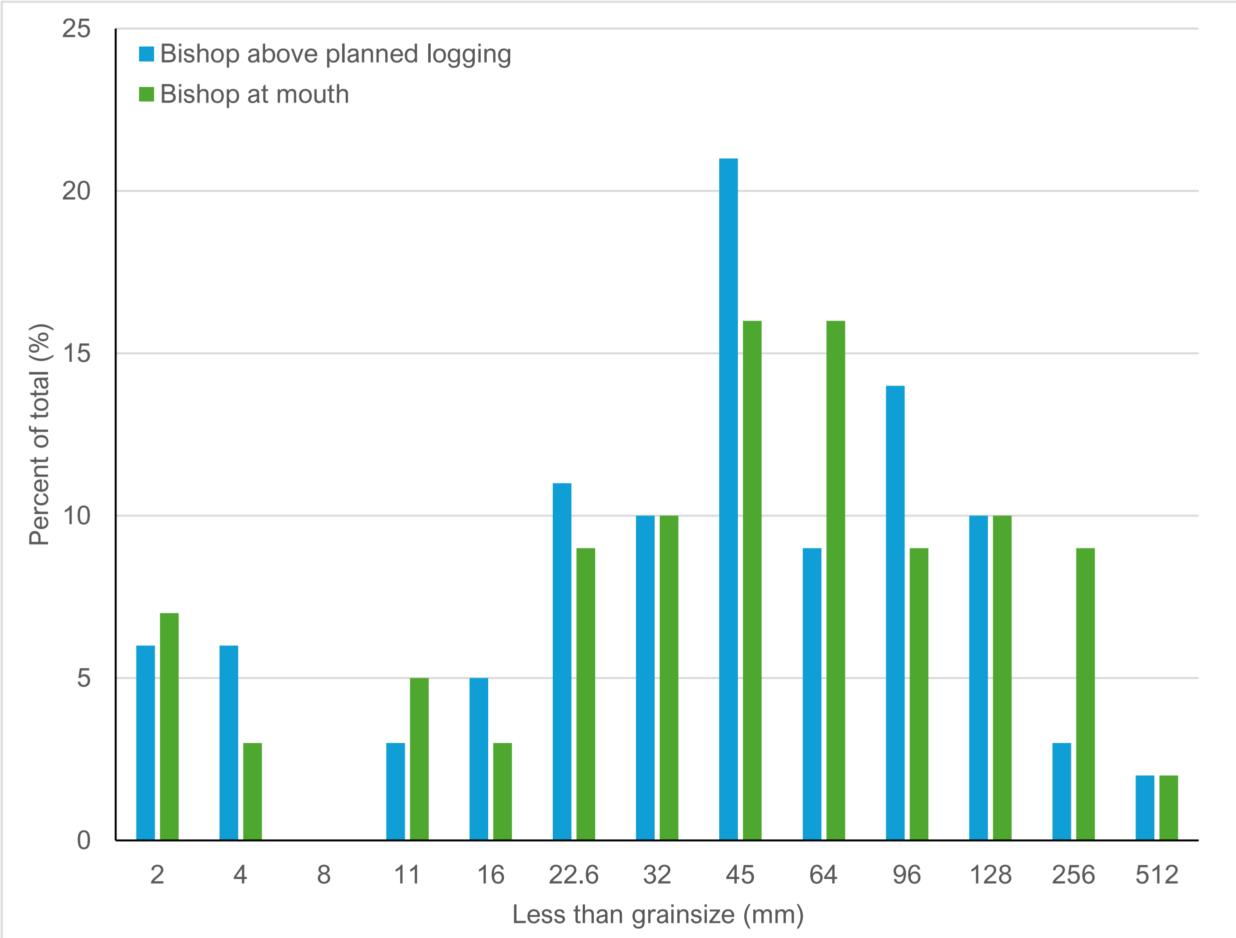


Figure 18. Streambed grain size distribution for the two Bishop Creek sites.

6.6 Stream electrical conductivity

Stream electrical conductivity measurements throughout the Loomis Creek watershed were used to provide an indication of spatial differences in the relative contribution of surface runoff versus groundwater to stream flow. Groundwater has higher conductivity than surface water due to the slower movement of subsurface water and concentration of dissolved ions that accumulate over time. Underlying geology influences the electrical conductivity of groundwater and surface water, with igneous material being less easily ionized and associated with low conductivity, while the dissolution of limestone releases calcium and carbonate ions resulting in higher conductivity.

An overall trend of increasing stream electrical conductivity was observed from the headwaters of Loomis Creek (at Online Map Site ID SD11, midway between CM05 and CM11) to the gauging site near the mouth (**Figure 19**). Values were lowest in the headwaters and increased by approximately 45 µS/cm at a point downstream of the beaver meadows and immediately upstream from the Bishop Creek confluence (Online Map Site ID SD07, near CM25) in July, September, and October, 2024. This increase may be due to an influx of groundwater into Loomis Creek between the two sampling locations.

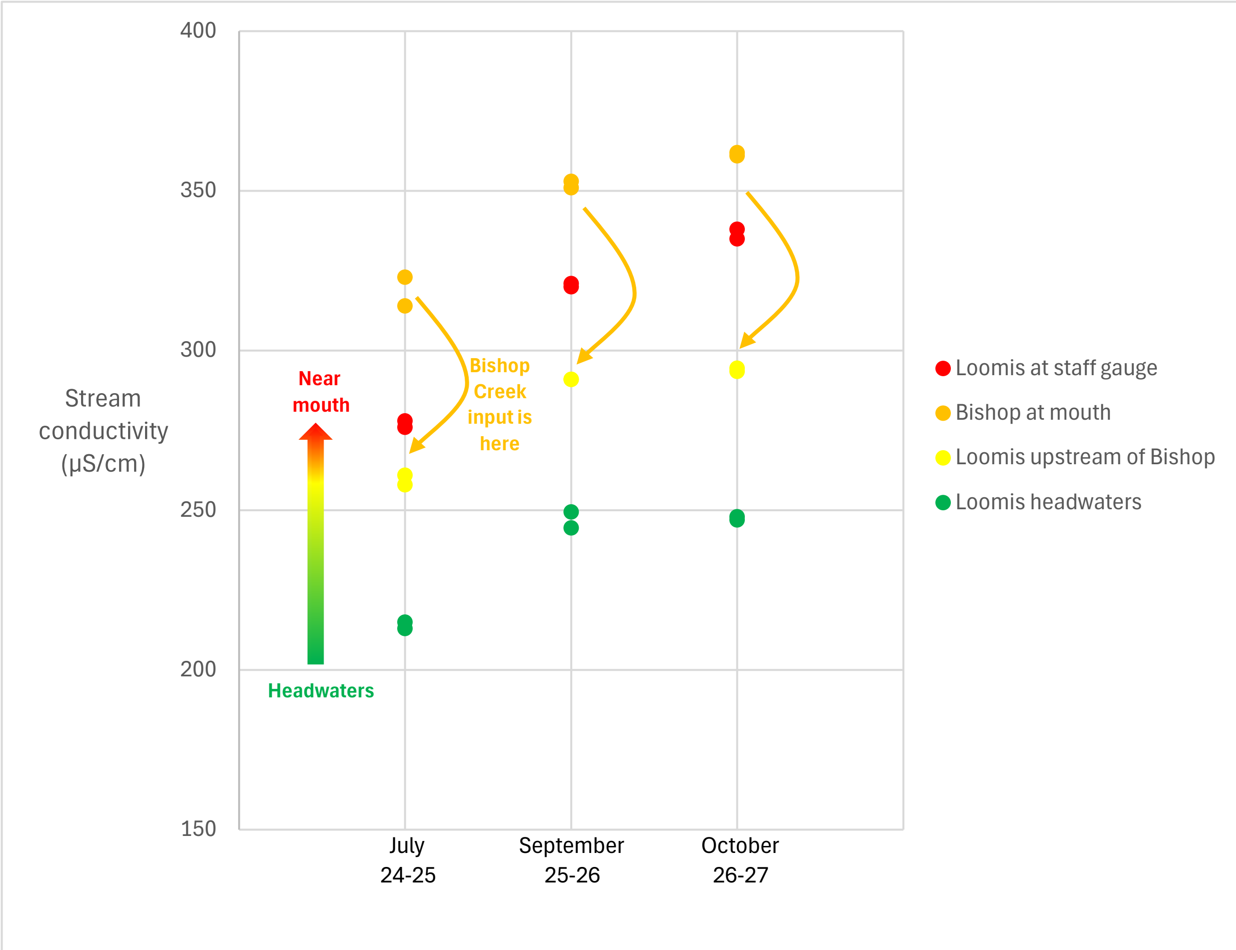


Figure 19. Spatial and temporal trends in conductivity at three sites on Loomis Creek and at the mouth of Bishop Creek.

Stream electrical conductivity in Bishop Creek was the second highest of any tributary to Loomis Creek next to the LSBS2-3 tributary (**Figure 19**, **Figure 20**). Stream electrical conductivity of Bishop Creek at the mouth was approximately 63 µS/cm higher than Loomis Creek immediately upstream from Bishop Creek (**Figure 19**).

Stream electrical conductivity of Loomis Creek at the staff gauge near the mouth was approximately 11-13% higher than Loomis Creek immediately upstream of Bishop Creek, reflecting the increase resulting from inputs from Bishop Creek (**Figure 19**).

Stream electrical conductivity measurements at all three mainstem sites on Loomis Creek as well as the site at the mouth of Bishop Creek, increased in September and October relative to July (**Figure 19**), coinciding with when runoff from snowmelt and precipitation decreased.

Stream electrical conductivity on two tributaries on the South side of Loomis Creek and five tributaries on the North side corresponded to observations of whether flows in these tributaries originated more from groundwater than surface runoff (**Figure 20**).

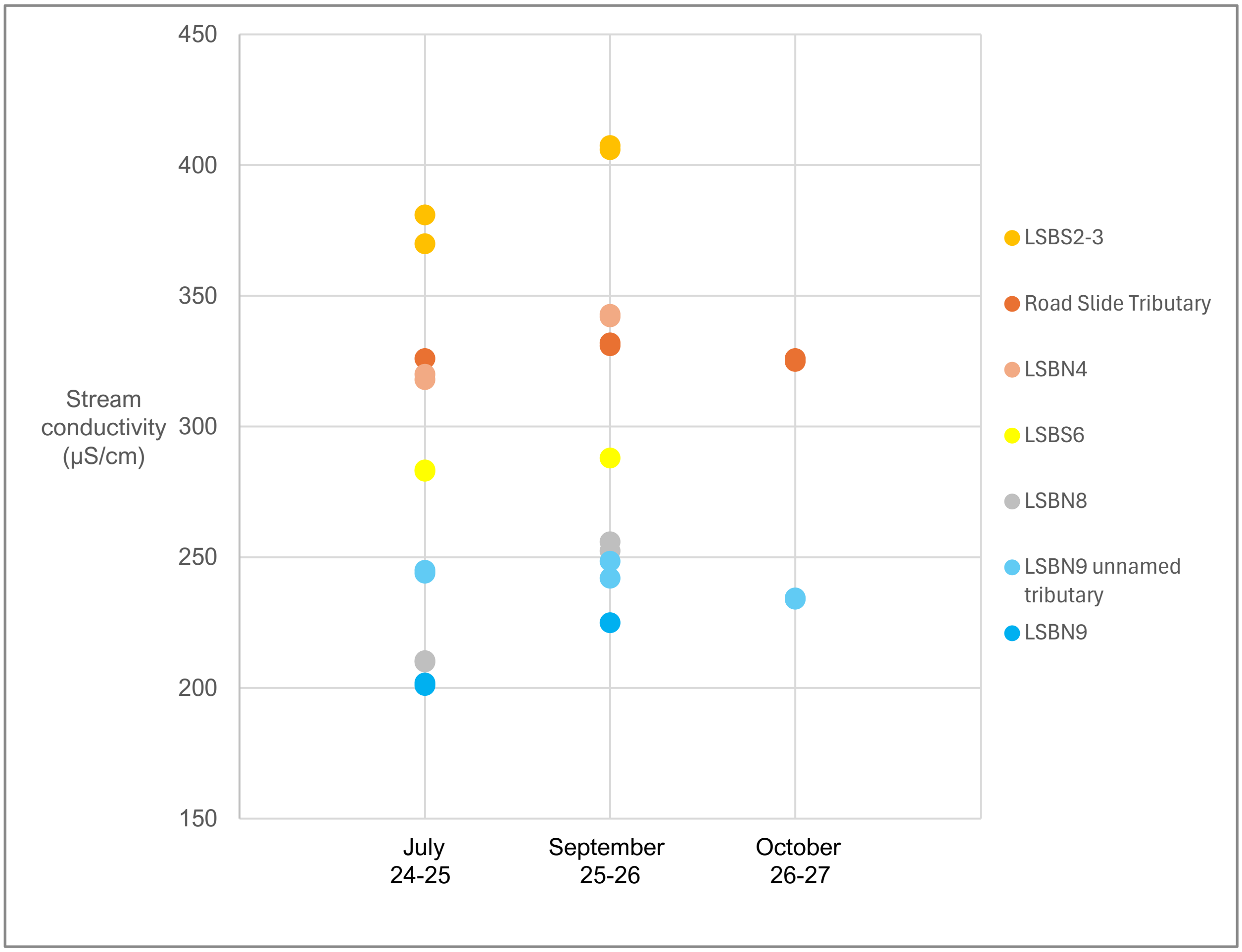


Figure 20. Spatial and temporal conductivity trends on seven Loomis Creek tributaries.

LSBS2-3 has the highest conductivity of any of the Loomis Creek tributaries measured. LSBN9, an unnamed tributary to LSBN9, and LSBN8 have low conductivity (**Figure 20**).

The Road Slide Tributary and LSBN4 have conductivity not as high, but close to that of Bishop Creek on the south side of Loomis Creek (**Figure 20**). These two tributaries continued to flow throughout the summer and fall of 2024 and do not have large catchments or areas above tree line that would accumulate a large snowpack.

LSBS6 has intermediate conductivity (**Figure 20**). The subwatershed includes alpine areas that accumulate a large snowpack, which may melt slowly due to the North facing aspect (**Figure 11**). This may result in more groundwater recharge and discharge within the subwatershed, resulting in higher conductivity.

6.7 Spatial differences in stream temperature

6.7.1 Mainstem of Loomis Creek

While temperatures on Loomis Creek upstream of Bishop Creek (Online Map Site ID: TL09), downstream of the LSBS2-3 confluence (Online Map Site ID: TL05), and at the mouth

(Online Map Site ID: TL02) remained within 0.5°C throughout the period data are available, the temperature of Loomis Creek in the headwaters was consistently 3°C cooler throughout July, August, and most of September (**Figure 21**). However, in October the temperature of all four sites converged and by the end of October, the Loomis Creek headwaters site was 0.5°C warmer than the three sites lower downstream on the mainstem (**Figure 21**).

The warmest daily average temperature the lower sites on Loomis Creek reached during the summer of 2024 was 10°C (**Figure 21**), with 14°C being the instantaneous maximum temperature measured anywhere on Loomis Creek. This was at the downstream limit of the beaver meadows upstream from Bishop Creek.

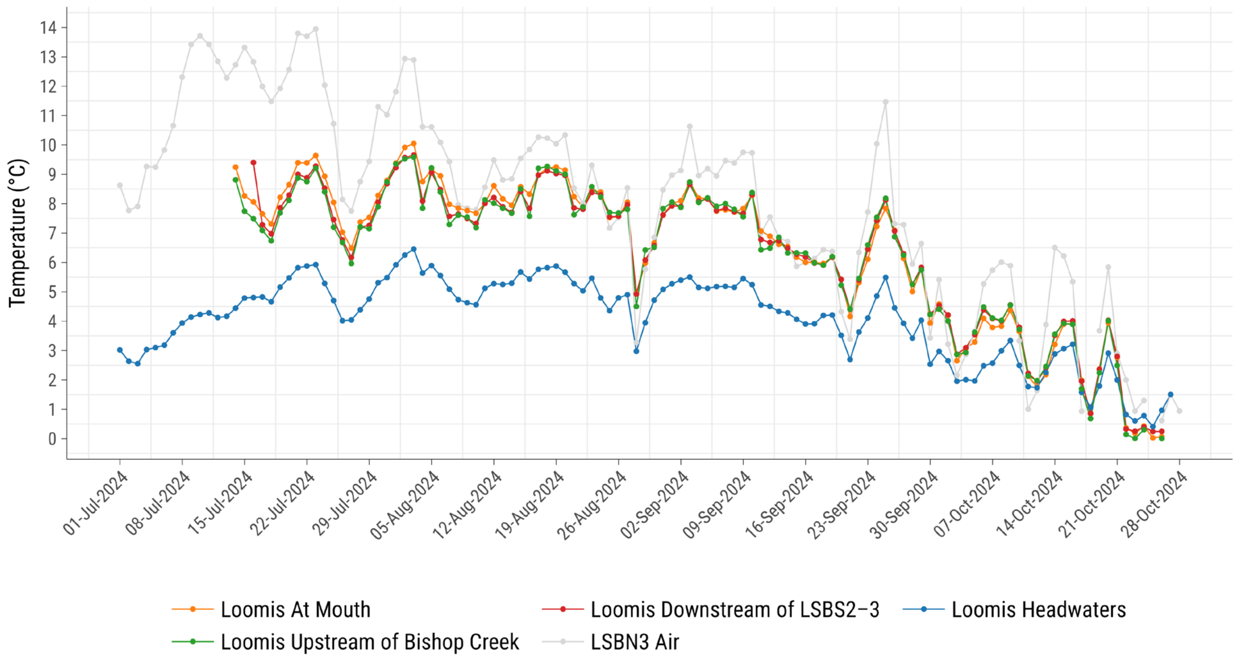


Figure 21. Daily average temperature at four sites on Loomis Creek and air temperature recorded on LSBN3.

6.7.2 Bishop Creek

Bishop Creek stream temperature at the mouth was on average less than 0.5°C warmer than at the point upstream of the planned logging (**Figure 22**). Bishop Creek stream temperature at the mouth was approximately 0.5-1.0°C cooler than Loomis Creek upstream of Bishop Creek throughout July and August, but in September the temperatures of the two streams converged (**Figure 22**).

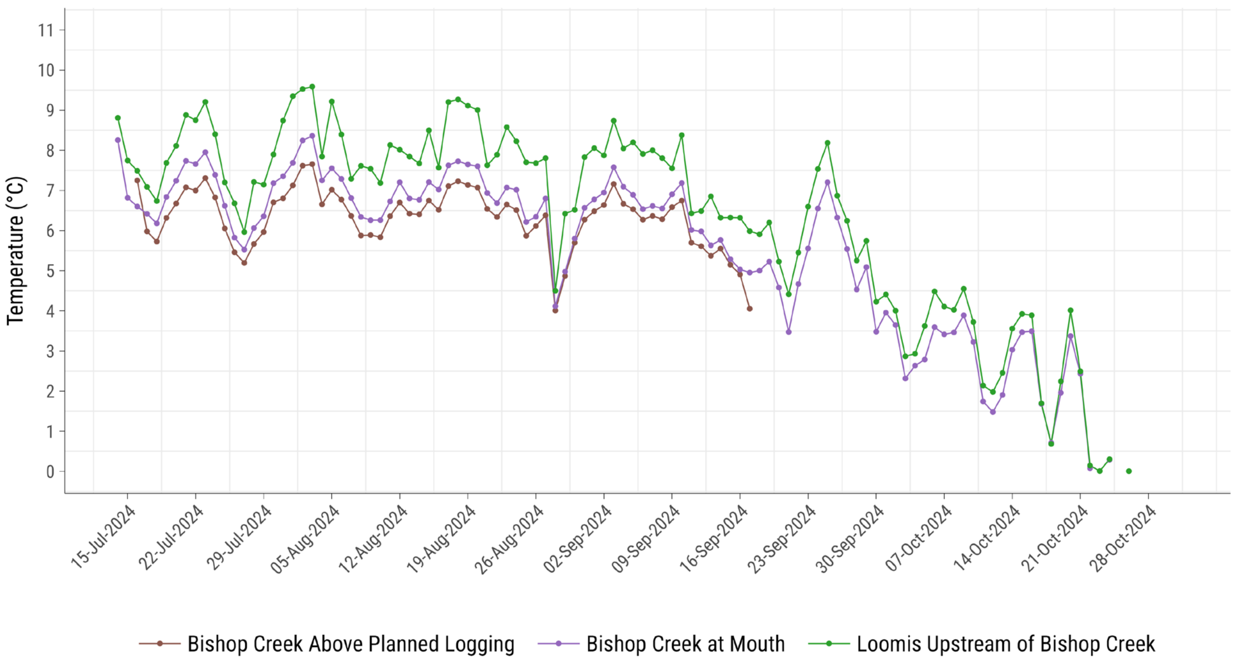


Figure 22. Daily average temperature for Bishop and Loomis creeks.

6.7.3 Highwood River

The temperature of Loomis Creek at the mouth remained consistently approximately 1.5°C cooler than the Highwood River immediately upstream throughout the monitoring period from July to October, 2024 (**Figure 23**). Stream temperature on the Highwood River was warmer downstream of the planned logging than immediately upstream of Loomis Creek, with a difference generally less than 0.5°C (**Figure 23**).

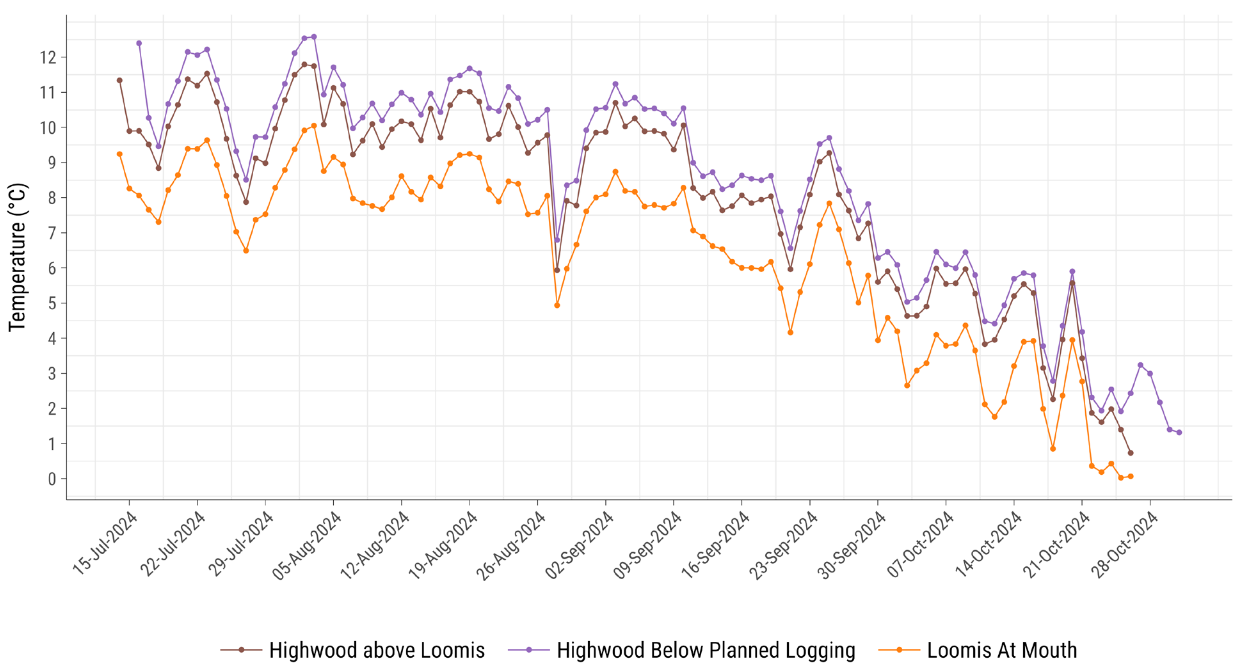


Figure 23. Daily average temperature for Highwood River and Loomis Creek.

6.7.4 Loomis Creek north side tributaries

Despite LSBN9, LSBN8, LSBN4, and the Road Slide Tributary being spread out on the North side of Loomis Creek from the headwaters to near the mouth at the Highwood River, these four tributaries showed similar fluctuations in daily average temperature over the course of the summer and fall (**Figure 24**). This suggests that while the flow in these streams may have originated from different sources (snowmelt, runoff, groundwater springs), the points where temperature was being monitored was distant enough from the source that air temperature was a more dominant determinant of stream temperature.

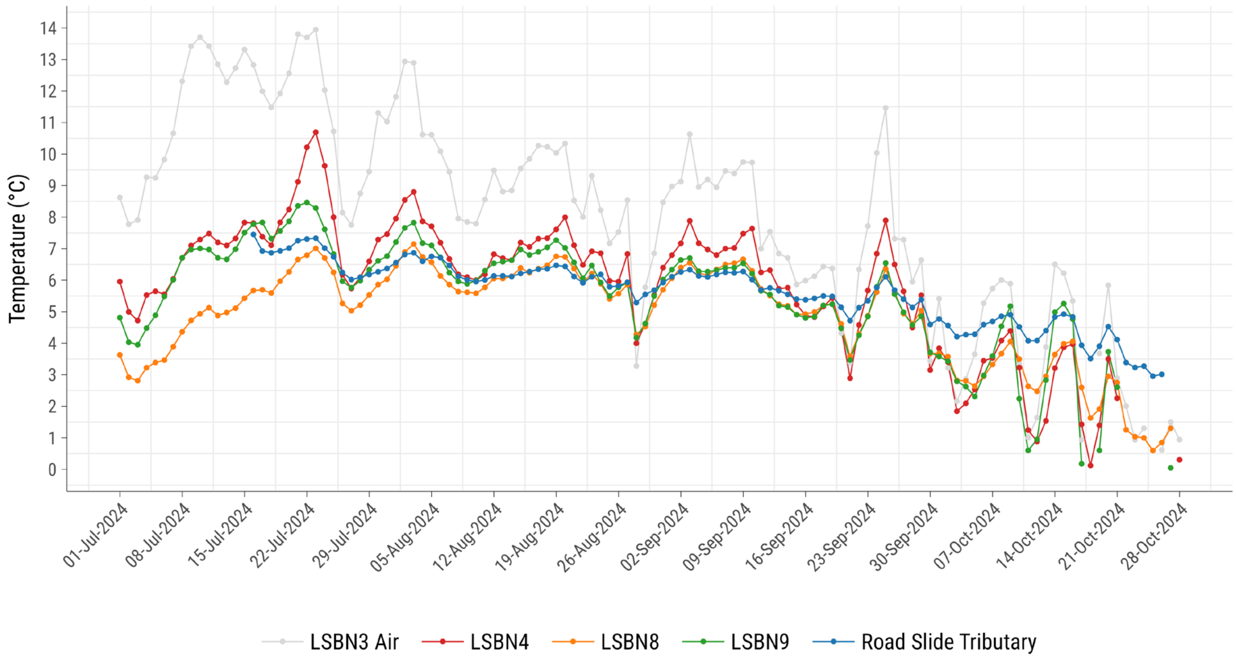


Figure 24. Daily average temperature for LSBN9, LSBN8, LSBN4, and the Road Slide Tributary and air temperature recorded on LSBN3.

LSBN3 is an intermitted stream that stopped flowing shortly after the temperature logger was installed, so the logger was recording air temperature in the shade on the forest floor near the edge of the beaver meadow within a planned cut block. Air temperature was also recorded beside the Road Slide Tributary with approximately 1 m off the forest floor, also in the shade and within a planned cut block. Daily average temperatures remained below 20°C at both sites, with the Road Slide Tributary being warmer than the LSBN3 site.

LSBN5 and LSBN7 monitoring sites did not show fluctuation in daily average temperature like the other four tributaries on the north side of Loomis Creek (**Figure 25**). These temperature loggers were installed on the Loomis Creek floodplain where there was likely significant groundwater upwelling. LSBN5 was 3°C warmer than LSBN7 in mid-July and roughly 1.5°C warmer by the end of October (**Figure 25**).

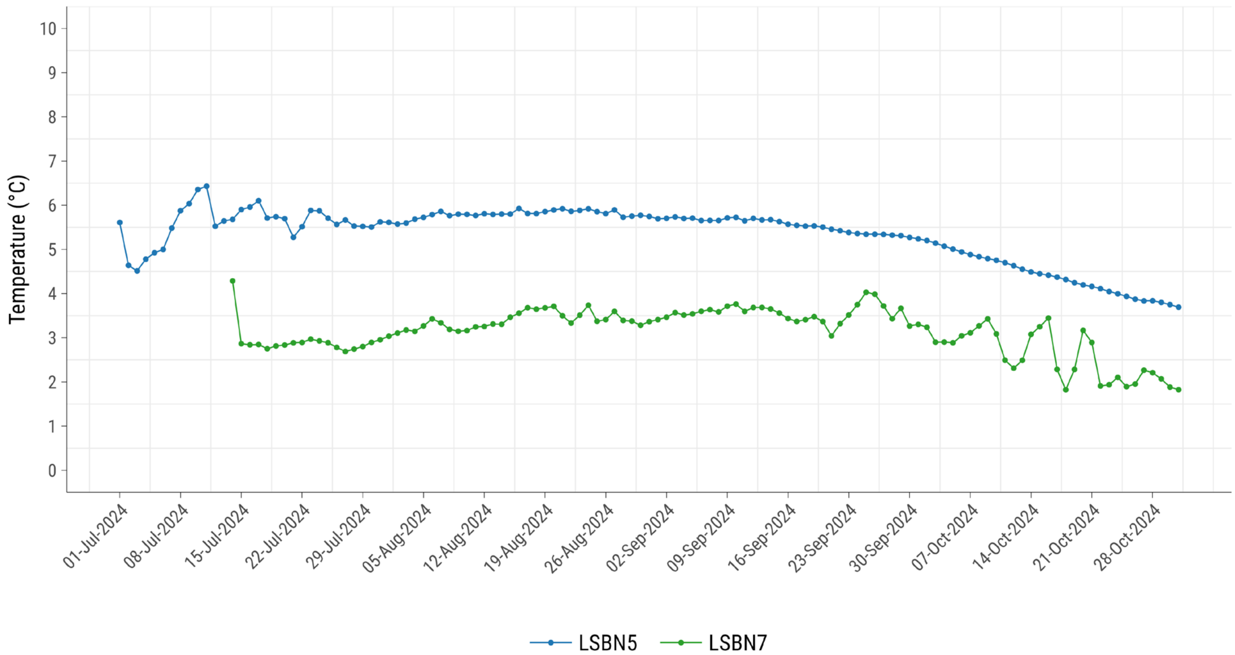


Figure 25. Daily average temperature for LSBN5 and LSBN7.

6.7.5 Loomis Creek south side tributaries

Besides Bishop Creek, stream temperature was monitored in the LSBS2-3 and LSBS6 tributaries on the south side of Loomis Creek (**Figure 26**).

However, daily average water temperature was significantly higher in LSBS2-3 than LSBS6 or any of the tributaries on the North side of Loomis Creek throughout most of the summer (**Figure 26**). This may reflect that the LSBS2-3 watershed is larger (2.95 km^2) than any of the other subwatersheds besides Bishop Creek (**Table 1**). Temperature was also monitored independently on LSBS2 immediately upstream from the confluence with LSBS3 and closely followed the daily fluctuations observed at LSBN2-3 (**Figure 26**).

Temperatures on LSBS6 were colder than on LSBS2-3 (**Figure 26**) or the tributaries on the North side of Loomis Creek that were not being monitored close to a point of groundwater discharge (LSBN9, LSBN8, LSBN4, Road Slide Tributary, **Figure 24**). The LSBS6 subwatershed has an alpine headwater area above tree line that accumulates a large snowpack that melts slowly due to the North facing aspect. This results in cooler temperatures.

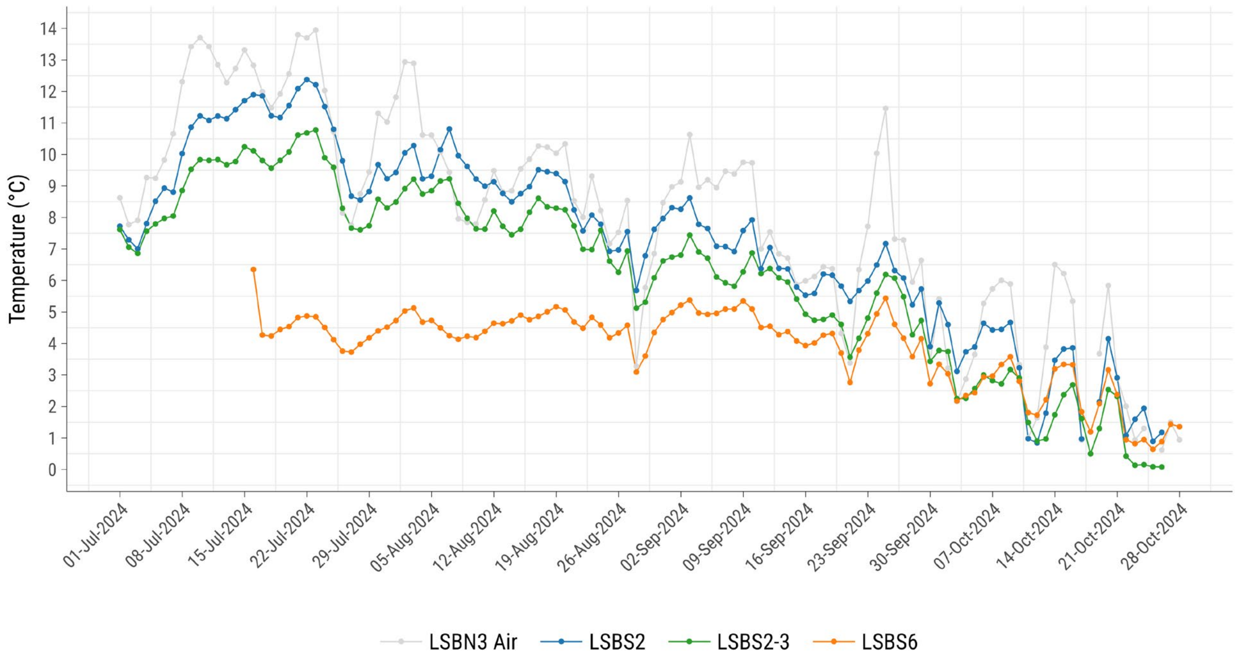


Figure 26. Daily average temperature for LSBS2, LSBS2-3, and LSBS6 and air temperature recorded on LSBN3.

6.8 Continuous flow measurements at the staff gauge

The three instantaneous measurements of flow were taken at the Loomis Creek staff gauge on July 24, September 25, and October 26, 2024. These were linked to simultaneous staff gauge readings (0.6935 m, 0.5735 m, and 0.535m, respectively) to develop a stage-discharge relationship (**Figure 27**) using the Fathom Scientific online software referred to as the “Salt Portal” (wit.fathomscientific.com). The rating curve currently being used is

Q = 4.727E+00(h - 0.417)^1.715

where, h, is the adjusted water level recorded by the level logger in the staff gauge. The water level is adjusted for barometric pressure using Solinst Levelogger 4.6.3 software and the offset between the level of the surface of water and the submerged logger.

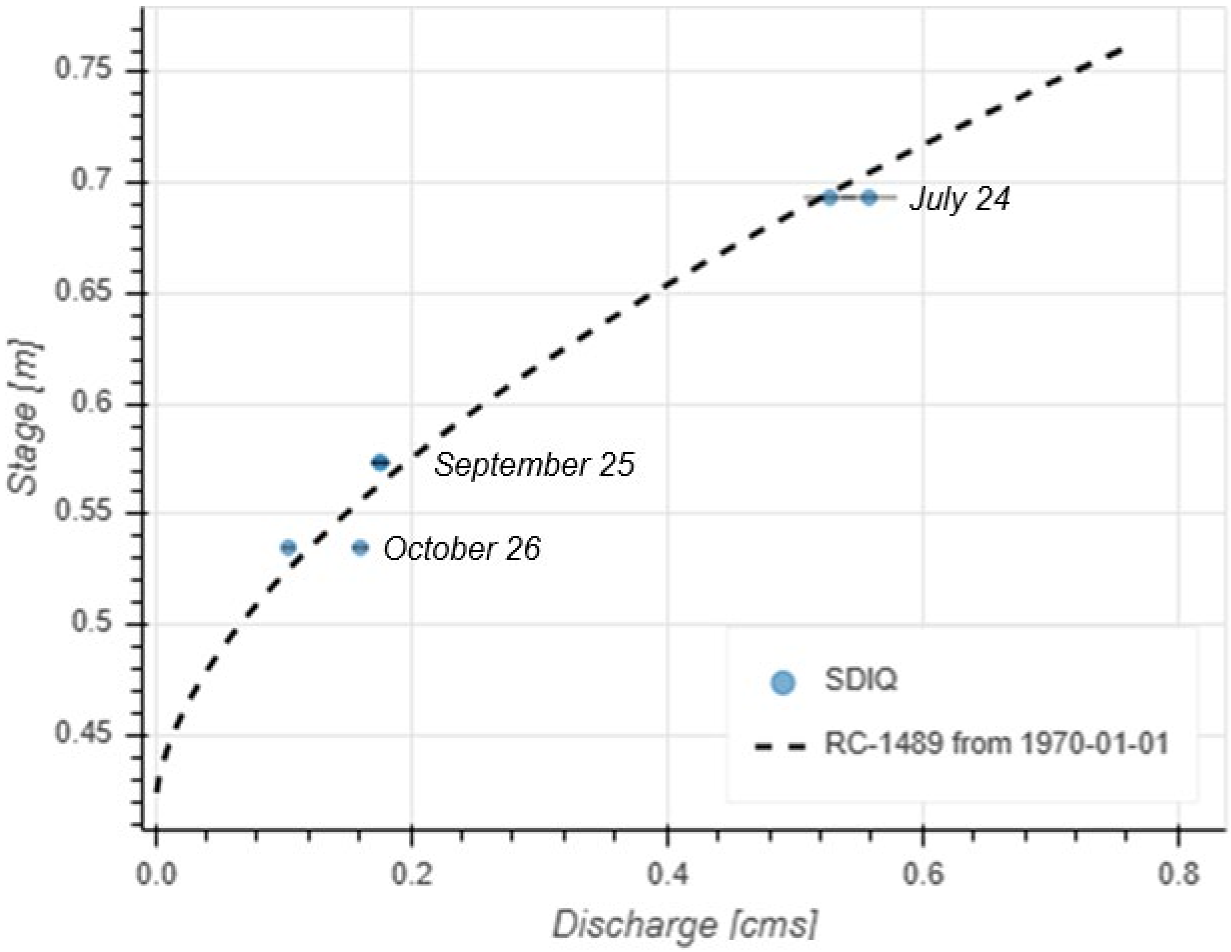


Figure 27. Loomis Creek stage-discharge relationship at the staff gauge.

The resulting continuous flow measurements for Loomis Creek from level logger data recorded from July 24 to October 26, 2024, are shown below (**Figure 28**). Flows declined over this period by approximately 74% from 0.47 to 0.12 m^2/sec.

6.9 Instantaneous flow measurements in the Loomis Creek watershed

Instantaneous flow measurements throughout the Loomis Creek watershed show that flows on Loomis Creek increase slightly more than double from the headwaters (Online Map Site ID: SD11) to the downstream limit of the beaver meadows (Online Map Site ID: SD07). At the confluence of Loomis and Bishop creeks, Bishop represents 30-40% of the combined instantaneous flow. The combined instantaneous measurements at this point were slightly greater than the measurements at the staff gauge. Instantaneous flows in the other Loomis Creek tributaries fluctuate, but measurements collected to date show LSBS6 and LSBN9 may be the largest contributors to flow downstream of the four headwater tributaries, which were not measured for instantaneous flows. Other tributaries with significant flows are the unnamed tributary to LSBN9, LSBN8, and the Road Slide Tributary.

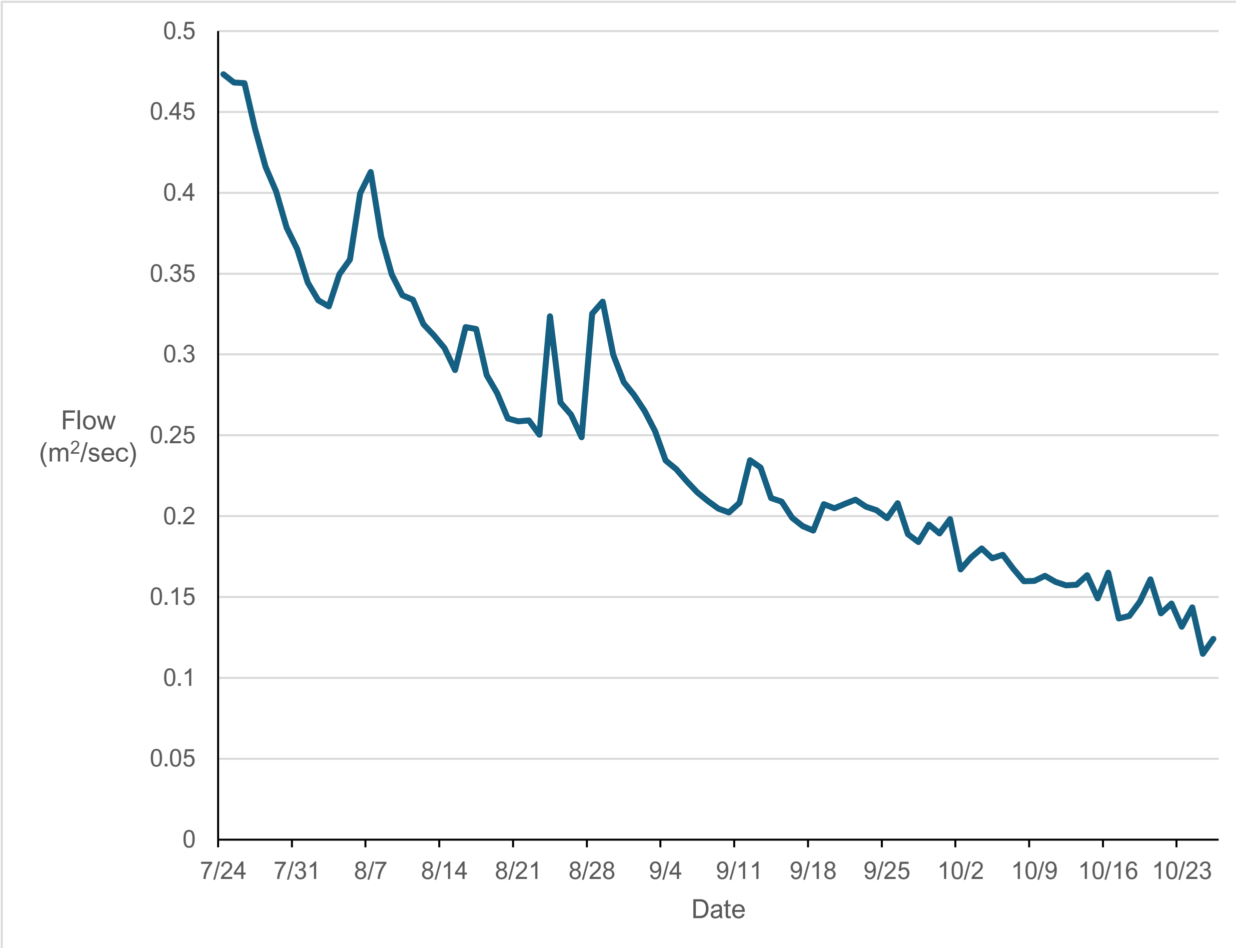


Figure 28. Loomis Creek daily average flow at the staff gauge, July-October 2024.

6.10 Total suspended solids measurements

As described above (**Section 6.2.1**), the largest cumulative source of sediment in the Loomis Creek watershed is currently local bank erosion along the tributary and mainstem channels, while the largest point source is a bank escarpment approximately 350 m downstream of the Bishop Creek confluence. This escarpment is actively eroding and releasing significant amounts of fine gravel, sand, and silt during rainfall events. There were other smaller sources of sedimentation to Loomis Creek associated with the historical logging road and cattle grazing on the road and along the creek, but sampling at these sites did not occur.

TSS samples were collected on only two days (June 29 and July 17, 2024), during locally significant rainfall events.

Sampling on June 29, 2024, occurred following several days of precipitation throughout southern Alberta. Samples consisted of just 1 L from each site. Samples from the mouth of Loomis Creek and from the Highwood River immediately upstream from Loomis Creek showed that TSS was higher in the river (16 mg/L) than in Loomis Creek at the mouth (6.0 mg/L). TSS on Loomis Creek upstream from Bishop Creek and upstream of the eroding escarpment was higher (7.7 mg/L) than at the mouth (6.0 mg/L), and levels in Bishop Creek and the LSBN2-3 tributaries were low (1.0 and <1.0 mg/L, respectively).

Sampling on July 17, 2024, occurred following a much smaller precipitation event in terms of duration and extent (less than 6 hours, localized over the upper Highwood River watershed). The eroding escarpment was identified as a source of the sedimentation within approximately one hour after precipitation began. Although samples could not be taken immediately upstream and downstream of the escarpment because sample bottles were not available at the time, Loomis Creek was photographed and observed to have low turbidity upstream of the escarpment (**Photo 15**). Photographs and video of the escarpment actively eroding were also taken as well as of Loomis Creek at trail crossings downstream of the escarpment (**Photo 7**, **Photo 8**). Triplicate samples (thee 1 L samples per site) were then collected from the mouth of Loomis Creek and from the Highwood River immediately upstream from Loomis Creek. Average TSS of Loomis Creek was 366.7 mg/L, while Highwood River was <1.0 mg/L.

Photo 15. Low turbidity in Loomis Creek upstream of escarpment during erosive event.

6.11 Loomis Creek watershed bull trout distribution

The Project has expanded on the current known distribution of bull trout in the Loomis Creek watershed (**Figure 29**). It has collected evidence of occurrence further upstream than previous electrofishing records had shown (Fish and Wildlife Internet Mapping Tool, FWIMT 2025), to a point midway through the beaver meadows on Loomis Creek near the confluence of LSBS6 (Online Map Site ID: ED3), a point near where the historical road crosses LSBS2-3 (Online Map Site ID: ED2), and to a point near the upstream limit of planned clearcut logging on Bishop Creek (Online Map Site ID: FO03).

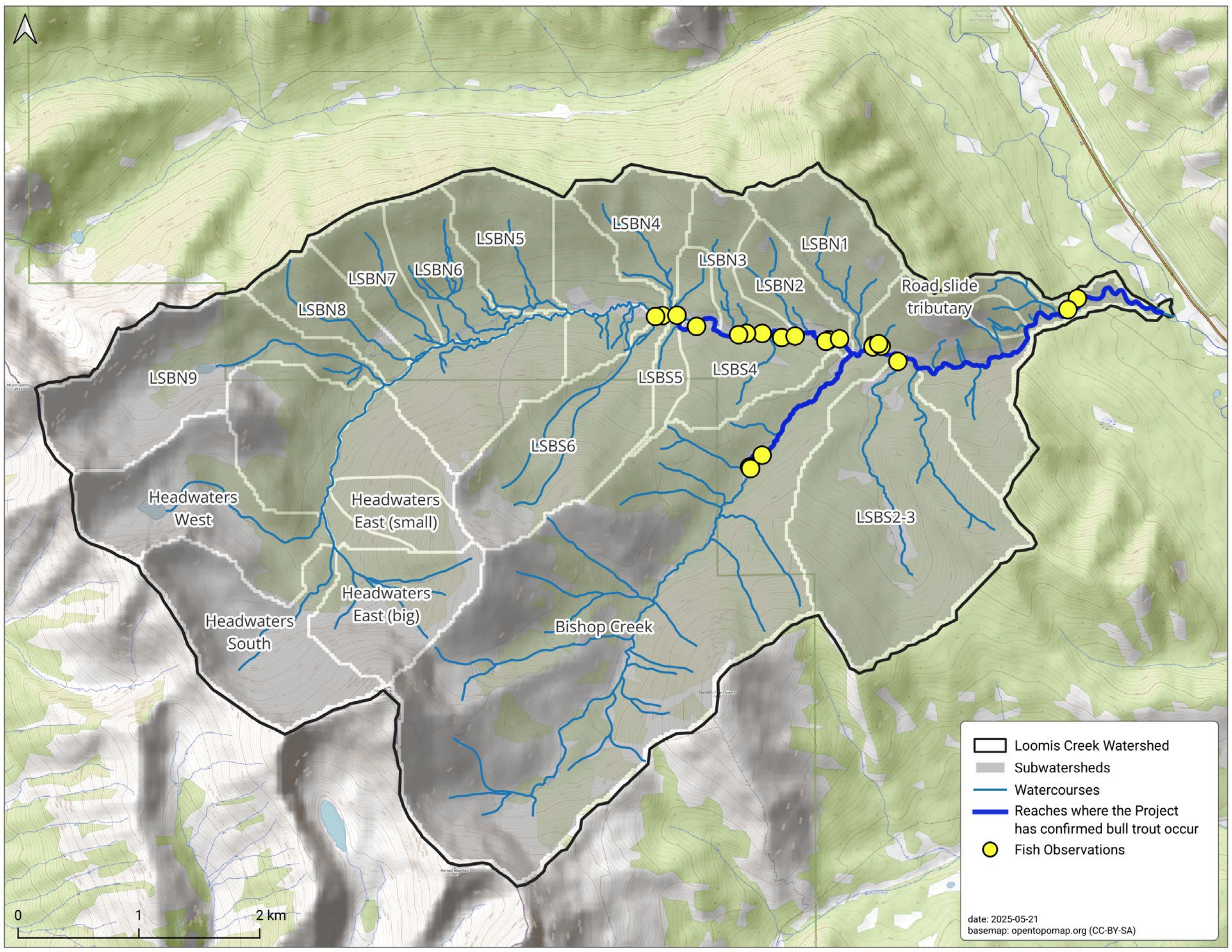


Figure 29. Where bull trout have been confirmed to occur by the Project.

6.11.1 Sampling bull trout environmental DNA

Bull trout eDNA (eSACO3) was detected in all field and laboratory replicates collected on November 21, 2023, at a site on the mainstem of Loomis Creek 500 m downstream of the Bishop Creek confluence (Online Map Site ID: ED1; Coombs 2023). This confirmed the presence of bull trout in Loomis Creek some distance upstream of this point.

On June 30, 2024, additional eDNA sampling on the LSBS2-3 tributary near the mouth of Loomis Creek but upstream from a section of steep gradient (Online Map Site ID: ED2) resulted in bull trout eDNA (gene target labeled eSACO3) being detected in two of the three 1 L field replicate samples (**Table 2**). Bull trout eDNA was detected in all eight of the laboratory replicates from these two field replicates. Lack of detection in one of the field replicates (**Table 2**) is likely due to heterogeneity in eDNA distribution. The three field replicate samples were collected from along the cross-sectional transect of the stream, so a low density of bull trout upstream from the sampling point or uneven mixing across the stream channel could result in one replicate sample not containing the target eDNA.

The samples were collected as flows were subsiding from a peak flow event in the area June 28-29, 2024, because it was thought bull trout may have been more likely to occur in the tributary during this time.

On September 24, 2024, additional eDNA sampling on Loomis Creek in the middle of the beaver meadows (Online Map Site ID: ED3) resulted in bull trout eDNA (gene target labeled eSACO3) being detected in all three of the 1 L field replicate samples (**Table 3**). In each of these, detection occurred in all eight of the laboratory replicates.

Table 2. Detection frequencies of the target sequence of eDNA for the IntegritE-DNA™ assay (/4) and the eSACO3 bull trout assay (/8) sampled from the LSBN2-3 tributary near the mouth.

Field replicate	Filtering time required (min:sec)	Sample volume filtered (ml)	Amplifiable DNA frequency (4 laboratory replicates)	eSACO3 frequency (8 lab replicates)
A	4:00	1000	4/4	8/8
B	4:00	960	4/4	8/8
C	4:00	940	4/4	0/8

Table 3. Detection frequencies of the target sequence of eDNA for the IntegritE-DNA™ assay (/4) and the eSACO3 bull trout (/8) assay sampled from Loomis Creek in the beaver meadows.

Field replicate	Filtering time required (min:sec)	Sample volume filtered (ml)	Amplifiable DNA frequency (4 laboratory replicates)	eSACO3 frequency (8 lab replicates)
A	4:00	2060	4/4	8/8
B	4:00	2020	4/4	8/8
C	4:00	1930	4/4	8/8

6.11.2 Trout observations

Three observations reflect the furthest upstream distribution of trout in Loomis Creek:

- On September 17, 2024, bull trout were observed in Bishop Creek up to a point on the creek near the upstream limit of planned clearcut logging (Online Map Site ID: FO03, **Photo 16**).
- On September 24, 2024, an unidentified trout species was observed near the mid point of the beaver meadows along Loomis Creek (Online Map Site ID: FO21).

- On July 14, 2024, a single unidentified trout species was observed in the LSBS2-3 tributary at the historical logging road crossing.

The trout observations on LSBS2-3 and Loomis Creek were immediately upstream from where bull trout eDNA was detected and support the species occurring at or above these locations. The observation on Bishop Creek was a confirmed bull trout sighting based on diagnostic features observed by Matt Coombs (**Photo 16**).

Bishop Creek is likely the only tributary to Loomis Creek large enough to support bull trout overwintering, although bull trout may occur seasonally in LSBS3 upstream of the confluence with LSBS2. Downstream of the confluence at the historical logging road (near Loomis Creek), LSBS2-3 stopped flowing for approximately one week in September, but sufficient flow to sustain bull trout may have continued at this time further upstream.

Downstream 100 m from the furthest upstream observation of trout on Loomis Creek, where bull trout eDNA was detected, YOY bull trout were observed rearing in calm backwater habitat of an oxbow channel on July 16 and 17, 2024 (**Photo 17**; Online Map Site ID: FO04). YOY are juveniles that hatched in the same year they are caught or observed. YOY were photographed and video recorded while snorkelling on July 17, 2024. This is at a location upstream from the furthest upstream bull trout redd observed in September 2024. It was difficult to confirm the YOY observed were bull trout based on the images collected (*Shona Derlukewich, pers. comm.*), but they were determined as such based on estimated size (30-50 mm total length), lack of evidence of brook trout (see *Section 6.11.4*), and the observations being before YOY cutthroat or rainbow trout would have emerged.

Photo 16. Bull trout observed in Bishop Creek near upstream limit of planned logging.

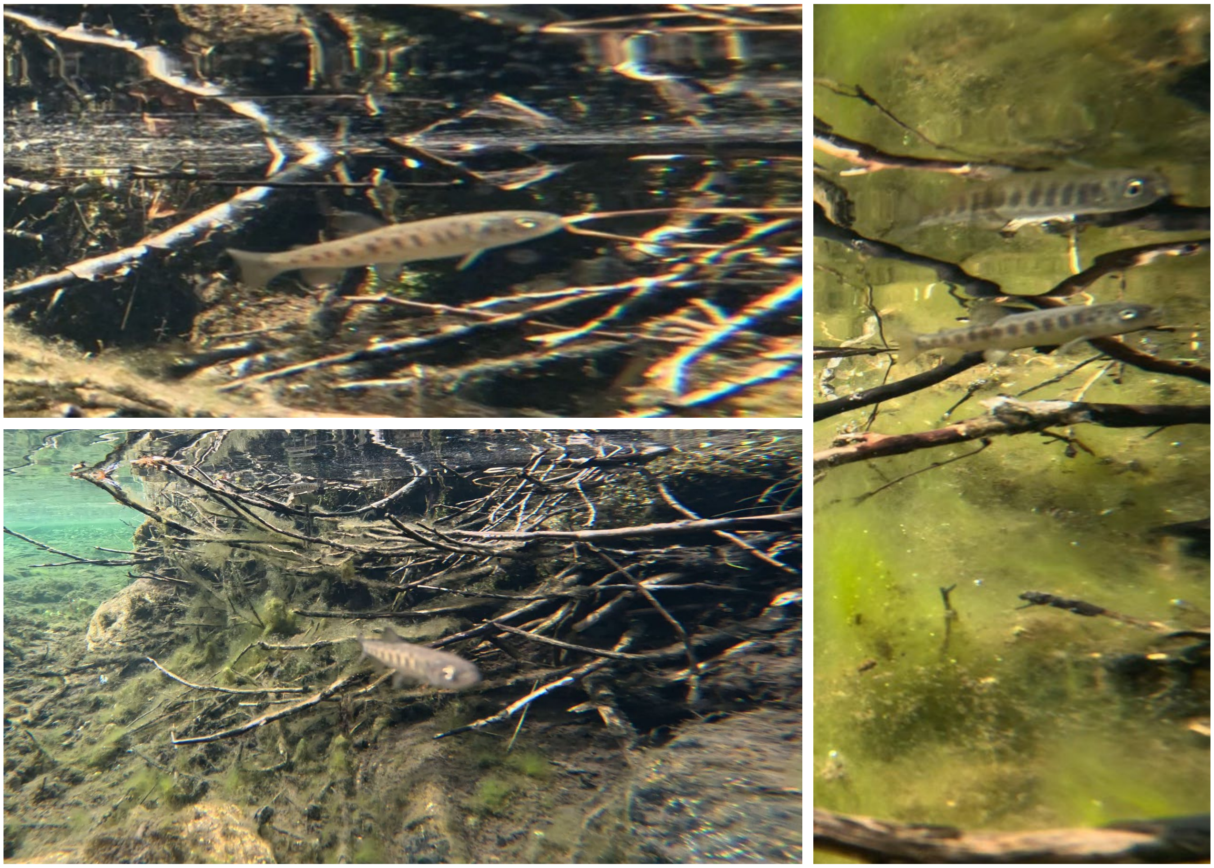


Photo 17. Bull trout YOY in calm backwater oxbow channel habitat on Loomis Creek.

6.11.3 Bull trout spawning

No bull trout redds were observed on Loomis Creek when the reach from the Highwood River to a point near the confluence of Bishop Creek was surveyed September 13, 2023. Juvenile trout were observed in this reach during the survey but not confirmed to be bull trout. One bull trout redd was observed in the Highwood River near the Highwood River bridge WFC had recently constructed and a short distance downstream of the Loomis Creek confluence during the redd survey of the Highwood River on the same day (**Figure 30**). Three additional bull trout redds were observed on the Highwood River within the zone of influence of WFC's AOP by Dave Mayhood on September 22 and October 9, 2023.

The first redd survey conducted on Loomis Creek in 2024 was on September 14, following a redd being observed with bull trout present on it during channel morphology measurements at the downstream end of the beaver meadows on September 11, 2024. The survey was conducted where the stream gradient of Loomis Creek is lower, from the Low Gradient Crossing to the upstream extent of the beaver meadows (**Figure 30**). Twelve bull trout redds were observed. A follow-up survey was conducted on September 24, 2024, and no additional redds were found. All redds were observed in an approximately 1 km reach of Loomis Creek in the downstream portion of the beaver meadows (**Figure 30**).

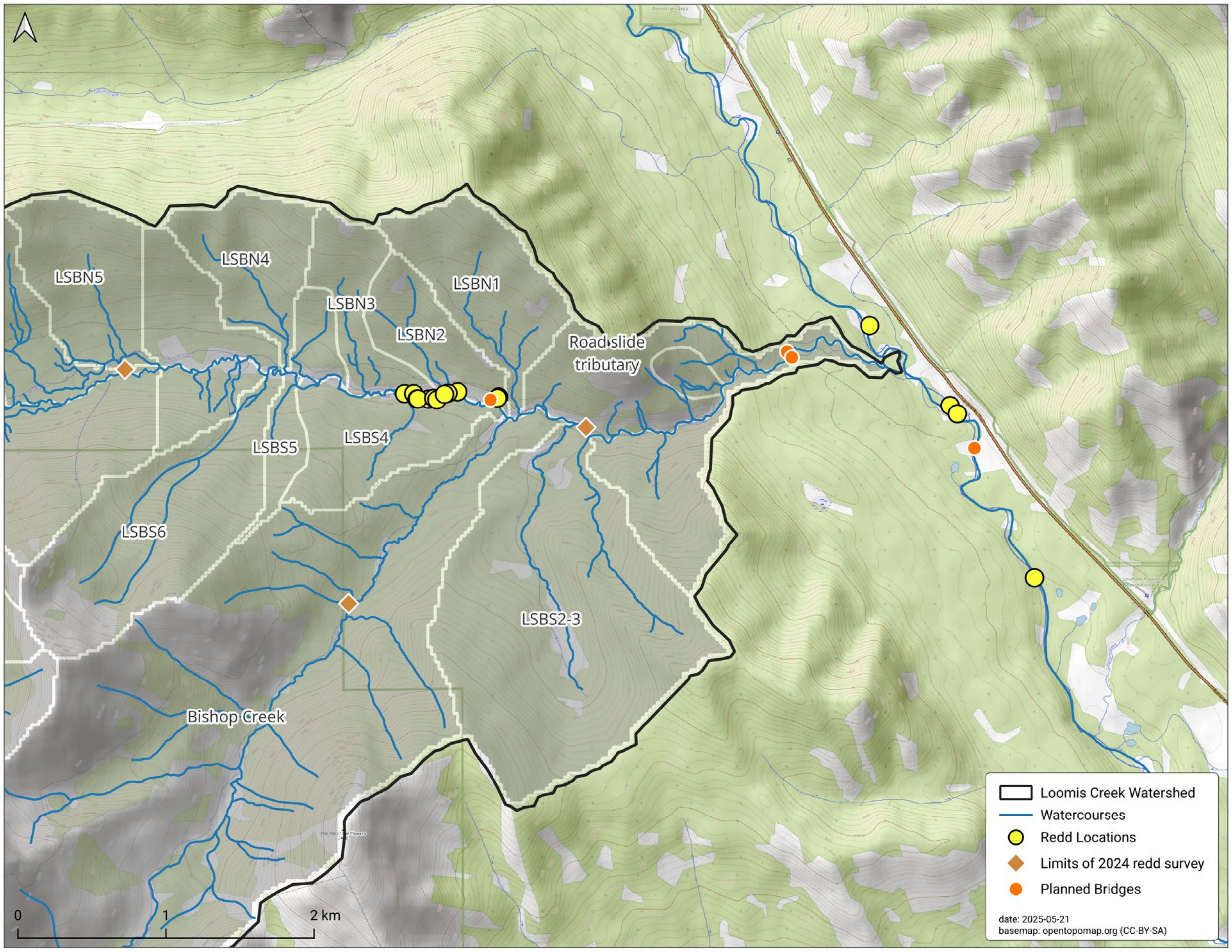


Figure 30. Start and end locations of 2024 bull trout spawning surveys on Loomis and Bishop creeks, 12 redds on Loomis Creek in 2024, four on the Highwood River in 2023.

Bull trout were observed at three of the redds, with active redd construction and spawning observed at one of the redds (Online Map Site ID: RLL07, **Photo 18**). The largest male bull trout observed was estimated to be 40 cm in length, while the female observed was smaller. Redds ranged in length from 0.8 m to 2.8 m.

A redd survey was also conducted on Bishop Creek on September 16, 2024, from the mouth to a point near the Don Getty Wildland Provincial Park boundary (**Figure 30**). No redds were observed. Whether bull trout spawn in Bishop Creek is unknown, but the species was observed throughout most of the reach surveyed, so it is used for feeding and rearing.

6.11.4 Sampling brook trout environmental DNA

While there are no records of brook trout being captured in Loomis Creek, there are records of brook trout being stocked in Loomis Creek in 1947 and 1949 (6,700 and 400 fish, respectively; see Fish Culture Stocking records in FWIMT at 50.4333 -114.8667), and the

Photo 18. Pair of bull trout spawning in Loomis Creek, male on the right.

species has been captured in beaver ponds along the Highwood River near Loomis Creek as recently as 2007 (e.g., see records in FWIMT at 50.4811 -114.7983 and 50.4643 -114.7782). Therefore, the eDNA samples from the sample station in the beaver meadows were tested for brook trout eDNA.

Brook Trout eDNA (eSAFO6) was not detected in any of the three 1 L field replicate samples (**Table 4**), consistent with previous electrofishing efforts in Loomis Creek that only captured bull trout and not brook trout.

Table 4. Detection frequencies of the target sequence of eDNA for the IntegritE-DNA™ assay (/4) and the eSAFO6 brook trout (/8) assay sampled from Loomis Creek in the beaver meadows.

Field replicate	Filtering time required (min:sec)	Sample volume filtered (ml)	Amplifiable DNA frequency (4 laboratory replicates)	eSAFO6 Frequency (8 lab replicates)
A	4:00	2060	4/4	0/8
B	4:00	2020	4/4	0/8
C	4:00	1930	4/4	0/8

6.12 Cattle grazing

During the Project in September 2023 and 2024, cattle from along the Highwood River were driven up into the Loomis Creek watershed by ranchers to graze in the beaver meadows and surrounding forest. These cattle were held within this upper portion of the watershed by a solar powered electric fence that crossed the steep valley of Loomis Creek on the historical logging road at a point between the Boulder Crossing and Low Gradient Crossing. Trampled bull trout redds and disturbance of riparian areas leading to erosion and sedimentation of spawning habitat were observed (**Photo 19**). Additional photos and locations of these impacts can be viewed on the Online Map.

7 Logging plan layout issues

All road crossings of water features associated with the logging plan will damage or destroy designated bull trout critical habitat wherever they are built. This is because all mapped and unmapped water features in the watershed are connected to, and support, habitat that bull trout rely on in the Loomis Creek watershed and therefore meet the definition of critical habitat in the SARA recovery strategy. Unless a clear span bridge is built over both the SARA designated 30 m riparian buffer around these water features and the in-stream habitat, SARA-listed riparian critical habitat will be damaged or destroyed. The location where a logging road is planned to cross Loomis Creek immediately upstream from where bull trout redds were found is one example of this (**Photo 2**), but every location where a planned road crosses mapped and unmapped water features within the logging plan will result in some riparian and possibly some instream critical habitat damage or destruction.

Many road crossings of water features are identified in the AOP logging plan within cut blocks and yet there is no forested buffer associated with the same water feature (**Figure 31**). This is inconsistent because if there is enough water to require a watercourse crossing structure for road construction, the SARA designated 30 m riparian buffer should also apply. This indicates that there are many water features within the cut blocks where the 30 m riparian buffer has not been applied. Some of the water feature road crossings that have no riparian buffer are identified on the Wet Area Mapping layer, while others are not.

Critical habitat damage or destruction associated with the logging plan will not just occur at watercourse crossings. Roads and cut blocks also parallel watercourses and overlap the designated 30 m SARA riparian critical habitat buffer. This is the case on both mapped and unmapped water features throughout the Loomis Creek watershed. At some locations the 30 m SARA riparian critical habitat buffer was not applied from the forested boundary around wetland areas, but instead just from the high-water mark on the watercourse within the wetland. This is despite the vegetation around the watercourse reflecting a broader area of wetland. Wetlands directly support bull trout critical habitat through floodwater and groundwater storage and gradual release as well as supporting the aquatic food chain.

Photo 19. Cattle damage to bull trout spawning habitat and riparian habitat on Loomis Creek.

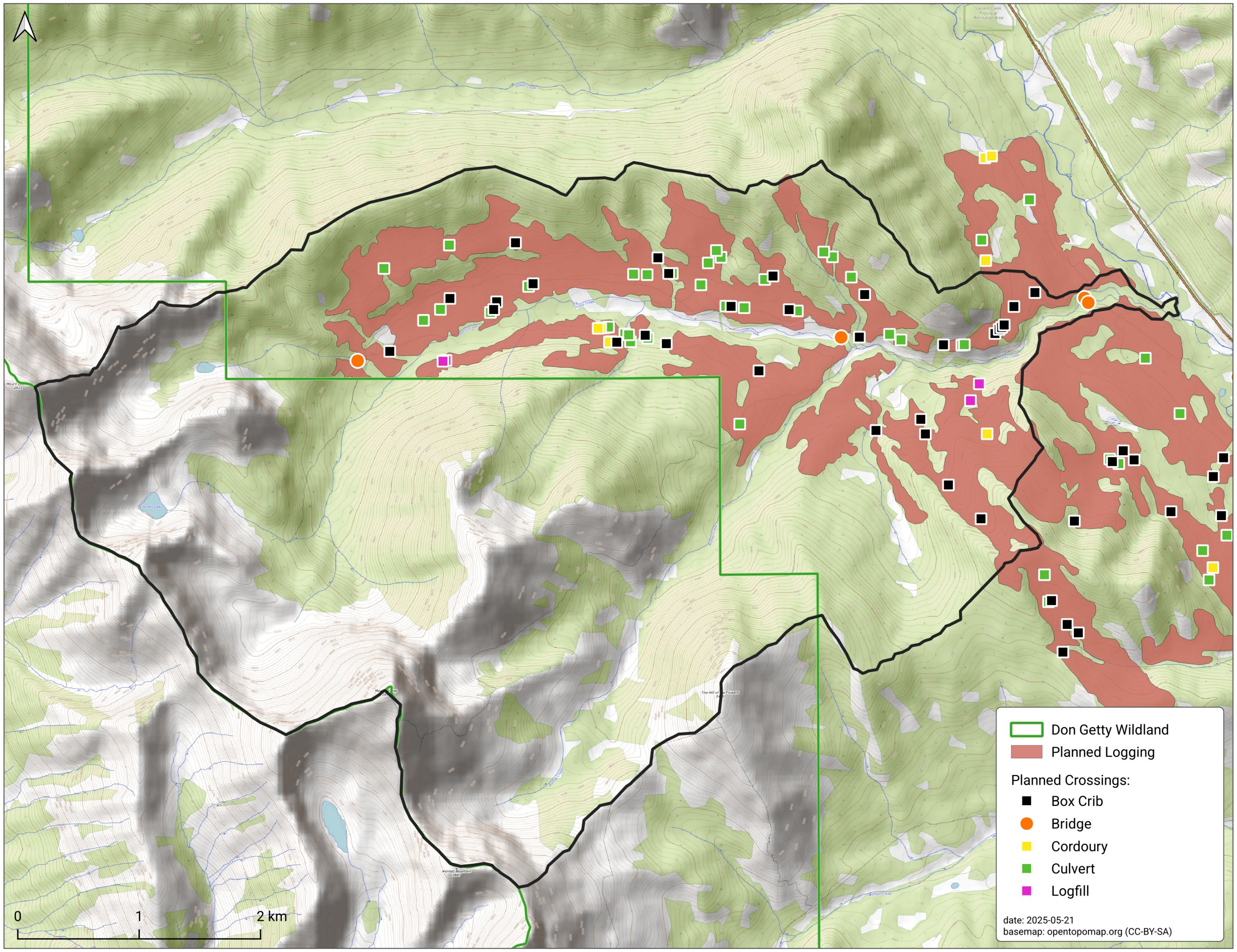


Figure 31. Planned crossings where roads are on a water feature that has not been buffered out of the cut block.

Specific examples of logging plan layout issues are summarized below and tabulated in **Appendix II**.

OGR-related layout issues were identified in the following categories:

- Planned roads on unstable ground vulnerable to land slides into creek
- Loomis Creek is misclassified as a small permanent stream despite having an average channel width greater than 5 m adjacent to the planned logging
- Planned clearcut logging within the applicable 60 m OGR riparian buffer for large permanent streams
- Planned roads within the applicable 100 m OGR riparian buffer for large permanent streams
- Planned roads crossing mapped and unmapped water features without planned watercourse crossing structures identified
- Meadows with clearcut to the forest boundary with no buffer
- The Loomis Creek beaver meadow is crossed by a road

7.1.1 Roads near and immediately upstream of spawning habitat

At one site (Online Map Site IDs: LI17, RLL01, RLL02) the historical logging road and the planned logging road overlap for approximately 300 m, paralleling Loomis Creek, and coming within approximately 10 m of where bull trout were observed spawning (**Photo 20**). At this location the road is on the edge of a steep bank above the creek. The planned road may have been placed here to overlap with the footprint of the historical logging road and minimize an increase in footprint. However, it lies on a steep bank above the creek. The risk of erosion and sedimentation from the road is high here at the same location where bull trout critical habitat is most sensitive (spawning, egg incubation, juvenile rearing). The proximity of the road to the creek, the steep slope between the road and the creek, and the limited vegetation between the road and the creek to act as a filtering buffer all increase the risk that bull trout will be harmed and critical habitat will be damaged by erosion and sedimentation.

The planned logging road crosses Loomis Creek at two locations:

1. the existing Blowout Crossing near the Highwood River
2. a new crossing 240 m upstream from the Bishop Creek confluence

The Loomis Creek crossing upstream of Bishop Creek (Online Map Site ID: LI23) is approximately 75 m upstream from the location described above where bull trout were observed spawning (Online Map Site IDs: LI17, RLL01, RLL02; **Photo 2**). The planned road will cross the downstream limit of the beaver meadows. Constructing and operating a bridge crossing over bull trout critical habitat immediately upstream from where spawning occurs is high risk. It could impact bull trout spawning, egg incubation, and juvenile survival. It also does not adhere to OGR Section 2.8.4, which state that in core and secondary grizzly bear management zones, roads and skid trails must avoid natural meadows, because the road crosses the downstream portion of the beaver meadows.

Photo 20. Location where a cut block boundary and planned road overlap the historical road and are within 10 m upslope from Loomis Creek where two bull trout redds were observed.

7.1.2 Loomis Creek misclassified as a small permanent stream

The bankfull width of the mainstem of Loomis Creek was measured at 10 sites adjacent to the planned logging from the Don Getty Wildland Provincial Park boundary downstream to the mouth near the Highwood River and the average bankfull width was 5.2 m (**Table 5**). Therefore, Loomis Creek was misclassified by WFC as a small permanent stream, because Table 4 of the OGRs state large permanent streams have a non-vegetated channel width greater than 5 meters. Table 6 of the OGRs requires buffer widths of 60 m buffer for cut blocks and 100 m buffer for roads along large permanent streams. These widths are being encroached on by planned logging roads and cut blocks along Loomis Creek.

Table 5. Bankfull widths at 10 Loomis Creek sites adjacent to the planned logging.

Online Map Site ID	Latitude	Longitude	Bankfull width (m)
CM11	50.46493	-114.872	3.9
CM16	50.46724	-114.86	5.5
CM19	50.46735	-114.845	4.8
CM25	50.46568	-114.824	4.8
CM29	50.46483	-114.821	4.6
CM31	50.46409	-114.815	4.9
CM32	50.46365	-114.811	6.8
CM34	50.46743	-114.799	5.1
CM35	50.46952	-114.793	6.1
CM36	50.46801	-114.788	5.7
			Average: 5.2

7.1.3 Cut blocks overlap large permanent stream riparian buffer

According to Table 4 of Section 2.17 (Aquatic and Riparian Area Protection) of the OGRs (Government of Alberta 2024), large permanent streams should have no disturbance or removal of timber within 60 m of the high-water mark. However, along the length of Loomis Creek portions of the cut blocks overlap this prescribed 60 m buffer (**Figure 32**). Some areas where cut blocks are within this 60 m prescribed buffer are near the Loomis Creek-Highwood River confluence, the Bishop-Loomis creek confluence, and upstream of the beaver meadows near the Don Getty Wildland.

According to Table 6 of Section 2.17 (Aquatic and Riparian Area Protection) of the OGRs (Government of Alberta 2024), watercourses with deeply incised unvegetated banks should have the buffer measured from the top of the incised valley. There are portions of Loomis Creek that are in a deeply incised valley, and in some cases, localized areas of the banks are unvegetated (e.g., **Photo 7**, see Online Map Site IDs ER05-ER08 for other examples), and yet the OGR buffers were not always been measured from the top of the valley but instead from the Loomis Creek highwater mark in the steep valley.

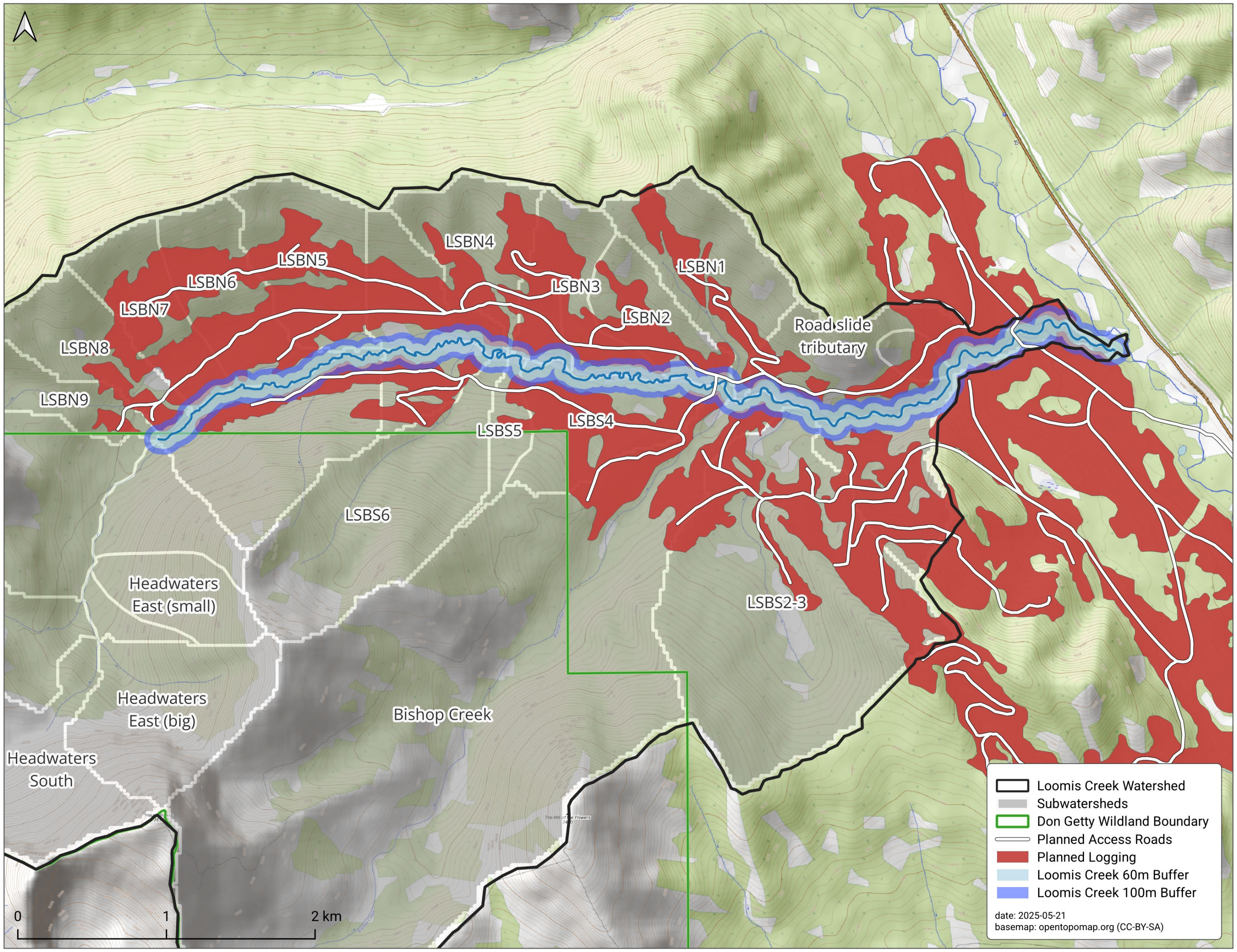


Figure 32. Parts of planned road and cut blocks within respective 100 m and 60 m buffers on large permanent streams.

7.1.4 Planned roads may overlap unstable ground

The historical logging road slid into Loomis Creek at latitude, longitude 50.466773 -114.802774, (Online Map Site ID: ER01, **Photo 21**). This occurred immediately adjacent to where the road crossed the Road Slide Tributary where there are groundwater saturated soils and steep slopes. The new planned road crosses other locations like this, and there is concern that the instability of ground has not been accounted for in road layout. The OGR best management practice is to avoid road slides from occurring by avoiding environmentally sensitive areas such as sensitive soils (e.g., erodible soils), waterbodies, and steep or unstable slopes (Government of Alberta 2024). The planned road crosses a steep groundwater saturated slope on the north side of Loomis Creek downstream of Bishop Creek (e.g., Online Map Site ID: CO133, **Photo 22**). Other locations in this area may also be vulnerable to landslides but were not photographed in 2024 (i.e., Online Map Site IDs: LI46, LI47, LI48, LI49).

7.1.5 Planned cut blocks overlap small permanent stream riparian buffer

According to Section 2.17 (Aquatic and Riparian Area Protection) of the OGRs (Government of Alberta 2024), small permanent streams with channel widths 0.7-5.0 m, even if they dry up during periods of drought, should have no disturbance or removal of timber within 30 m of the high-water mark. It was observed that this buffer width has not been followed in some locations, even on some of the largest tributaries to Loomis Creek. A summary of whether tributaries might meet the OGR definition of small permanent streams with this riparian buffer and whether existing riparian buffers are less than 30 m are summarized in **Appendix II**, **Table II- 1**.

7.1.6 Cut blocks predominantly on south facing slopes

The distribution of slope aspect over the planned clearcut areas within the Loomis Creek watershed showed that nearly 50% of the area has a southern aspect (24.8% south facing, 23.2% southeast facing; **Figure 33**). Snow melt will occur more rapidly in these areas due to greater solar radiation and lack of shading due to forest removal, resulting in earlier and higher peak flows in the tributaries draining these areas.

7.1.7 Planned roads cross streams with no crossing structure planned

Planned roads cross mapped and unmapped streams with no crossing structure shown on the AOP. Examples of these locations are summarized in **Appendix II, Table II- 2**.

7.1.8 Wetlands not buffered with 30 m SARA critical habitat buffer

Throughout the Loomis Creek watershed there are planned clearcut areas within 30 m of various types of wetland habitats or overlapping these areas. This is despite the 30 m SARA buffer apparently applying to all water features that support bull trout critical habitat by storing and supplying water and nutrients to lower elevation streams where bull trout occur.

Photo 21. Section of historical logging road situated on saturated soils that slid into Loomis Creek.

Photo 22. Steep slope with saturated soils above Loomis Creek that the planned logging road crosses.

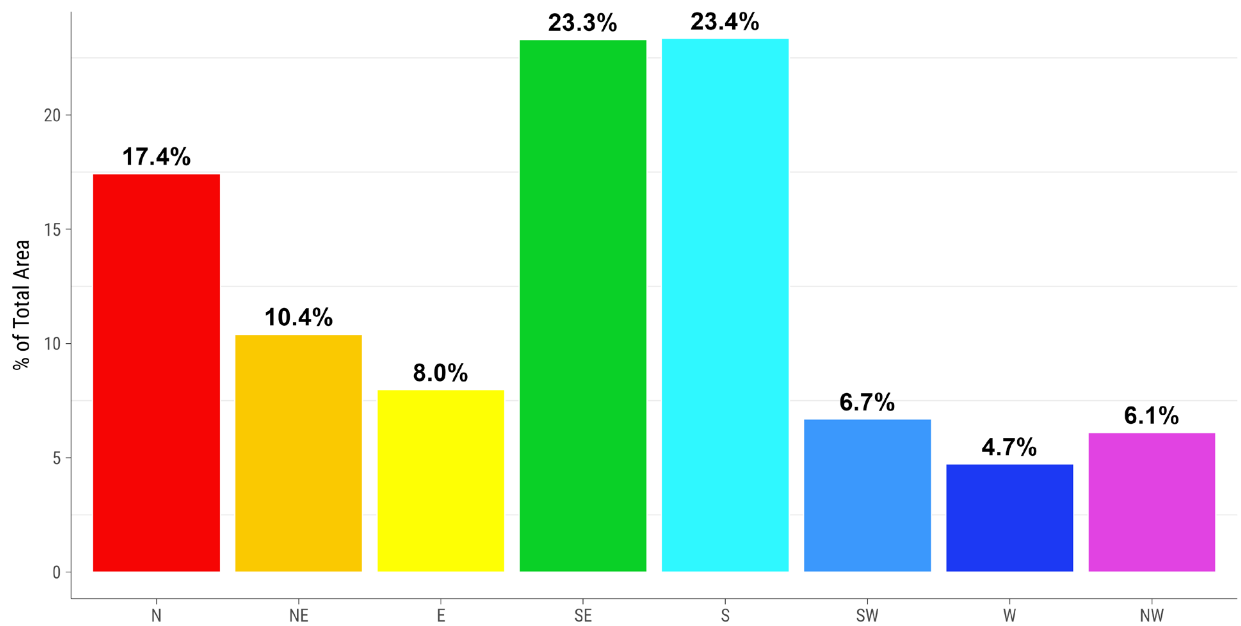


Figure 33. Direction slopes are facing for the planned clearcuts in Loomis Creek watershed.

The OGRs state that "forest industry activities including forest harvest, road construction and use, crossings and other associated activities should avoid wetlands as a first step where feasible" and that "avoidance should always be the primary consideration for any activity that could adversely affect wetlands" (Government of Alberta 2024). However, as described above, the logging plan crosses the beaver meadows on Loomis Creek, which are wetlands where bull trout are spawning (**Photo 2**). There are also locations where planned cut blocks overlap wetlands or are laid out right up to the boundary of wetlands without a 30 m SARA critical habitat buffer. These include sites along the beaver meadows in the mid reach of Loomis Creek, sites adjacent to other wetlands along Bishop Creek and LSBS2 and LSBS3 tributaries, and sites adjacent to other wetland areas throughout the watershed (**Figure 34**). These sites are summarized in **Appendix II**, **Table II- 3**.

Planned clearcut logging areas overlap with 1.67 ha of areas mapped by either the Alberta Biodiversity Monitoring Institute or Bow River Basin Council as wetlands in the Loomis Creek watershed (**Figure 34**), while these logging areas overlap 26.7 ha of area mapped by Alberta's Wet Area Mapping (WAM) layer in the watershed (**Figure 35**). It would be precautionary to avoid any forest removal overtop of wetlands, WAM areas, or within 30 m of these areas, unless on-the-ground surveys during the wettest period of the year show these areas are not connected to groundwater or surface water. Both Alberta's WAM layer and wetland information (Derived Ecosite Phase) are listed in the OGRs as information that may be useful when developing a harvest area design (Government of Alberta 2024).

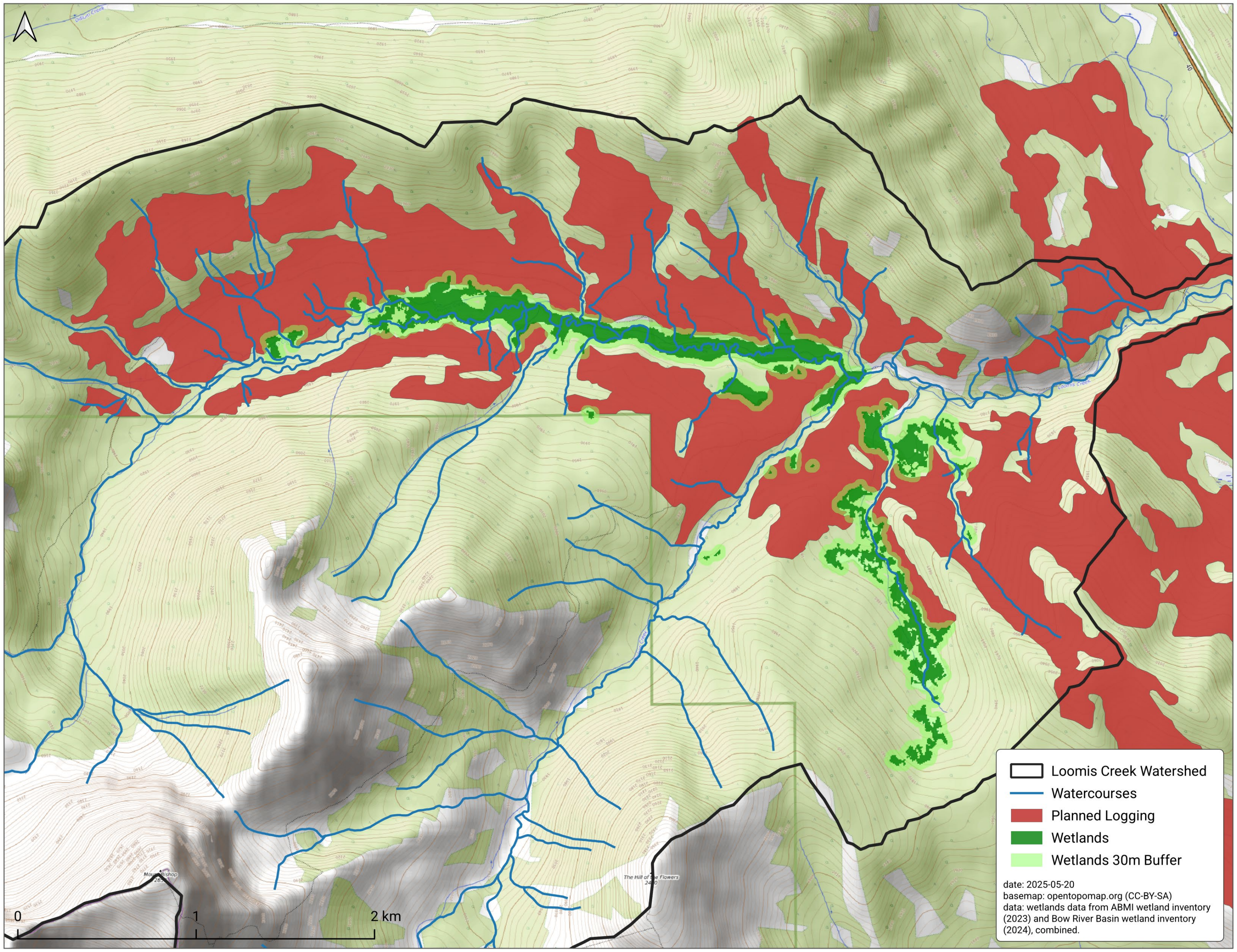


Figure 34. Planned logging overlapping or within 30 m of areas mapped as wetlands.

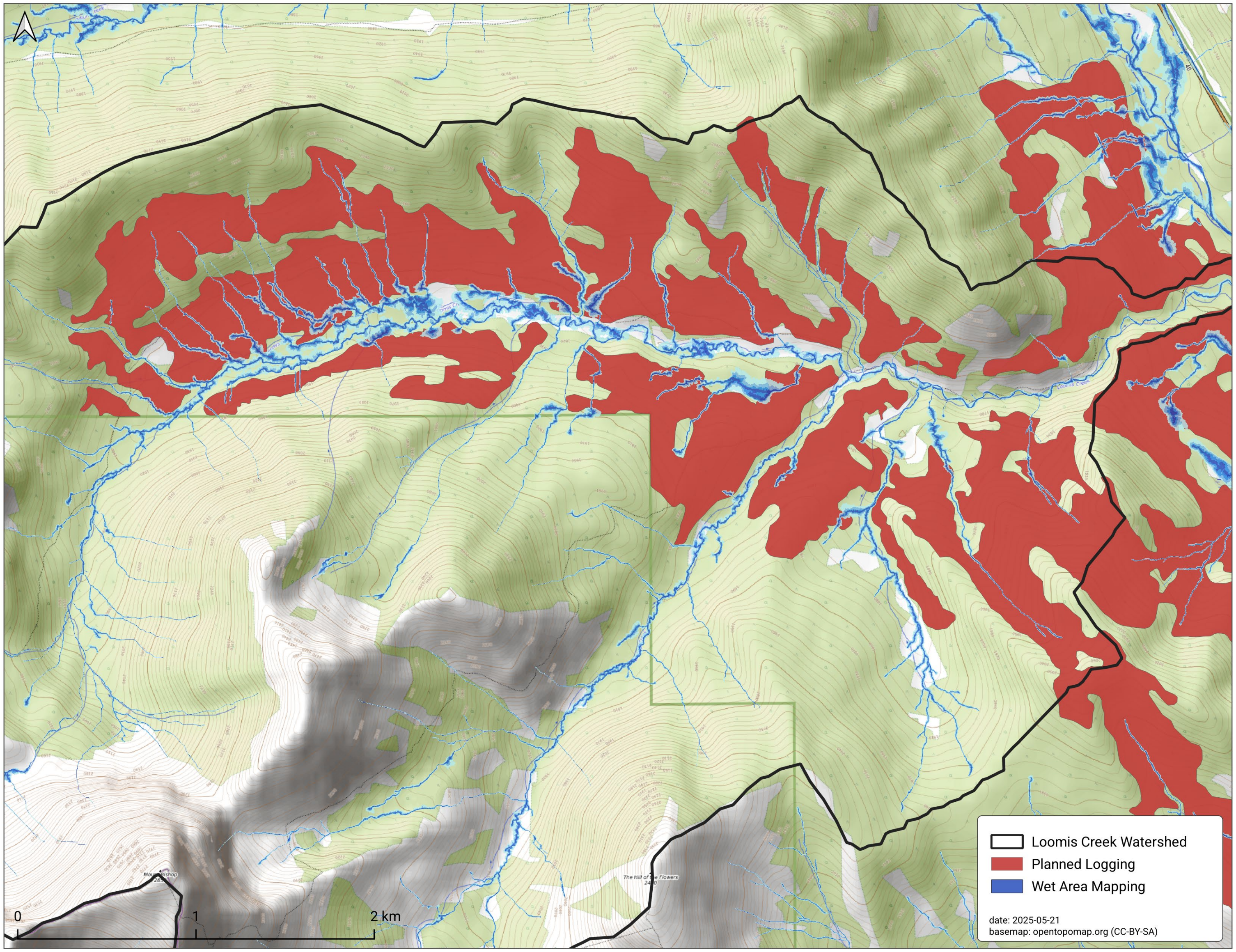


Figure 35. Planned logging overlapping parts of the provincial Wet Area Mapping layer.

8 Discussion

8.1 Summary of Phase 1 results

The Loomis Creek eco-hydrology Phase 1 study completed a coarse scale assessment of:

1. channel morphology, geometry, and bedload of Loomis Creek and tributaries,
2. disturbance history of flood, fire, and logging in the watershed focusing on the effects on stream channels and riparian areas,
3. discharge and spatial patterns in stream flow, temperature, electrical conductivity, and TSS,
4. distribution of bull trout and where spawning and rearing habitat is in relation to changes in channel morphology and the planned logging footprint, and
5. locations where the logging plan is a risk and does not follow required buffers.

The entire length of Loomis Creek surveyed from the headwaters to the Highwood River is an alluvial stream channel, showing signs of past flood disturbance throughout. There is a transition from a semi-alluvial step pool morphology in the headwaters, to a riffle pool morphology throughout the mid reach and beaver meadows, and back to a semi-alluvial cascade with boulder and step pool morphology on the lower reaches (**Figure 13**). Historical logging was selective along the headwaters of Loomis Creek, while historical wildfire covered the lower half of the watershed (**Figure 2**), but these disturbances are not currently associated with signs of erosion, incisement, bank instability, or lack of LWD on the mainstem channel of Loomis Creek.

All south side tributaries that were assessed (Bishop Creek, LSBS6, and LSBS2-3) and four of the north side tributaries (LSBN1, LSBN5, LSBN8, LSBN9) have alluvial channel morphologies. Another six north side tributaries are primarily groundwater fed or intermittent and do not have alluvial channel morphologies (Road Slide Tributary and LSBN2, LSBN3, LSBN4, LSBN6, and LSBN7). At sites surveyed across the watershed, subwatershed characteristics, including the area above tree line and the predominant slope aspect, are reflected in trends of increasing channel cross-sectional area (m^2) and D90 (cm) with upstream drainage area (km^2). This result aligns with the hydrologic model predictions that the planned clearcut logging will increase mean annual flow by 9% and 2- and 20-year peak flows by 9-10% as well result in earlier and more rapid freshet (Chernos et al. 2024).

Even though historical logging in the 1940s-1960s was selective harvest only and covered a smaller portion of the subwatersheds on the North side of Loomis Creek, disturbance of some of the tributary channels downstream of this logging is still evident. Although not to the same extent as clearcut logging, selective harvest may have still increased snow accumulation, rate of melting, and runoff, leading to more flashy and erosive flow in tributaries. On LSBN9, a large amount of sediment has moved downstream since historical logging occurred (**Photo 13**), leading to channel aggradation and to avulsion and localized sections of the historical logging road being washed out. Channel incisement on LSBN5 and LSBN4 has also occurred adjacent to logged areas (**Photo 14**). Although signs of sediment inputs into Loomis Creek from LSBN9, LSBN5, and LSBN4 are not apparent now, signs of this may have disappeared over time. Similarly, channel disturbance resulting from hydrologic changes after historical logging in the other subwatersheds (LSBN6, LSBN7, and LSBN8) may have occurred but since disappeared.

Two days of sampling showed that TSS levels are highly variable spatially and temporally in the watershed. After several days of rain throughout southern Alberta, TSS was lower in Loomis Creek (6 mg/L) than the Highwood River (16 mg/L). However, on another day when TSS in Loomis Creek in the beaver meadows and Highwood River was <1 mg/L, a few hours of localized rain on an eroding bank escarpment downstream of the beaver meadows resulted in TSS increasing rapidly downstream of the escarpment and was 367 mg/L at the mouth of Loomis Creek. The escarpment was the only significant point source of TSS found in the Loomis Creek watershed. Prolonged TSS exposure even at lower concentrations can result in sublethal to lethal effects on trout eggs and larvae (Newcombe & Jensen 1996), but because the escarpment is located downstream from where bull trout spawning and rearing were occurring, the population-level effects on the bull trout may not be significant. Juveniles (2–3-year-old) and adults presumably still occupy the lower reaches of Loomis Creek, migrating back upstream to the beaver meadows to spawn. The elevated TSS measured at the mouth of Loomis Creek maintained over 5-10h would only be expected to cause “moderate physiological stress and moderate habitat degradation” to juvenile salmonids (Newcombe and Jensen 1996), although longer exposure could cause mortality.

Loomis Creek discharge declined over the summer and fall, reflecting a snowmelt dominated hydrograph. Flow in the creek doubles from the headwaters to the downstream limit of the beaver meadows. Tributary inputs do not amount to this increase, suggesting there is significant exchange of surface and hyporheic flow, with different reaches having more upwelling or downwelling. Flow may remain more constant along Loomis Creek downstream of Bishop Creek and the Highwood River. This may be because tributary and groundwater inputs are minimal downstream of Bishop Creek, which contributes 30-40% of the combined instantaneous flow at the confluence with Loomis Creek. Other tributaries with significant flows are LSBN9, LSBN8, LSBS6, LSBS2-3, and the Road Slide Tributary.

Headwater snowmelt and groundwater keep the temperature of Loomis Creek where bull trout occur well below an upper threshold of 14°C mean August temperature. Stream temperature and electrical conductivity on tributaries was consistent with whether the source of flow appeared to be predominantly surface runoff and snowmelt or groundwater.

Where bull trout were observed spawning and rearing in the beaver meadows highlights that the mid reach of Loomis Creek is the highest quality fish habitat in the watershed. This reflects the low gradient, apparent high-volume exchange of surface to hyporheic flow, fine grainsize and mobile bedload allowing for spawning and rearing, and riffle-pool morphology across a broad floodplain. Suitable low-velocity habitats (e.g., pools, back eddies, side channels, oxbows, beaver ponds) provide habitat for juvenile and larger fish to feed and overwinter. Bull trout likely occur upstream into the headwaters of Loomis Creek but were only confirmed halfway up the beaver meadows. On Bishop Creek, bull trout were observed near the upper limit of where logging is planned.

Issues with the layout of the logging plan include:

- Roads and clearcut blocks overlap the required provincial OGR buffers on streams and overlap federal SARA critical habitat riparian buffers on some mapped and unmapped water features, including wetlands. This includes a planned road on a steep slope within 10 m of where bull trout were spawning, and a road and bridge over the beaver meadows along Loomis Creek immediately upstream from where bull trout were spawning.
- A road overlaps steep slopes on the North side of Loomis Creek that appear to be groundwater saturated near where the historical road slumped into Loomis Creek.
- Roads cross some streams without any watercourse crossing structure identified.
- Cut blocks are predominantly on south facing slopes, which receive the highest amount of solar radiation, resulting in rapid snowmelt and higher erosive peak flows.

8.2 Anticipated hydrologic impacts of the logging plan

1. Relative to the size of the Loomis Creek watershed, the logging plan will result in an Equivalent Clearcut Area (ECA) of 19%, which is considerably higher than in other subwatersheds in the Highwood River watershed. As reported by Chernos et al. 2024, the next highest subwatersheds in terms of percent of total area clearcut are Wilkinson Creek (8% + 3% juvenile stands) and Lower Cataract Creek (6% + 4% juvenile stands). While there has been historical logging and wildfire disturbance in the watershed and the bull trout population has persisted, the resulting hydrologic changes were not as large as those predicted by the current logging plan. Historical logging was selective harvest and spread out over 2-3 decades from the 1940s to 1960s. It also covered a much smaller area than the planned logging. The historical wildfire of 1936 only covered the lower half of the watershed where the snowpack and resulting runoff are much lower. The most hydrologically sensitive and reactive headwaters were not burned. The wildfire was also a patchy disturbance that did not result in total forest removal like the planned clearcuts.
2. Hydrologic modelling shows there is potential for the logging to increase mean annual flow by 9% and 2- and 20-year peak flows by 9-10% (Chernos et al. 2024). The freshet will also occur earlier and be more rapid, and peak flows will become more variable. These hydrologic changes are predicted on both the mainstem of Loomis Creek and to varying degrees on the tributaries draining subwatersheds where logging occurs. The entire mainstem channel and tributaries downstream of the logging will be susceptible to much higher rates of bedload mobility.
3. Local incisement, avulsion, aggradation, degradation in the tributary channels may result in fine and coarse sediment being deposited into Loomis Creek. Entrenchment already observed after the historical logging on LSBN4 and LSBN5 may increase and appear on other tributaries. Peak flows may displace functional LWD jams that are retaining bedload material, leading to more rapid channel erosion. Increased flows could flush sediment down to the beaver meadows causing channel aggradation and avulsion. Signs of aggradation is already visible immediately above the beaver meadows (**Photo 6**, Online Map Site ID CO104).

4. While areal photos show that the stream channel in the beaver meadows has remained relatively stable between 1949 and present (**Photo 23**), this habitat stability is not predicted to last with the hydrologic changes resulting from the logging. This is because the mid reach of Loomis Creek meanders over a broad floodplain of finer bedload material formed by glacial retreat and subsequent centuries of beaver activity. The entire stream bedload is already mobile under the current flow regime. Finer bedload material starts moving at 60% of bankfull flows and the amount of bedload movement increases as flows increase. The predicted increases in stream flow will result in more bedload movement as the D90 (cm) increases. Degradation and aggradation on the mainstem will be greater than has occurred under a natural disturbance regime.

Photo 23. Comparison of historical (1949) and recent (2013) imagery of a section of Loomis Creek in the beaver meadows showing channel stability over 64 years.

5. Bull trout have significant levels of spawning site fidelity, building redds in the same location year after year. Changes in channel morphology could reduce the quantity and quality of bull trout spawning and rearing habitat, and microhabitat sites with appropriate hyporheic groundwater exchange could be damaged or destroyed. The channel cross-sectional area (m^2) to upstream watershed area (km^2) showed the active channel bankfull area was reduced at the downstream limit of the beaver meadows where bull trout spawning was observed (**Figure 14**). This is consistent with bull trout selecting areas of hyporheic downwelling as spawning sites (Baxter and Hauer 2000) and suggests surface flows in the mainstem of Loomis Creek are lost to subsurface flows near the downstream limit of the beaver meadows.

   If the Loomis Creek stream channel within the beaver meadows becomes incised and entrenched, YOY will not be able to access calm backwater oxbow channel habitat for rearing. Cumulatively, these changes could reduce the availability, suitability, productivity of the only spawning and rearing habitat available to sustain the Loomis Creek population. With hydrologic changes predicted to last at least 50 years as the forest regrows following being clearcut, and with bull trout generation time being approximately 7 years, the population may not be able to be maintained.

6. Planned logging is also going to cause direct physical loss of riparian areas, damage or destroy instream critical habitat, and put bull trout at risk of reduced survival and growth or mortality if roads result in erosion and sedimentation.

8.3 Phase 1 insights

8.3.1 Logging disturbs tributary channel morphology

Historical logging has disturbed the channel morphology of some of the tributaries on the north side of Loomis Creek. These tributaries drain subwatersheds with south facing aspects. The clearest examples of this are the LSBN9 and LSBN5 subwatersheds. Channel incisement was observed along most of the length of LSBN5 from the headwaters to the mouth near Loomis Creek. Large amounts of sediment movement on LSBN9 have resulted in channel avulsion and the historical logging road has been washed out. Therefore, even though historical logging was less extensive than the planned logging will be in these subwatersheds and was selective harvest resulting in just partial forest removal rather than clearcut, LSBN9 and LSBN5 show that south facing subwatersheds are hydrologically reactive to forest removal. Even though LSBN5 is a smaller subwatershed with lower elevation than LSBN9, channel disturbance was still observed.

Clearcut logging would increase the depth of the snowpack more than historical logging did, and rapid early onset melting will likely result in more erosion than the historical logging did. This could result in sediment entering Loomis Creek. Excess fine sediment is harmful to bull trout, particularly when exposure is long lasting and particularly for eggs, YOY, and juveniles that are unable to move away from areas with high TSS. Excess course bedload material (i.e., cobble) can also be harmful in areas where bull trout spawn, because it is too large to allow redds to be built for spawning. There likely have already been inputs of fine sediment from LSBN5 and course bedload material from LSBN9 into

Loomis Creek following historical logging, and these inputs could increase with larger hydrologic changes associated with the planned logging.

8.3.2 Tributary channel cross-sectional area reflects subwatershed characteristics

The cross-sectional area of the bankfull flow in tributary channels is a proxy for average annual discharge (approximately the 1.5 to 2-year return-period flow). Patterns in the channel cross-sectional areas of tributary channels (m^2) to upstream subwatershed areas (km^2) reflect differences in subwatershed physical characteristics that are consistent with the hydrologic model predictions that annual and peak flows will increase with the planned clearcut logging (Chernos et al. 2024).

- Although LSBS6 has an alpine headwater area above tree line, the north aspect and forest covering most of the watershed likely results in reduced solar radiation and smaller peak flows, limiting the channel cross-sectional area.
- LSBS2-3 is another north facing lower elevation subwatershed that also has a small channel cross-sectional area.
- Even most of the tributaries draining south facing subwatersheds of Loomis Creek have small channel cross-sectional areas, reflecting that forest regrowth and some hydrologic recovery has occurred since logging ended in the 1960s.
- However, LSBN9 is the one northside tributary where a large channel cross-sectional area was measured, upstream of the historical logging. This reflects the large area of the LSBN9 subwatershed above tree line (**Figure 7**) and the predominantly south facing aspect of the subwatershed (**Figure 11**). Like clearcuts, this area above tree line accumulates a deeper snowpack and melts more rapidly, resulting in higher stream discharge and larger channel cross-sectional area. Downstream within the area historically logged on LSBN9, channel aggradation (infilling), avulsion (new channel), and flow going subsurface, result in reduced channel cross-sectional area.
- Of the four headwater tributaries surveyed, the western subwatershed has the greatest proportion of south facing aspects (37%) and the greatest channel cross-sectional area (m^2), further demonstrating how south facing treeless areas in subwatersheds result in higher discharge.

8.3.3 Size of mobile bedload reflects watershed characteristics

Size of the mobile bedload (D90, cm) and the overall bedload grainsize distribution reflect physical differences in subwatersheds. Like cross-sectional area (m^2) and upstream watershed area (km^2), the capacity of an alluvial channel to move sediment (D90, cm) increases with upstream watershed area and discharge and decreases as channel gradient decreases. While none of the tributaries currently supply large inputs of bedload material to Loomis Creek, the observed trend in increasing D90 (cm) with upstream watershed area (km^2) provides a reference point for comparison. With the increased frequency and magnitude of bankfull (or greater) flows predicted following the clearcut logging, the largest mobile bedload size will increase on all downstream reaches. There will be more bedload movement, and the overall bedload grainsize distribution will shift in reaches where the size of bedload coming in is different from the size of the bedload leaving.

Like tributary sites with large channel cross-sectional areas, tributaries sites where the D90 (cm) was larger are in subwatersheds that have headwater areas above tree line (southern headwaters, LSBN9, and LSBS6). These areas accumulate a larger snowpack that can melt quickly, resulting in higher peak flows that mobilize larger bedload material.

On LSBN9 the D90 (cm) is slightly lower downstream of the historical logging (CM06) than upstream (CM08), but this could be because channel avulsion has occurred and CM06 is on a newly forming channel. Another factor is the flows on LSBN9 start to go subsurface at CM06, so the stream has less power to move bedload than upstream at CM08.

Large D90 (cm) measurements on LSBS6 and the southern headwaters stream despite these subwatersheds having predominantly north facing slopes (**Figure 11**) show that areas without forest cover can still produce high flows even without south facing slopes. This shows that clearcuts on the south side of Loomis Creek in north facing subwatersheds will also contribute to the overall flow increases in Loomis Creek.

The mid reach of Loomis Creek has a smaller channel bed grain size distribution than the upper and lower reaches because the gradient is lowest here. This explains why bull trout spawning was only observed in the mid reach where suitable gravel substrate occurs.

8.3.4 Electrical conductivity of streams reflects different inputs sources

Differences in stream electrical conductivity measured across the Loomis Creek watershed may correspond to the proportion of stream flow coming from surface runoff (snow melt and rain) versus groundwater. Groundwater latency times and drainage from wetlands associated with higher salinity may also be important factors.

Bishop Creek has the second highest electrical conductivity of any tributary to Loomis Creek, next to the adjacent LSBN2-3 tributary. Whether conductivity is high in these two tributaries due to groundwater inputs, inputs from wetlands with high conductivity, or due to differences in the underlying geology was not investigated. However, the increase in electrical conductivity on Loomis Creek upstream to downstream of Bishop Creek suggests that the amount of flow in Loomis Creek coming from Bishop Creek is significant.

Shallow groundwater with a shorter latency time may have lower electrical conductivity than groundwater from deeper sources with a longer latency time. Shallow groundwater may also contribute more to stream flows at higher elevations in watersheds where bedrock is covered by a thinner layer of overburden. This may explain why electrical conductivity on tributaries higher in the Loomis Creek subwatershed (LSBN8 and LSBN9) increased a small amount from July to September, but remained low in September and October, even when groundwater was contributing more to flows because the snowpack had mostly melted by this time. In contrast, groundwater contribution to flows on the Road Slide Tributary, LSBN4, and LSBN2-3 may be from a deeper source, explaining why electrical conductivity on these tributaries is much higher.

Flows in LSBN9 and LSBN8 decreased significantly from the beginning of July to the end of October, likely reflecting that snow melt as a dominant source of flow. Flows in these and other similar tributaries could rise and fall faster if the planned logging proceeds. In contrast, flows in LSBN4 and the Road Slide Tributary remained relatively constant from the beginning of July to the end of October, reflecting a groundwater source. Higher elevations, steeper slopes, deeper snowpack contributing more to flows, and higher runoff rates all make subwatersheds more reactive to the effects of clearcut logging. Therefore, the planned logging is likely to result in more significant changes to the timing and frequency of bankfull (or greater) flow events in south facing subwatersheds that are higher up in the Loomis Creek watershed than those at lower elevations.

Groundwater recharge and discharge rates could also change following the clearcut logging. Faster runoff and reduced shading could reduce recharge and increase evaporation. As referenced by (Chernos et al. 2024), there is some evidence to suggest that regenerating forest stands can have higher rates of rainfall interception and evapotranspiration than a mature forest, both of which could potentially further reduce groundwater recharge and discharge (Goeking and Tarbarton 2020, Grondsdahl et al. 2019).

8.3.5 Stream temperature reflects different inputs sources

Temperature monitoring provides a benchmark for comparison if the logging proceeds and stream temperature increases. Mean August temperature is a strong determinant of bull trout habitat suitability (as reviewed in Galloway et al. 2016), with a mean August temperature of 14ºC being the upper threshold for bull trout occurrence (Heinle et al. 2020). Temperatures did not approach this threshold anywhere on Loomis Creek or on the Highwood River upstream of Loomis Creek and downstream of the planned logging. The increase in stream temperatures from upstream to downstream sites on the Highwood River may reflect the wide floodplain the river flows across and the increase in solar radiation it is exposed to between these two points.

Stream temperature in the headwaters of Loomis Creek remained distinctly colder than three other points on the creek between Bishop Creek and the Highwood River throughout most of the summer and fall. This may be because the headwaters are closer to where snow is melting and groundwater is discharged. Stream temperature in the headwaters of Loomis Creek was slightly warmer than between the Bishop Creek and Highwood River confluences at the end of October, further suggesting the headwater site is close to where groundwater is discharged and that groundwater becomes the primary source of flow during low flow periods when precipitation and runoff are lowest.

8.3.6 Road erosion and sedimentation is a significant risk to evaluate

Sedimentation observed from the eroding bank escarpment downstream of Bishop Creek does not reduce the significance of other sources of TSS to Loomis Creek that may result from the planned logging. Roads built on unstable slopes saturated with groundwater could also initiate new landslides that could become significant sources of TSS to Loomis Creek that could result in changes to channel morphology. Prolonged inputs from improperly located, constructed, and maintained stream crossings could also lead to large enough sediment inputs that channel morphology could be altered. Bull trout spawning and rearing was observed upstream of the TSS point source, and crossings upstream of locations were bull trout spawn, eggs are incubating, and juveniles are rearing could elevate the risks associated with sediment inputs substantially. Even small inputs of sediment could reach Loomis Creek and impact juvenile survival and growth, particularly along the beaver meadows, where logging is planned on both sides of the creek. Given the sensitivity of bull trout eggs and rearing juveniles to sediment, a more detailed assessment of the planned roads in relation to erosion and sedimentation risk is warranted.

8.4 Concluding summary related to logging plan layout issues

Given the large scale of the planned clearcut logging in the Loomis Creek watershed, the hydrological impacts resulting from a high ECA will not be mitigated by the SARA and OGR buffer requirements. These minimum requirements may also not protect broad and diverse riparian functions that can extend further beyond uniform buffer widths. However, despite being insufficient to address watershed-scale hydrologic effects, these legal requirements are a regulatory measure currently in place to manage clearcut logging in watersheds with native trout critical habitat. Ensuring buffers are appropriately applied requires ground surveys to locate and map water features throughout the planned logging area.

8.5 Concluding summary of risk to the Loomis Creek bull trout population

The anticipated degree of hydrologic alteration in the Loomis Creek watershed that is predicted to occur with the planned logging (Chernos et al. 2024), and the Phase 1 eco-hydrology assessment results, together highlight the vulnerability of the SARA-listed bull trout critical habitat in the watershed, if the large scale clearcut harvest proceeds.

The predictions of an increase in mean annual flow of 9%, increase in 2- and 20-year peak flows of 9-10%, and earlier and more rapid freshets (Chernos et al. 2024) will result in channel disturbance where bull trout occur. This will particularly be the case in the mid reach of Loomis Creek where the stream bedload is finer material that is already entirely mobile under the current flow regime before any hydrologic alteration from the logging occurs (i.e., **Figure 16**: D90 <10 cm, **Figure 17**: 95% of the bedload material <10 cm diameter). SARA-listed bull trout critical habitat in this reach could be damaged or destroyed through loss of channel length as stream meanders are cutoff by avulsion. Incisement and erosion could occur as channel degradation occurs, and the gravel substrate critical for bull trout spawning, egg incubation, and juvenile rearing could be washed downstream.

Damage or destruction of bull trout critical habitat is also likely to occur on tributary channels. The effects of the increases in mean annual and peak flows and earlier and more rapid freshets predicted for Loomis Creek (Chernos et al. 2024) will be greater on the north side tributaries with south facing slopes that are most hydrologically sensitive to clearcut logging. The logging plan will clearcut 19% of the Loomis Creek watershed, while the proportion of some individual subwatersheds that will be harvested will be much greater. This will result in greater snow accumulation, faster snow melt, and faster and higher amounts of runoff. Channel incisement and erosion are likely, resulting in avulsion, aggradation, and degradation of the tributary channels.

Damage or destruction of bull trout critical habitat will start to occur from altered forest hydrology immediately after logging is completed, but recovery will require forest regrowth, which is slow and predicted to take at least 50 years (Chernos et al. 2024). Full hydrologic recovery may not occur for a century.

The effects of the historical wildfire of 1936 were likely smaller than the predicted effects of the planned clearcut logging. Only the lower half of the watershed burned where snow accumulation, precipitation, and runoff are much lower than in the hydrologically reactive headwaters. Forest cover was also not completely removed by the fire, unlike clearcuts.

The Phase 1 eco-hydrology assessment has confirmed for the first time that Loomis Creek is occupied by a resident bull trout population and showed that it relies heavily (if not entirely) on a lower gradient, alluvial reach of the stream in the middle of the watershed for spawning as well as YOY rearing and overwintering. Bull trout are broadly distributed in the Loomis and Bishop creek watersheds, but spawning was only observed in a 1 km reach of Loomis Creek within the beaver meadows. Observations of YOY upstream from this reach document rearing habitat use and suggest spawning may occur further upstream. No permanent barriers to upstream movement were found in the upper reaches of Loomis or Bishop creek that were surveyed, and detection of bull trout eDNA in one tributary (LSBS2-3) suggests bull trout can occupy the lower reaches of some tributaries, at least seasonally.

The low gradient reach of fish habitat on Loomis Creek where spawning and rearing is occurring is elevated above the Highwood River by 3 km of higher gradient stream channel with a forced step pool channel morphology in some locations (**Figure 13**). In both 2009 (Eisler and Popowich 2010) and in the current assessment, force step pools were noted as resulting in barriers to upstream bull trout migration. These barriers isolate the resident Loomis Creek bull trout population from immigration from the larger Highwood River bull trout population. While the location of the barriers changed between 2009 and 2024, reflecting that forced steps are a dynamic channel feature, the presence of these steps before and after the 2013 flood event suggests a barrier is often present that prevents immigration into Loomis Creek from the Highwood River. Increases in mean and peak flow events on Loomis Creek could result in more of these types of upstream barriers developing as more LWD and bedload material are swept downstream creating more step pools. No brook trout eDNA was detected in the beaver meadows, suggesting the forced step barriers on Loomis Creek are protecting the bull trout population from invasion by this non-native species.

There is potential for direct harm or mortality of bull trout from road mass wasting or crossing failures leading to large inputs of sediment to Loomis Creek. It is also likely that the predicted increases in flow and peak flow variability resulting from forest removal will lead to prolonged changes to instream spawning and rearing habitat quantity and quality.

With bull trout generation time typically being 7 years (COSEWIC 2012, ASRD and ACA 2009), the Loomis Creek population may not be able to persist through a prolonged reduction in habitat productivity or even total loss of essential spawning or rearing habitat. Given that the population is small (only 12 redds observed in 2024) and that supplemental immigration from the larger Highwood River population is unlikely and given that SARA prohibits harming the species or damaging or destroying bull trout habitat, the logging plan represents a high risk to the sustainability of this population. Damage or destruction of bull trout critical habitat on Loomis Creek leading to decreased population productivity (growth, survival, recruitment), puts the Loomis Creek population at risk of declining fish abundance or total extirpation. Given the long-term recovery goal within all historically occupied areas is to protect, maintain, and recover self-sustaining populations, the clearcut logging plan does not appear to represent an acceptable level of risk.

9 References

Alberta Sustainable Resource Development (ASRD) and Alberta Conservation Association (ACA). (2009). Status Of the Bull Trout (*Salvelinus confluentus*) in Alberta: Alberta Sustainable Resource Development. Wildlife Status Report NO. 39 (Update 2009). Edmonton, Alberta. 48 pp. (https://open.alberta.ca/publications/9780778591788).

Al-Chokhachy, R., Black, T. A., Thomas, C., Luce, C. H., Rieman, B., Cissel, R., Carlson, A., Hendrickson, S., Archer, E. K. (2016). Linkages between unpaved forest roads and streambed sediment: why context matters in directing road restoration. *Restoration Ecology*, 24(5), 589-598. (https://www.researchgate.net/publication/303089652).

Baxter, C. V., & Hauer, F. R. (2000). Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (Salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences, 57(7), 1470-1481. (https://www.researchgate.net/profile/Frederick-Hauer/publication/249531456)

Buttle, J. M., Boon, S., Peters, D. L., Spence, C., Van Meerveld, H. J., & Whitfield, P. H. (2012). An overview of temporary stream hydrology in Canada. *Canadian Water Resources Journal/Revue Canadienne Des Ressources Hydriques*, 37(4), 279-310. (https://www.tandfonline.com/doi/pdf/10.4296/cwrj2011-903).

Canadian Parks and Wilderness Society (CPAWS). (2025). Native Trout Critical Habitat Loss in Southern Alberta. *Canadian Parks & Wilderness Society - Southern Alberta Chapter, Calgary, Alberta*. (cpaws-southernalberta.org/wp-content/uploads/2025/02/Forestry-Critical-Habitat-Report-2025.pdf).

Chernos, M., Green, K., Potter, C., & MacDonald, R.J. (2024). Watershed Assessment and Partial Risk Analysis for Loomis Creek and the upper Highwood River, Alberta. MacDonald Hydrology Consultants Ltd. Prepared for Alberta Forestry and Parks. Freedom of Information and Protection of Privacy Request #: FO000-2024-G-24 (https://cpaws-southernalberta.org/wp-content/uploads/2025/05/MacHydro-Loomis-Report-FOIP.pdf).

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). (2012). COSEWIC assessment and status report on the Bull Trout Salvelinus confluentus in Canada. *Committee on the Status of Endangered Wildlife in Canada*. Ottawa. iv + 103 pp. (https://ecprccsarstacct.z9.web.core.windows.net/files/SARAFiles/legacy/cosewic/sr_omble_tete_plat_bull_trout_1113_e.pdf).

Coombs, M. (2023). Winter environmental DNA survey for bull trout in Loomis Creek. *Prepared for Canadian Parks and Wilderness Society*. (December 2023). (https://cpaws-southernalberta.org/wp-content/uploads/2024/01/CPAWS_Loomis_Creek_Bull_Trout_eDNA_survey_final_report.pdf).

D'Angelo, V. S., & Muhlfeld, C. C. (2013). Factors influencing the distribution of native Bull Trout and Westslope Cutthroat Trout in streams of western Glacier National Park, Montana. *Northwest Science*, 87(1), 1-11. (https://www.researchgate.net/profile/Clint-Muhlfeld/publication/267877013).

Downing, D.J. & Pettapiece, W.W. (2006). Natural Regions and Subregions of Alberta. *Natural Regions Committee 2006. Government of Alberta. Pub. No. T/852*. (https://open.alberta.ca/publications/0778545725).

Eisler, G. R., & Popowich, R. C. (2010). Mountain whitefish spawning assessment and fluvial bull trout redd survey in the Highwood River, 2009. Prepared for Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta. iii+36 +appendices

Fisheries and Oceans Canada. (2019). Recovery Strategy and Action Plan for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Alberta population (also known as Saskatchewan-Nelson River populations) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 61 pp + Part 2. (https://ecprccsarstacct.z9.web.core.windows.net/files/SARAFiles/legacy/plans/RsAp-TruiteFardeeOuestWestslopeCutthroatTrout-v00-2019-Eng.pdf).

Fisheries and Oceans Canada. (2020a). Recovery Strategy for the Bull Trout (*Salvelinus confluentus*), Saskatchewan-Nelson Rivers populations, in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. viii + 130 pp. (https://ecprccsarstacct.z9.web.core.windows.net/files/SARAFiles/legacy/plans/Rs-BullTroutOmblesTetePlateSaskNelson-v00-2020Sept-Eng.pdf).

Fisheries and Oceans Canada. (2020b). Recovery Strategy for the Rainbow Trout (*Oncorhynchus mykiss*) in Canada (Athabasca River populations). Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 90 pp. (https://ecprccsarstacct.z9.web.core.windows.net/files/SARAFiles/legacy/plans/Rs-AthabascaRainbowTroutTruiteArc-en-ciel-v00-2020Sept-Eng.pdf).

Fraley, J. J., & Shepard, B. B. (1989). Life history, ecology and population status of migratory bull trout (Salvelinus confluentus) in the Flathead Lake and River system. *Northwest science.*, *63*(4). (https://rex.libraries.wsu.edu/esploro/fulltext/journalArticle/Life-History-Ecology-and-Population-Status/99900502518801842?repId=12332825430001842&mId=13333056850001842&institution=01ALLIANCE_WSU).

Fluker, S. C., & Mayhood, D. W. (2020). Environmental Stewardship of Public Lands? The Decline of Westslope Cutthroat Trout along the Eastern Slopes of the Rocky Mountains in Alberta. *Pub. Land & Resources L. Rev.*, *42*, 39. (https://www.researchgate.net/publication/342978970).

Galloway, B. T., Muhlfeld, C. C., Guy, C. S., Downs, C. C., & Fredenberg, W. A. (2016). A framework for assessing the feasibility of native fish conservation translocations: applications to threatened Bull Trout. *North American Journal of Fisheries Management*, 36(4), 754-768.

(https://scholarworks.montana.edu/bitstreams/44c309ab-7821-4d6a-90b7-2877395ce5ff/download).

Goeking, S. A., & Tarboton, D. G. (2020). Forests and water yield: A synthesis of disturbance effects on streamflow and snowpack in western coniferous forests. *Journal of Forestry*, 118(2), 172-192. (https://www.researchgate.net/publication/339217504).

Government of Alberta. (2014). South Saskatchewan Regional Plan 2014-2024 (amended May 2018). Government of Alberta, Edmonton, Alberta. (https://open.alberta.ca/publications/9781460139417).

Government of Alberta. (2023). Alberta Bull Trout Recovery Plan. *Alberta Species at Risk Recovery Plan No. 46. Edmonton, Alberta, 64 pp.* (https://open.alberta.ca/publications/alberta-bull-trout-recovery-plan).

Government of Alberta. (2024). Alberta Timber Harvest Planning and Operating Ground Rules. Forestry, Parks and Tourism. Edmonton, Alberta. (https://open.alberta.ca/publications/timber-harvest-planning-and-ogr-2024).

Green, K. C., & Alila, Y. (2012). A paradigm shift in understanding and quantifying the effects of forest harvesting on floods in snow environments. *Water Resources Research*, 48(August), 1–21. (https://doi.org/10.1029/2012WR012449).

Green, K., Coombs, M., Potter, C., Chernos, M., & MacDonald, R.J. (2021). Ecohydrological Assessment of the Upper Oldman River 2020/2021. *Report funded by and prepared for Fisheries and Oceans Canada, Habitat Stewardship Program 2020 Project Number DFO CA No. 2020-HSP-C&A-004*, 247p. (https://doi.org/10.6084/m9.figshare.26906452.v1).

Gronsdahl, S., Moore, R. D., Rosenfeld, J., McCleary, R., & Winkler, R. (2019). Effects of forestry on summertime low flows and physical fish habitat in snowmelt-dominant headwater catchments of the Pacific Northwest. *Hydrological Processes*, 33(25), 3152-3168. (https://open.library.ubc.ca/media/download/pdf/52383/1.0402929/5).

Hagen, J. & Decker, S. (2011). The Status of Bull Trout in British Columbia: A Synthesis of Available Distribution, Abundance, Trend, and Threat Information. *Fisheries Technical Report No. 110*. Prepared for: Ministry of Environment, Ecosystems Protection & Sustainability Branch, Aquatic Conservation Science Section, Victoria, BC. (https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=36019)

Hancock, C. A., & Wlodarczyk, K. (2025). The role of wildfires and forest harvesting on geohazards and channel instability during the November 2021 atmospheric river in southwestern British Columbia, Canada. *Earth Surface Processes and Landforms*, 50(1), e6065.

Harrelson, C. C. Rawlins, C. L., & Potyondy, John P. (1994). Stream channel reference sites: an illustrated guide to field technique (*Gen. Tech. Rep. RM-245*). US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p. (https://research.fs.usda.gov/treesearch/20753).

Heinle, K. B., Eby, L. A., Muhlfeld, C. C., Steed, A., Jones, L., D'Angelo, V., Whiteley, A. R., & Hebblewhite, M. (2021). Influence of water temperature and biotic interactions on the distribution of westslope cutthroat trout *(Oncorhynchus clarkii lewisi*) in a population stronghold under climate change. *Canadian journal of fisheries and aquatic sciences*, 78(4), 444-456. (https://www.researchgate.net/publication/346470296).

Howell, P. J., & Sankovich, P. M. (2012). An evaluation of redd counts as a measure of Bull Trout population size and trend. *North American Journal of Fisheries Management*, 32(1), 1-13. (https://www.researchgate.net/publication/254311310).

Isaak, D. J., Rieman, B., & Horan, D. (2009). A watershed-scale monitoring protocol for bull trout. *Gen. Tech. Rep. RMRS-GTR-224*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 25 p. (https://www.fs.usda.gov/rm/pubs/rmrs_gtr224.pdf).

Kaeding, L. R., & Mogen, J. T. (2023). Annual redd counts across two decades are indicators of changing migratory bull trout population sizes in two proximate Montana creeks. River Research and Applications, 39(5), 993-997.

Mayhood, D. W., & J. Killeen. (2024). Watershed assessments for upper Highwood-Loomis Creek proposed logging 2023-2025. *FWR Technical Report No. 2024/03-1. 57 p.* (https://doi.org/10.6084/m9.figshare.25425889.v1).

Montgomery, D. R., & Buffington, J. M. (1997). Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, 109(5), 596-611. (fs.usda.gov/biology/nsaec/fishxing/fplibrary/Montgomery_1997_Channel-reach_morphology_in_mountain.pdf).

Moore, R. D. (2005). Slug injection using salt in solution. *Streamline Watershed Management Bulletin*, 8(2), 1-6. (https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=392e384b3ac76e4877d6412f1751ea27a8d2b951).

Morrison, A., Westbrook, C. J., & Bedard-Haughn, A. (2015). Distribution of Canadian Rocky Mountain wetlands impacted by beaver. *Wetlands*, 35, 95-104. (https://sci-hub.se/https:/link.springer.com/article/10.1007/s13157-014-0595-1).

Newcombe, C. P., & Jensen, J. O. (1996). Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management*, 16(4), 693-727. (lwb-registry-867.s3.ca-central-1.amazonaws.com/Documents/W2015L2-0001/Diavik - Amendment Application - TSS - Supplementary Info - Newcombe and Jensen 1996 - Oct 29_15.pdf).

Pham, H. C., & Alila, Y. (2024). Science of forests and floods: The quantum leap forward needed, literally and metaphorically. *Science of the Total Environment*, 912, 169646. (https://waterbucket.ca/wp-content/uploads/sites/6/2024/03/Science-of-forests-and-floods_Feb2024.pdf).

Pomeroy, J. W., Stewart, R. E., & Whitfield, P. H. (2016). The 2013 flood event in the South Saskatchewan and Elk River basins: Causes, assessment and damages. *Canadian Water Resources Journa*, *41*(1-2), 105-117. (https://www.tandfonline.com/doi/pdf/10.1080/07011784.2015.1089190).

Robinson, M. D., Bransfield, J., & Gaboury, M. (2018). Line Creek large woody debris enhancement project: applying long-term monitoring and research to habitat rehabilitation design. *British Columbia Mine Reclamation Symposium; University of British Columbia. Norman B. Keevil Institute of Mining Engineering*. (https://open.library.ubc.ca/soa/cIRcle/collections/59367/items/1.0374934)

Sappa, G., Ferranti, F., & Pecchia, G. (2015). Validation of salt dilution method for discharge measurements in the upper valley of Aniene River (central Italy). *In 13th International Conference on Environment, Ecosystem and Development (EED'15)*. (https://www.researchgate.net/profile/Flavia-Ferranti/publication/309779646).

Smith, C. M., Wilson, B., Rasheed, S., Walker, R. C., Carolin, T., & Shepherd, B. (2008). Whitebark pine and whitepine blister rust in the Rocky Mountains of Canada and northern Montana. *Canadian Journal of Forest Research*, 38:982-995. (https://www.academia.edu/download/89646699/713360886fcaafe00486ef13979cd4a5abb8.pdf).

Spray Lakes Sawmills. (2021). Forest Management Plan. Spray Lakes Sawmills. Cochrane, Alberta. (https://spraylakesawmills.com/woodlands/forest-management-planning/detailed-forest-management-plan/).

Warnock, W. G., & Rasmussen, J. B. (2013). Abiotic and biotic factors associated with brook trout invasiveness into bull trout streams of the Canadian Rockies. *Canadian Journal of Fisheries and Aquatic Sciences*, 70(6), 905-914. (https://cdnsciencepub.com/doi/pdf/10.1139/cjfas-2012-0387).

Winkler, R., Spittlehouse, D., & Boon, S. (2017). Streamflow response to clear-cut logging on British Columbia's Okanagan Plateau. *Ecohydrology*, 10(2), 1–15. (https://doi.org/10.1002/eco.1836).

Wohl, E. (2017). The significance of small streams. *Frontiers of Earth Science*, 11, 447-456. (https://www.researchgate.net/profile/Ellen-Wohl/publication/315972169).

Wolman, M. G. (1954). A method of sampling coarse river-bed material. *Eos, Transactions American Geophysical Union*, *35*(6), 951-956. (https://lmpublicsearch.lm.doe.gov/SiteDocs/SW-A-006094.PDF).

Appendix I Types of wetlands in the Loomis Creek watershed

To our knowledge, wetlands in the Loomis Creek watershed have not been assessed on-the-ground. However, under Alberta's Wetland Classification System (ESRD 2015), the two broad types that may occur are mineral wetlands and fens. The beaver meadows may be considered mineral wetlands because they are periodically inundated by surface water from adjacent stream channels during flooding or the construction of beaver dams. In contrast, fens are not flooded by surface water but instead kept saturated by groundwater. Soils in mineral wetlands include some mineral soil, while in fens they are almost entirely made up of decomposing organic material. Measuring soil organic composition and peat thickness can be required to distinguish between fens and mineral wetlands, which has been done elsewhere in the Highwood River watershed (Morrison et al. 2014).

Both deep and shallow zones occur in the Loomis Creek watershed mineral wetlands. Deep zones have surface water pooling in beaver ponds, emergent vegetation, and the presence of narrow-leaved graminoids adapted to seasonally or permanently saturated soils. Shallow zones have water tolerant graminoids and forbs adapted to periodic flooding.

Possible fens in the Loomis Creek watershed are <200 m in diameter (**Photo I- 1**). They appear to be permanently saturated with groundwater and are not associated with large, permanently flowing streams. Vegetation is dominated by sedges (Carex spp.) and dense mats of bryophyte species. Shrubs are absent or less than two metres tall.

The Alberta merged wetland inventory does not cover the upper Highwood River watershed, but wetland boundaries in the Loomis Creek watershed were mapped and classified based on aerial imagery by the Alberta Biodiversity Monitoring Institute and by the Bow River Basin Council. These two datasets show wetlands account for a relatively small proportion of the Loomis Creek watershed area (1.1% and 1.7%, respectively).

The Province of Alberta's Wet Area Mapping (WAM) layer shows a higher proportion (5.1%) of the watershed area is covered by either surface or shallow groundwater.

Wetland sites smaller than the fens described above occur throughout the Loomis Creek watershed, even at higher elevations. These areas may be permanently or semi-permanently wet if they are associated with groundwater discharge, or they may be temporary or seasonal groundwater recharge areas, with surface water only present for a short period of time after snowmelt or heavy rainfall (**Photo I- 2**).

Photo I- 1. Example of a potential fen in the LSBS2-3 subwatershed.

Photo I- 2. Examples of small wetland sites within planned clearcut logging areas at the Online Map Site IDs shown.

Appendix II Logging plan layout issue examples

Table II- 1. Summary of Loomis Creek tributary buffer issues on laid out cut blocks

Tributary names listed from lower to upper Loomis Creek watershed	Tributary may be a small permanent and require OGR 30 m buffer	Tributary has some or no buffering	Online Map Site IDs with photos where cut blocks overlap 30 m OGR & critical habitat buffer
Unnumbered tributary just northeast of Road Slide Tributary	Yes, but bankfull width was not measured; flow is not perennial	None	LI02 LI03
Road Slide Tributary	Yes, bankfull width was measured 0.6 m but may average >0.7 m overall; flow is perennial	None	LI13 LI30 CO064 CO066 CO145 CM33 SD02
Unnumbered tributary just west of Road Slide Tributary		None	LI12
Unnumbered tributary just east of LSBN1		<30 m	CO133
LSBS2-3, east fork	Yes, bankfull width was >0.7 m; flow may be perennial	None or <30 m	LI06 LI07 LI08 LI09
LSBS2-3, west fork	Yes, bankfull width was >0.7 m; flow may be perennial	<30 m	CO019
Groundwater seepage area on south bank of Loomis Creek at Bishop Creek confluence		<30 m	LI40
LSBN2	Yes, bankfull width was measured 0.53 m but may average >0.7 m overall; flow may be perennial	None	LI14 LI38 CM24
Unnumbered tributary on south side of Loomis Creek opposite LSBN2&3		None and <30 m	CO138 CO139 CO140 CO141 CO142
LSBN3	Yes, bankfull width was >0.7 m in some locations; flow is not perennial	None	LI15 LI37 CM23 CO135 CO030

Tributary names listed from lower to upper Loomis Creek watershed	Tributary may be a small permanent and require OGR 30 m buffer	Tributary has some or no buffering	Online Map Site IDs with photos where cut blocks overlap 30 m OGR & critical habitat buffer
LSBN4	Yes, bankfull width was 0.8 m downstream of road and 1.06 m upstream of road	<30 m	CO001 CO002 CO032 CO043 CM21 CM22 TL11 SD04
LSBN5	Yes, bankfull width was 0.65 m downstream of road and 0.9 m in the headwaters; flow is not perennial along the entire length of stream	None	LI35 LI41 CO096 CO105 CO106 CO107 CO108 CO109 CO110 CO111 CO112 CO113 CO114 CO115 CO116 CM17 CM18
LSBN6	Yes, bankfull width was 0.75 m near mouth and 0.48 m in the headwaters of the sub-basin; flow is not perennial along the entire length of the stream, but surface or subsurface flow connecting all Site IDs was assumed	None	LI18 – western branch of LSBN6 LI19 LI33 LI34 CO120 CO119 CO118 CM14
Unmapped tributary between LSBN6-7		None	LI25
LSBN7	Yes, bankfull width was 0.22 m near mouth and 0.7 m upstream of historical logging road; flow is not perennial along the entire length of the stream, but surface or subsurface flow connecting all Site IDs was assumed	None	LI24 LI26 LI27 LI43 LI44 CO045 CM13 CM12 TL14

Tributary names listed from lower to upper Loomis Creek watershed	Tributary may be a small permanent and require OGR 30 m buffer	Tributary has some or no buffering	Online Map Site IDs with photos where cut blocks overlap 30 m OGR & critical habitat buffer
LSBN8	Yes, bankfull width was 0.95 m and 1.2 m upstream and downstream, respectively, of large clearing from historical logging; flow is perennial adjacent to cut blocks	<30 m	CO038 CO039 CO125 CO126 CO127 CO128 CM09 CM10
Unnumbered tributary south of LSBN9	Yes, bankfull width 0.7 m at CM07 and even wider at historical logging road crossing, 0.5 m above road; flow is perennial	None at LI31	LI31 CO041
Unnumbered tributary on Don Getty boundary	Yes, bankfull width > 0.7 m; flow is perennial	<30 m	LI21 (no site photos, but click the link to download site video)
Unnumbered tributary to Bishop Creek on west side		None	LI39
Unnumbered tributary to Loomis Creek just east of LSBS6		<30 m	CO070

Table II- 2. Summary of stream-road crossings but no crossing structure is identified.

Tributary names listed from lower to upper Loomis Creek watershed	Online Map Site IDs at or near where the planned road crosses the stream but there is no planned crossing structure identified	Approximate Lat/Long where a planned road crosses the watercourse without a crossing structure identified on the AOP
Bishop Creek	LI29 (no road on the AOP map, but crossing laid out on the ground)	50.4621344 -114.8259226
LSBN5	LI32	50.4700246 -114.8600742 50.4700330 -114.8607826
LSBN6	LI19	50.4693954 -114.8671873
Unnumbered tributary south of LSBN9	CO041 LI31 SD10	50.4637201 -114.8803565

Table II- 3. Examples of wetland areas where the 30 m SARA buffer was not applied.

Stream within the wetland listed from lower to upper Loomis Creek watershed	Online Map Site IDs at or near a wetland area that has no 30 m SARA buffer applied	Description of unbuffered area
Loomis Creek	Online Map Site IDs LI10, LI11 near the Road Slide Tributary	Wet areas, including springs and pools, on the North side of Loomis Creek near the Road Slide Tributary
LSBS3	Between Online Map Site IDs CO021-CO019 and areas south, east, and west of these points	Cut blocks are not buffered 30 m from the boundary of the entire wetland area in the LSBS2-3 subwatershed
Bishop Creek	Locations on both sides of Bishop Creek: west bank near Online Map Site ID CO047, west bank near Online Map Site IDs FB03 and SS02, on east bank small meadow just south of Online Map Site ID LWD05	Near these Site IDs the cut blocks are not buffered 30 m from the boundary of the wetland areas where the forest stops
Loomis Creek	Between Online Map Site IDs LI20, CO102, CO043, LI37, LI17	In some locations between these Site IDs the cut blocks are not buffered 30 m from the northern boundary of the beaver meadow wetlands where the forest stops
Loomis Creek	Online Map Site ID LI33	Cut blocks are not buffered 30 m from the boundary of the wetlands to the east and west of Online Map Site IDs LI33 where the forest stops
Tributaries throughout the Loomis Creek and upper Highwood River watershed	**Figure 31** and the AOP map show where planned road crossing structures within the planned cut blocks cross water features that have not be buffered out of cut blocks	With the planned logging and planned crossings layers shown on the Online Map, many wet areas can be located where road crossing structures are within the planned cut blocks and have not been buffered out of cut blocks

Appendix III Additional methods details

Channel morphological types and descriptions used for the Project are summarized below (Montgomery and Buffington 1997).

Table III- 1. Channel morphological types and descriptions used for the Project.

Morphology type	Description
Bedrock	Bedrock controlled
Colluvial	Angular colluvium in channel not moving under normal spring freshet
Cascade with boulders	Boulders >25cm diameter, gradient generally >5%
Cascade with cobbles	Cobbles <25cm diameter, gradient generally >5%
Forced riffle pool	Large woody debris is controlling riffle pool development
Riffle pool	Gradient generally <2%, cobbles or gravels in riffles
Forced step pool	Woody debris is forcing steps, gradient generally 5-10%
Step pool	Cobbles and stone lines are forming steps, only occasional wood steps
Plane bed	Uniform look with scattered cobbles or boulders and gradients generally 2-5%, looks like a step pool but larger cobbles and boulders have not formed steps
Intermittent	Some channel bank development but channel may be vegetated

i. How channel cross-sectional area was measured

Bankfull stage was identified in the field by the geometry of the channel banks and the presence of vegetation, which indicates the area of inundation during the average spring freshet. Flow cross-sectional area was determined by extending a fiberglass measuring tape across the channel width and measuring the depth from bankfull stage to the channel bed at equally spaced intervals. The bankfull cross-sectional area was then calculated by multiplying the bankfull width by the average bankfull depth.

ii. How stream gradient was measured

Stream gradient was measured using the Theodolite mobile app and a 2 m measuring stake held or placed 10-30 m upstream from where the observer was standing. By focusing the camera at the same height on the measuring stake corresponding to the eyes of the observer, the app records the rise in gradient as a percentage slope when a photo is taken.

iii. How stream-riparian interaction and large woody debris were assessed

The abundance and function of large woody debris (LWD) was assessed at each of the 36 channel morphology sites. Abundance was estimated as the average number of pieces of LWD per 10 m reach of stream within the approximately 50 m length of stream that was considered part of each channel morphology site. LWD function at each site was then either assigned to one of the following categories or given a custom description:

- Elevated above and spanning
- Function jams
- Functional partial pieces
- Functional single pieces
- On upper banks
- Parallel to banks
- Partial functional jams
- Small woody debris including branches and roots

Photos of LWD were taken at each of the 36 channel morphology sites, as well as at other sites throughout the Loomis Creek watershed.

iv. How the largest mobile grain size (D90, cm) was measured

Data on the largest actively mobile grain size (D90, cm) was collected at all 36 channel morphology sites. This is a measure of the diameter of the 90th percentile of the mobile bedload. The largest mobile grains on the channel bed provides information about the capacity of the channel to move sediment (Green et al. 2021). It increases with increasing discharge (volume) or flow and flow depth and decreases as channel gradient decreases. It may change on Loomis Creek with changes in discharge and channel depth following the planned logging.

Estimating the D90 (cm) involves visually surveying the channel bed and selecting five of the largest, obviously mobile grains and measuring their intermediate axis (neither the longest nor shortest of the three mutually perpendicular sides, see Harrelson et al. 1994). Large, angular colluvial blocks that are obviously not mobile or cobbles and boulders that are moss or lichen covered or embedded in the channel bed are not considered in the estimation of the D90 (cm). The D90 (cm) grain is likely mobile during floods with magnitudes exceeding 1:5 to 1:10 return-period.

v. How Wolman pebble counts were conducted

The Wolman pebble count (Wolman 1954) is used to provide information on the longitudinal changes in sediment transport capacity, sediment supply, and changes in sediment size. It is conducted by walking across the bankfull channel width and, with each step, selecting the grain that falls under the surveyor's big toe (Green et al. 2021). The grain is removed from the bed and the intermediate axis is measured categorically by passing the grain through a gravelometer with square grid openings equal to the Phi-scale (X^2mm) from 8mm to 128mm. If the grain is too large to pick up the axis diameter is estimated in place as either less than 256mm or less than 512mm. The channel is crossed between the bankfull indicators enough times to survey at least 100 grains from the channel bed. Grains less than 8mm are estimated as either less than 4mm or less than 2mm based on the judgment of the surveyor. The Wolman pebble count process means that immobile lag material and mobile sediment are both counted in the survey (Green et al. 2021). Consequently, the grainsize distribution resulting from the pebble count does not necessarily relate to the distribution of the mobile bedload and for this reason, if there are immobile grains on the channel bed, there will be a discrepancy between the maximum mobile grainsize (Green et al. 2021) estimate and the D90 (cm) determined from the Wolman method.

Wolman pebble counts were undertaken at five channel morphology sites on Loomis Creek and two on Bishop Creek, upstream and downstream of the planned logging.

vi. How the staff gauge location was selected

The lower 1.5 km of Loomis Creek upstream from the Highwood River to the confluence of the Road Slide Tributary was surveyed on July 23, 2024, to identify the best site to install the staff gauge. Five potential sites were identified, and the site selected had optimal characteristics and was near the mouth to monitor the entire flow of the creek.

The Loomis Creek staff gauge was located where it was installed because a bedrock ledge is present immediately upstream, which should bring subsurface alluvial flows to the surface so that measured flows are more representative of total discharge. The staff gauge was bolted directly to the bedrock wall of a pool below the ledge, providing more secure attachment that should be more robust to sheering from ice in winter and high flows during the spring freshet. The large size and depth of the pool where the staff gauge sits reduces wave action, reducing variability of the level logger measurements and increasing the overall accuracy of flow measurements.

vii. TSS analysis

TSS samples were collected in either 1 L Nalgene™ Wide-Mouth Lab Quality high density polyethylene sample bottles (June 29, 2024) or laboratory-supplied sample bottles suitable for TSS analysis (July 17, 2024). All samples met Bureau Veritas acceptability criteria and QA/QC standards. Standard methods used involved filtering a known volume of the sample through a weighed filter paper, drying the filter and residue, and then calculating the weight of the solids remaining. For samples collected on June 29, 2024, Volatile Suspended Solids (VSS) and Fixed Suspended Solids (FSS) were analysed separately, to compare the organic and inorganic components of TSS. However, due to the additional cost of this analysis, only total TSS was analysed for the samples collected on July 17, 2024.

The Bureau Veritas laboratory and analytical protocols followed are referenced as “AB SOP-00061” and “SM 24 2540 D m”, respectively. While these protocols are not publicly available, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, EPA, APHA or the Quebec Ministry of Environment. The Bureau Veritas QA/QC program includes method blanks, control standards samples, certified reference material standards, method spikes, replicate, duplicates, surrogates, and instrument blanks.

viii. Temperature logger details

Table III- 2. Stream and air temperature monitoring sites in Loomis Creek watershed

Mainstem Loomis Creek	**Online Map Site ID**	**Install date**	**Download date**
Upstream of planned logging	TL17	7/1/2024	10/27/2024
Upstream of Bishop Creek below beaver meadow	TL09	7/14/2024	10/26/2024
Downstream of LSBS2-3 confluence	TL05	7/16/2024	10/26/2024
Loomis Creek at the mouth near Highwood River	TL02	7/14/2024	10/26/2024
South side tributaries			
LSBS2-3 at historical logging road crossing	TL06	7/1/2024	10/26/2024
LSBS2 near LSBS3 confluence	TL07	7/1/2024	10/26/2024
Bishop Creek upstream of planned logging	TL18	7/16/2024	9/17/2024
Bishop Creek at mouth	TL08	7/14/2024	10/26/2024
LSBS6 near mouth	Tl12	7/16/2024	11/3/2024
North side tributaries			
LSBN9 at historical logging road crossing	Tl16	7/1/2024	10/27/2024
LSBN8 at historical logging road crossing	TL15	7/1/2024	10/27/2024
LSBN7 on Loomis Creek floodplain	TL14	7/14/2024	11/3/2024
LSBN5 in beaver meadows	Tl13	7/1/2024	11/3/2024
LSBN4 downstream of historical logging road	TL11	7/1/2024	11/3/2024
Road Slide Tributary at cut block boundary	TL03	7/16/2024	10/26/2024
Highwood River			
Highwood River downstream of logging	TL19	7/16/2024	11/3/2024
Highwood River upstream of Loomis Creek	TL01	7/14/2024	10/26/2024
Air temperature			
Road Slide Tributary within cut block	TL04	7/16/2024	10/26/2024
LSBN3	TL10	7/1/2024	11/3/2024

Appendix IV Channel morphology details

Summary tables (*see written descriptions of the three mainstem reaches and headwater, southside, northside tributaries below*)

Table IV- 1. Site IDs, stream and morphology types, and descriptions for 36 channel morphology sites in Loomis Creek watershed.

Online Map Site ID	Stream type	Site description	Morphology type	Channel notes
CM01	Tributary	Loomis eastern alpine headwater basin (big) with no past logging	Cascade bolder	Channel eroded down to bedrock in some areas
CM02	Tributary	Loomis southern alpine headwater basin with no past logging	Colluvial	Bedrock in some areas
CM03	Tributary	Loomis western alpine headwater basin with no past logging	Colluvial	
CM04	Tributary	Loomis eastern alpine headwater basin (small) with past logging	Colluvial	Trib intermittent and in a steep gully 5m deep
CM05	Mainstem	Loomis mainstem below alpine headwaters	Step pool	
CM06	Tributary	LSBN9 downstream of past logging -Site 1 (new channel)	Forced step pool	Steps from exposed root networks, cascade - cobble between steps
CM07	Tributary	LSBN9 downstream of past logging -Site 2 (original channel), channel aggregation (in filled) in 2013 flood	Overflow channel	Washed-out bridge above site on historical logging road, channel shows incisement there but not at site, unnamed LSBN9 tributary flows into site now
CM08	Tributary	LSBN9 upstream of past logging	Cascade bolder	Forced step pool sections upstream and downstream of site
CM09	Tributary	LSBN8 downstream of past logging	Forced step pool	Channel is locally incised at site, downstream of salt site and hunt camp, intermittent flow
CM10	Tributary	LSBN8 upstream of past logging	Colluvial	Forced step pool sections
CM11	Mainstem	Loomis mainstem downstream of LSBN8 & 9 tributaries	Riffle pool	
CM12	Tributary	LSBN7 downstream of past logging	Intermittent	Flows beneath surface in places
CM13	Tributary	LSBN7 upstream of past logging	Colluvial	
CM14	Tributary	LSBN6 downstream of past logging	Intermittent	Channel incised into glacial floodplain, site on cut block boundary (layout issue)
CM15	Tributary	LSBN6 near upper limit of historical logging, organic bridges, channel disappears below historical logging road	Colluvial	Site is where flow starts at a spring, dry swale upslope
CM16	Mainstem	Loomis upstream of beaver meadows	Riffle pool	Channel incised 1.5 m into glacial floodplain
CM17	Tributary	LSBN5 downstream of past logging, channel dry at time of survey	Forced step pool	Entrenched and channelized with 1 m deep scour pool, deeper downstream of site
CM18	Tributary	LSBN5 headwaters some limited past logging	Colluvial	Flows beneath surface in places
CM19	Mainstem	Loomis mainstem middle of beaver meadow	Riffle pool	
CM20	Tributary	LSBS6	Forced step pool	May be incised due to historical fire
CM21	Tributary	LSBN4 downstream of existing road/trail	Forced step pool	Colluvial in some areas, incisement downstream of trail may be from logging or fire
CM22	Tributary	LSBN4 upstream of existing road/trail	Forced step pool	Step pool in sections, not as incised as below road
CM23	Tributary	LSBN3	Intermittent	Forced step pool sections
CM24	Tributary	LSBN2	Colluvial	Forced step pool sections, in incised gully from trail upstream to planned logging road crossing where site placed, incisement not recent, cause unknown
CM25	Mainstem	Loomis mainstem upstream of Bishop Creek	Riffle pool	Near downstream limit of beaver meadows
CM26	Tributary	Bishop Creek at mouth	Step pool	Boulders are creating steps 5-10 m apart
CM27	Tributary	Bishop Creek upstream of planned logging	Forced riffle pool	
CM28	Tributary	LSBN1	Forced step pool	No incisement at site but incised up to 0.5 m downstream of site
CM29	Mainstem	Loomis mainstem downstream of Bishop Creek	Riffle pool	Step pool lower down
CM30	Tributary	LSBS2-3 downstream of 2-3 confluence	Cascade boulder	Riffle pool further upstream where gradient is lower
CM31	Mainstem	Loomis at the downstream of limit of the lower gradient reach	Step pool	Site immediately upstream from trail crossing; gradient & D90 increase below site
CM32	Mainstem	Loomis mainstem between Boulder and Low Gradient crossings	Cascade boulder	No bank failure at site, but historical logging road washed out and channel incised on right upstream bank above site
CM33	Tributary	Road Slide Tributary at downstream of limit of cut block boundary	Forced step pool	Flow is subsurface at times under moss and logs, within cut block, no buffer
CM34	Mainstem	Above Blowout Crossing	Cascade boulder	Bedrock channel controls upstream and downstream of site
CM35	Mainstem	Just below braiding at Blowout Crossing, just above bedrock channel controls further downstream	Step pool	
CM36	Mainstem	Loomis mainstem at mouth, channel confined by LWD and bedrock	Step pool	Forced step at upstream limit of site

Table IV- 2. Channel geometry, floodplain width, and flood disturbance at 36 channel morphology sites in Loomis Creek watershed.

Online Map Site ID	Site description	Average bankfull depth (m)	Bankfull Width (m)	Cross-sectional area (m^2)	Area upstream (km^2)	Grad -ient (%)	Channel incised (m)	Floodplain width (m)	Flood disturbance history
CM01	Eastern headwater basin	0.05	2.10	0.11	1.08	23	0	5	Infrequent, no channel forming floods in several decades
CM02	Southern headwater basin	0.06	3.30	0.21	1.52	24	0	None	Infrequent, last sign likely pre-2013 event
CM03	Western headwater basin (big)	0.23	1.30	0.30	1.59	12	0	None	Infrequent, last sign likely pre-2013 event
CM04	Eastern headwater basin (small)	0.03	0.30	0.01	0.48	31	0.25	None	None
CM05	Mainstem Headwaters	0.19	3.30	0.62	5.07	7	1	15	Infrequent, multiple levees, no bedload movement since 2013
CM06	LSBN9 new channel in logged area	0.10	1.24	0.13	1.84	11	0.25	None	Infrequent, channel from 2013 event or earlier
CM07	LSBN9 original channel in logged area	0.08	0.70	0.06	1.84	5	0	None	Infrequent, last sign from 2013 event or earlier
CM08	LSBN9 upstream of past logging	0.16	2.90	0.45	1.70	16	0.5	None	None
CM09	LSBN8 downstream of past logging	0.11	0.95	0.10	0.53	13	0.25	None	None
CM10	LSBN8 upstream of past logging	0.05	1.20	0.06	0.42	20	0.4	None	None
CM11	Mainstem Downstream of LSBN8&9	0.25	3.90	0.97	9.25	2	0.5	250	Extensive 2013 meandering above site revegetating slowly
CM12	LSBN7 downstream of past logging	0.03	0.22	0.01	0.54	0.5	0	None	None
CM13	LSBN7 upstream of past logging	0.05	0.70	0.04	0.35	29	0	None	None
CM14	LSBN6 downstream of past logging	0.02	0.75	0.02	0.70	1	1	600	Paleo floodplain
CM15	LSBN6 near upper limit of logged area	0.02	0.48	0.01	0.32	22	0	None	None
CM16	Mainstem upstream of beaver meadows	0.27	5.50	1.48	10.47	2	1.5	600	Ancient, incised floodplain, no recent channel forming floods
CM17	LSBN5 downstream of past logging	0.10	0.65	0.06	0.71	5	1	None	None, down cutting during 1-2 year flood events still ongoing
CM18	LSBN5 headwaters, limited logging	0.01	0.90	0.01	0.22	5	0	None	None
CM19	Mainstem middle of beaver meadow	0.28	4.80	1.35	14.26	3	0.75	60	Infrequent, but activate & inactivated oxbows near site
CM20	LSBS6	0.11	1.10	0.12	1.51	8	0.25	None	None
CM21	LSBN4 downstream of existing road/trail	0.06	0.80	0.05	0.66	8	0.25-0.75	None	None but still down cutting during 1-2 year events
CM22	LSBN4 upstream of existing road/trail	0.08	1.06	0.08	0.59	5	0.5	None	None
CM23	LSBN3	0.04	0.45	0.02	0.39	19	0-0.25	None	None
CM24	LSBN2	0.04	0.53	0.02	0.31	12	0-0.25	None	None, incisement ancient, banks now treed and vegetated
CM25	Mainstem Upstream of Bishop Creek	0.18	4.80	0.84	17.00	2	0.25-0.5	50	Infrequent, no channel forming floods in past decades
CM26	Bishop at mouth	0.50	2.20	1.11	7.87	6	0.5	50	Infrequent, no channel forming floods in past decades
CM27	Bishop upstream of planned logging	0.19	2.90	0.56	6.91	4	0	None	Infrequent, no channel forming floods in past decades
CM28	LSBN1	0.04	0.65	0.03	0.83	24	0	None	Infrequent, channel fully vegetated below site
CM29	Mainstem downstream of Bishop Creek	0.35	4.60	1.59	25.81	2	0.25	40	Infrequent, no channel forming floods in past decades
CM30	LSBS2-3 downstream of 2-3 confluence	0.12	1.50	0.17	2.91	6	0	None	Infrequent, no channel forming floods in past decades
CM31	At Low Gradient Crossing	0.39	4.85	1.91	28.99	2	0	20	Infrequent, small bank failure on right upstream bank
CM32	Between Boulder-Low Gradient crossing	0.25	6.80	1.72	29.15	3	0.25	None	No recent channel forming floods, but bank erosion upstream
CM33	Road Slide Tributary	0.08	0.60	0.05	0.10	19	0.25	None	None
CM34	Above Blowout Crossing	0.34	5.10	1.72	30.15	6	0.5	~10	2013 and 1995 flood levees on both banks with LWD
CM35	Below Blowout Crossing	0.31	6.10	1.89	30.34	3	1.25	~25	No recent channel forming floods; point bar from 2013 at site
CM36	Mouth	0.42	5.70	2.40	30.38	5	0.75	~20	No channel forming events, 1995 levee with spruce

Table IV- 3. Bedload movement and size, sediment supply, and fine sediment deposits at 36 channel morphology sites within Loomis Creek watershed.

Site ID	Site description	Bed load movement	Avg D90 (cm)	Finer sediment deposits on or above banks, bar top, interstitial	Any ongoing upstream sediment supply
CM01	Eastern headwater basin	Very little, mostly moss covered immobile lag	3.2	Some on small floodplain, most interstitial to cobbles and deposited in pools	No indication of an ongoing upstream sediment supply, very little fresh colluvium
CM02	Southern headwater basin	Bedload angular colluvium immobile expect in infrequent floods	11.2	Interstitial, not on banks, finer sediment washed away up to high-water mark	Banks, headwaters, colluvial landslides scarps
CM03	Western headwater basin (big)	Most rocks moss covered, less bedload movement than main channel of Loomis	4.6	Not up on banks, interstitial, finer sediment washed down	Only from small localized left upstream cut bank, some colluvial inputs from banks
CM04	Eastern headwater basin (small)	Very limited	5.6	Not up on banks, interstitial, fine sediment present remains in channel	No significant sediment inputs, local channel only
CM05	Mainstem Headwaters	Lots of immobile lag covered with moss, no significant bed load movement since 2013	8.8	Fine sediment elevated on banks of floodplain; stream incised in floodplain	No, just banks collapsing in small areas
CM06	LSBN9 new channel in logged area	Bright bedload recently or frequently mobile	8.0	Interstitial, no floodplain, some bank deposits upstream-downstream of site	Channel downcutting trail above site, this is more recent erosion than above CM07
CM07	LSBN9 original channel in logged area	Large amount of bedload movement in 2013, none since, channel filled in with bedload	1.6	Interstitial, may have been overbank as well but floodplain now vegetated	Channel downcutting trail above site, but no recent erosion there
CM08	LSBN9 upstream of past logging	Mossy larger lag angular colluvium immobile, only small cobble moving	9.6	Interstitial, no floodplain	Local colluvium was the original sediment source, but banks fully vegetated now
CM09	LSBN8 in logged area	Bright bedload is present, recently or frequently mobile	6.0	Interstitial only, no floodplain	Local banks only
CM10	LSBN8 upstream of past logging	50% bright bedload recently or frequently mobile, 50% mossy larger lag or boulders	5.0	Interstitial only, no floodplain	Local banks only, colluvial scarp upstream at (CO128) but material has not reached site
CM11	Mainstem Downstream of LSBN8&9	Algae covered, mostly immobile, but bedload movement further upstream in 2013	6.0	Bar top, interstitial, channel margins	Upstream channel, fine sediment from local banks, some limited inputs from LSBN8&9
CM12	LSBN7 downstream of past logging	Bedload is only fine sediment	0.1	Substrate entirely fine organics and sand, no alluvium	No sediment inputs or transport due to minimal flow, just local channel source
CM13	LSBN7 upstream of past logging	Some bright bedload, but majority not mobile and moss covered	1.0	Interstitial only	No sediment inputs or transport due to minimal flow, just local channel source
CM14	LSBN6 downstream of past logging	Some rock and sand bedload upstream of site, but site only has organic fines	0.1	Substrate entirely fine organics and sand, no alluvium	No significant upstream source, local banks sources only
CM15	LSBN6 near upper limit of logged area	Mossy larger lag or boulders, only course gravel mobile	3.6	Interstitial only	No significant upstream source, just local channel; transport minimal due to low flow
CM16	Mainstem upstream of beaver meadows	Bedload cobble or smaller with algae, still mostly immobile lag, movement minimal	8.8	Bar top and interstitial only, not deposited on floodplain or banks	No, local incised bank sources only
CM17	LSBN5 downstream of past logging	Mostly organic and sand material being down cut, almost no rocks	1.8	Interstitial only, channel incised due to historical logging	No, local banks sources only
CM18	LSBN5 headwaters, limited logging	None, larger lag with course gravel that is not mobile	0.1	Interstitial only, alluvium at site is glacial deposited	No sediment inputs or transport due to minimal flow, just local channel source
CM19	Mainstem middle of beaver meadow	Most bed sediment mobile in bankfull or slightly higher flows	12.2	No bank deposits, primarily on channel margins, some in oxbows	Local bank failures only, slow process of transport from headwaters takes centuries
CM20	LSBS6	80% 20% immobile to mobile	11.0	Interstitial only	No, local banks sources only
CM21	LSBN4 downstream of existing road/trail	Lots of immobile lag, only small gravel mobile	3.4	Interstitial only	No, local banks sources only
CM22	LSBN4 upstream of existing road/trail	Most bed material is sediment and mobile	3.0	Interstitial only	No, local banks sources only
CM23	LSBN3	Only fine sediment is mobile, no floodplain	0.1	Vegetated draw with one small plunge scour pool, no alluvial bedload	Inputs from cattle on trail may not reach Loomis due to low flow and beaver meadows
CM24	LSBN2	Only fine sediment is mobile	0.1	Substrate mostly fines and organics,	Inputs from cattle on trail may not reach Loomis due to low flow and beaver meadows
CM25	Mainstem Upstream of Bishop Creek	Most of bed sediment mobile because small in diameter	10.2	Only on channel margins and in deeper pools, interstitial to small cobble	Small localized collapsing banks; cattle; transport from headwaters takes centuries
CM26	Bishop at mouth	Most of bed sediment mobile in average year	8.4	Interstitial only to margins of channel, tail of pools	Banks only which are mostly stable; bedload transport from headwaters takes centuries
CM27	Bishop upstream of planned logging	Mossy larger lag or boulders, 50% immobile lag, 50% mobile sediment	5.6	Interstitial only, some fine sediment on gravel bars closer to Loomis Creek	Local banks and headwaters sources; local tributaries too small to transport sediment
CM28	LSBN1	Most of bedload is immobile, only moves during major floods (e.g., 2013)	1.8	Interstitial only	Limited inputs from fully vegetated banks and channel due to low/intermittent flow
CM29	Mainstem downstream of Bishop Creek	Bed sediment mobile, except larger colluvial boulders at end of reach	9.4	Interstitial only	Banks, local channel sources, some input from an old road crossing Loomis above site
CM30	LSBS2-3 downstream of 2-3 confluence	No evidence of channel forming floods in past several decades	1.0	Interstitial only, some channel margin deposits further upstream	Local banks source
CM31	At Low Gradient Crossing	Small immobile cobble covered in fine sediment, more embedded than site upstream	9.2	Interstitial only, fine sediment on mid channel bar downstream of site	Escarpments below Bishop confluence are the largest point sources; local bank failure
CM32	Between Boulder & Low Gradient crossing	Most bed sediment mobile other than boulders	16.4	Interstitial only, in eddy behind large boulder mid channel	Escarpments below Bishop confluence are largest point sources, washed out logging road
CM33	Road Slide Tributary	Substrate is small but still mostly immobile	2.6	Interstitial and at channel margins only	Flows too low to erode bank, just exposed soil from fallen trees
CM34	Above Blowout Crossing	Mossy larger lag with mobile bedload in between	10.4	Interstitial, some bar top from 2013 event starting to be covered in vegetation	Escarpments below Bishop confluence are largest point sources, local banks armoured
CM35	Below Blowout Crossing	No significant bed load movement since 2013, mossy larger lag and boulders	10.6	Interstitial, some bar top	Escarpments below Bishop confluence are largest point sources, alluvial material from Blowout Crossing resulting in channel aggradation has not reached the site
CM36	Mouth	Mossy larger lag with mobile boulders and angular colluvium	14.4	Interstitial, some bar top now vegetated after event like larger and before 2013	Escarpments below Bishop confluence are largest point sources, local banks and scarps a smaller source

Table IV- 4. Bank condition, riparian disturbance, riparian stand characteristics, large woody debris abundance and function.

Site ID	Site description	Riparian fire or logging	Bank condition	Riparian stand characteristics	Large woody debris function	LWD pieces per 10m
CM01	Eastern headwater basin	Not apparent at local site	Laid back, vegetated	Mixed age conifers, <20 cm diam, channel interaction limited	Parallel to banks, all small avalanche debris, old and long-lived, covered in moss, some functioning	1
CM02	Southern headwater basin	Not apparent at local site	Laid back, vegetated	Mixed age conifers, 50-60 cm diam max, channel interaction limited	Limited amount, no new pieces since 2013, mostly small, larger pieces are parallel or swept downstream quickly	1
CM03	Western headwater basin (big)	Not apparent at local site	Laid back, vegetated	Mixed age conifers, 40-50 cm diam max, channel interaction limited	Limited amount, some fresh, some old, 30 cm diameter max, suspended and single functional pieces, not moving	1
CM04	Eastern headwater basin (small)	Logged 75 m upstream	Laid back, vegetated	Mixed age conifers, 50-60 cm diam max, no interaction with channel	Limited amount, suspended or collapsed into channel, old, not moving, long lived	1
CM05	Mainstem Headwaters	Logging 100 m downstream	Laid back, vegetated	Mixed age conifers, 20-60 cm diam max, floodplain too wide for interaction	More beyond site, swept out of site in 2013, one 40 cm diameter piece in a jam, no fresh pieces, no recent movement	1
CM06	LSBN9 new channel in logged area	Logged	Laid back, vegetated	Mixed age conifers, 10-30 cm diam max, limited interaction due to logging	Limited due to logging/young forest and new channel is, no new pieces, some single functional pieces	1
CM07	LSBN9 original channel in logged area	Logged	Laid back, vegetated	Mixed age conifers, 20-30 cm diam max, limited interaction due to logging	Limited due to logging/young forest, LWD is old and long lived	2
CM08	LSBN9 upstream of past logging	Not apparent at local site	Laid back, vegetated	Mature conifers, 50-60 cm diam max	Rotten, collapsed, 50 cm diameter max above/below site, smaller at site, old, mostly suspended or parallel	1
CM09	LSBN8 downstream of past logging	Logged	Scoured, overhanging	Mixed age conifers, 20-40 cm diam max, no interacted with channel	One large functional piece from logging, otherwise limited, old, not moving, functioning partial pieces	2
CM10	LSBN8 upstream of past logging	Not apparent at local site	Laid back, vegetated	Spruce max diam 100 cm, large spruce are all dead	10-100 cm diameter, old, not moving, functioning single pieces	2
CM11	Mainstem Downstream of LSBN8&9	Logged	Laid back, vegetated	Mature conifers, 60 cm diam max, trees were greater than 60 cm diam	Not moving downstream, 10-70 cm diameter, suspended above channel, one single partially functioning piece	2
CM12	LSBN7 downstream of past logging	Logged	Laid back, vegetated	Mature conifers	No flows to recruit LWD, suspended or collapsed, not moving	3
CM13	LSBN7 upstream of past logging	Logged downslope	Laid back, vegetated	Mature conifers	No flows to recruit LWD, suspended or collapsed, not moving, small functional jams of twigs and branches	2
CM14	LSBN6 downstream of past logging	Logged	Vertical, vegetated	Mixed age conifers	No flows to recruit LWD, suspended or collapsed, not moving	5
CM15	LSBN6 near upper limit of logged area	Logged	Laid back, vegetated	Mixed age conifers	No flows to recruit LWD, collapsed functional pieces, organic bridges, no pieces moving	2
CM16	Mainstem upstream of beaver meadows	Logged nearby, not on banks	Vertical, vegetated	Mature mixed age conifers, 10-40 cm diam max, trees collapse over channel	Extensive jams upstream of site, majority suspended then collapsing, no movement	1
CM17	LSBN5 downstream of past logging	Logged	Vegetated, overhanging	Mixed age conifers, 10-30 cm diam max, stumps 80 cm diam max	No flows to recruit LWD, riparian logging so no new pieces, small branches and roots only	0
CM18	LSBN5 headwaters, limited logging	Site near upper limit of logging	Vertical, vegetated	Mixed age conifers	No flows to recruit LWD, riparian logging so no new pieces, small branches and roots only, no LWD movement	0
CM19	Mainstem middle of beaver meadow	Not apparent at local site	Vertical, vegetated	Woody shrubs, conifers rare, limited channel interaction	Only one old piece pushed up onto banks from past flood	0
CM20	LSBS6	Burned	Vegetated, overhanging	Mixed age conifers, 30 cm diam max, 40-80 cm before fire, no interaction	Old, small functional pieces and roots from incisement, 20-40 cm diameter pieces upstream of site	2
CM21	LSBN4 downstream of existing road/trail	Just a logging road crossing	Vegetated, overhanging	Juvenile conifers <20 cm diam max, younger than above trail, no interaction	One functional jam upstream of site, no functional pieces within site	0
CM22	LSBN4 upstream of existing road/trail	Burned, no sign of logging	Vegetated, overhanging	Mixed age conifers, 30-40 cm diam max, 80 cm before fire, no interaction	No flows to recruit LWD; old, rotten single functioning pieces, now young forest	4
CM23	LSBN3	Not apparent but did burn	Laid back, vegetated	Mixed age conifers	Old rotted, collapsed, functional pieces upstream of site holding back sediment, none within site	0
CM24	LSBN2	Not apparent but did burn	Laid back, vegetated	Mixed age conifers	Small functional pieces	3
CM25	Mainstem Upstream of Bishop Creek	Burned	Vertical, vegetated	Woody shrubs cover beaver meadows, conifers rare, no channel interaction	None because no riparian forest and pieces are not being moved downstream	0
CM26	Bishop at mouth	Not apparent but did burn	Vegetated, overhanging	Woody shrubs only, no riparian trees within 50-100 m	One small functional jam 50 m upstream	1
CM27	Bishop upstream of planned logging	Not apparent but did burn	Vertical, vegetated	Mixed age conifers and shrubs, 10-25 cm diam max, 40 cm before fire	Functional pieces creating pools, no new pieces, not moving, up to 30 cm diameter	1
CM28	LSBN1	Not apparent but did burn	Laid back, vegetated	Mixed age conifers, 20 cm diam max, similar size when burned	Abundant, <20 cm diameter max, suspended or collapsed, long lived, no movement	8
CM29	Mainstem downstream of Bishop Creek	Burned	Laid back, vegetated	Mixed age conifers and shrubs, 20 cm diam max, minimal interaction	No functional pieces, one large, old parallel piece 30 cm diameter, no riparian trees so no inputs	0
CM30	LSBS2-3 downstream of 2-3 confluence	Not apparent in 1949 imagery	Laid back, vegetated	Mixed age conifers, natural regen; no new LWD, only willows, young spruce	None at site, only small branches and roots, some old functional pieces upstream and downstream of site	0
CM31	At Low Gradient Crossing	Not apparent but did burn	Laid back, vegetated	Mixed age pine & deciduous shrubs, 20-30 cm diam max, some interaction	None in site, functional jam below site; mid-channel gravel bar below site from local LWD	0
CM32	Between Boulder & Low Gradient	Not apparent but did burn	Laid back, vegetated	Mature spruce with deciduous shrubs, 40 cm diam max	None in site, swept downstream in 2013, large functional jam downstream is old, created mid channel vegetated bar	0
CM33	Road Slide Tributary	Not apparent but did burn	Vegetated, overhanging	Mixed and mature conifer stand, 50 cm diam max	Single functional pieces, flows to low to recruit LWD, LWD not moving but creates steps	1
CM34	Above Blowout Crossing	Not apparent but did burn	Scoured, vertical	Mixed age conifers, 10-40 cm diam max, channel interaction limited	Limited inputs due to bedrock above, 30 cm diameter max, LWD swept down quickly or pushed out of channel in 2013	1
CM35	Below Blowout Crossing	Burned	Scoured, overhanging	Mixed age conifers, 10-50 cm diam max	Suspended, no functional pieces, 30 cm diameter max, no movement since 2013	2
CM36	Mouth	Burned	Scoured, overhanging	Mixed age conifers, 15-30 cm diam max, 40 cm before fire, some interaction	One single functional piece, one partial functional jam, 40 cm diameter max, swept downstream quickly	1

Detailed channel morphology descriptions of separate parts of the watershed

i. Channel morphology of Loomis Creek in the headwaters

In the headwaters of Loomis Creek where the stream gradient is higher (7%), a cascade channel morphology with boulders predominates (**Photo IV- 1**), as observed at the single mainstem channel morphology site at this location (Online Map Site ID CM05). Small pools are frequent and spaced one channel width apart or less. The channel is confined by steep valley slopes with no floodplain in some sections, while it is incised into the floodplain from the 2013 event in others. There are no signs of flood disturbance since the 2013 event, and typical 1-2 year high flow events are not overtopping the existing floodplain. The average size of the mobile bedload (D90) at Online Map Site ID CM05 is 9 cm. Ongoing sediment delivery is primarily from local bank erosion during flood events, and there were no significant inputs of sediment observed from upstream sources such as avalanche gullies. Although historical logging occurred upstream and downstream of Online Map Site ID CM05, the adjacent riparian forest was not harvested and there are no signs of channel incisement of Loomis Creek resulting from the logging. LWD was mobilized by the 2013 flood event and has been swept downstream, resulting in some reaches of stream having no LWD while others have small or large accumulations across the mainstem channel (**Photo IV- 2**). A small log jam was present at the downstream limit of Online Map Site ID CM05, while larger log jams were observed further upstream (Online Map Site IDs CO082, CO083, CO084).

ii. Channel morphology of Loomis Creek in the mid-reach

Downstream of the headwaters, riffle pool channel morphology predominates along the mainstem of Loomis Creek throughout the mid-reach and stream gradient is consistently 2-3% (**Photo IV- 3**). Riffle pool morphology was recorded at Online Map Site ID CM11 below the confluence of the two largest tributaries on the North side of Loomis Creek (LSBN8, LSBN9), upstream of, within, and downstream of the beaver meadows (Online Map Site IDs CM16, CM19, CM25), and below the confluence of Bishop Creek (Online Map Site ID CM29) to the Low Gradient Crossing (Online Map Site ID CM31). In this reach, larger pools are present, but they are spaced further apart (one every 5-7 channel widths). LWD is abundant in the mid-reach of Loomis Creek upstream of the beaver meadows (**Photo IV- 4**), with riparian trees falling from collapsing banks and remaining in place, suspended over the channel, until decay results in them collapsing into the channel (Online Map Site IDs CM11, CO046, CO085, CO097, CO098, CO100, CM16, CO104). The low stream gradient and broader floodplain are not conducive to sweeping LWD downstream. LWD is largely absent within the beaver meadows due to trees being absent from the floodplain adjacent to the channel. Downstream of the beaver meadows and upstream of the Low Gradient Crossing, LWD abundance increases but remains low relative to the reach upstream of the beaver meadows due to a less dense riparian forest.

The mainstem reach of Loomis Creek upstream of the beaver meadows is incised 1.5 m into a broader floodplain approximately 600 m wide. This incisement is not a result of

Photo IV- 1. Loomis Creek headwaters cascade boulder channel morphology.

Photo IV- 2. LWD log jam in Loomis Creek headwaters.

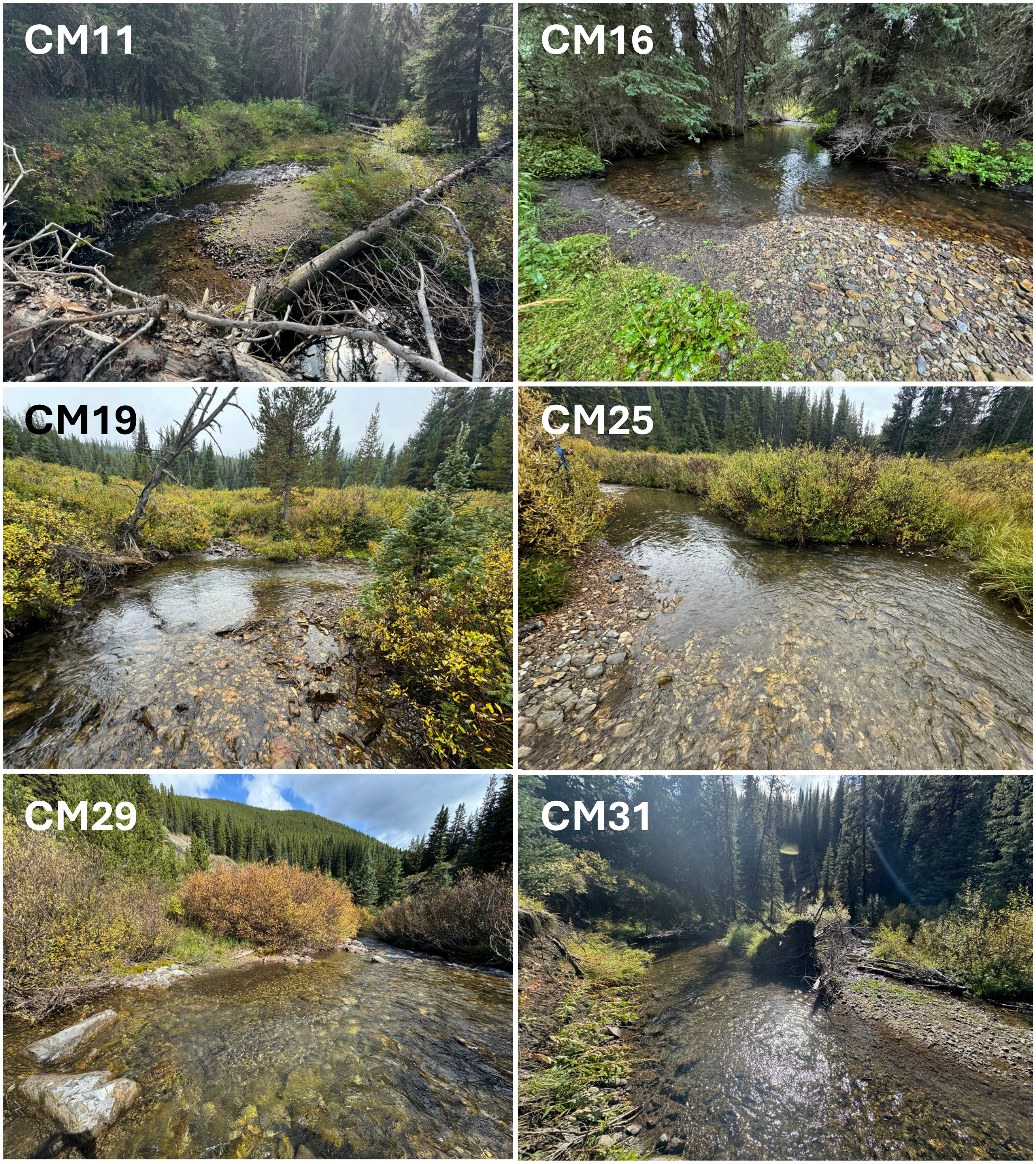


Photo IV- 3. Riffle-pool channel morphology at six sites on the low gradient mid reach of Loomis Creek with Online Map Site IDs.

Photo IV- 4. Abundant LWD in the mid reach of Loomis Creek upstream of the beaver meadows.

contemporary flows, but pre-historic conditions during the mini-ice age, which may have ended as recently as 1850. During this time, glaciers were much more advanced and deposited large amounts of sediment in areas like the mid-reach of Loomis Creek. When the glaciers retreated there were higher flows that cut through this sediment, however, it was not deposited evenly, which is why there are reaches with deep incisement close to reaches without any incisement (e.g., Online Map Site ID CO099 is a short distance downstream of CM16). The position of the Loomis Creek channel at CM16 has not changed since glacial retreat, and the stream is now undersized for the size of the channel it lies in.

Sediment delivery in the mid-reach of Loomis Creek is primarily from the upstream channel and local bank erosion. Collapsing riparian trees upstream of the beaver meadows and collapsing banks and beaver dams within the beaver meadows are the primary sediment sources upstream of Bishop Creek.

There is one significant point source of sediment approximately 300-400 m downstream of the Bishop Creek confluence and 20-120 m downstream from the Cattle Crossing. At this location steep valley escarpments on both the North and South banks of Loomis Creek have collapsed or slumped into Loomis Creek. The largest feature is on the North bank closest to the Cattle Crossing. It was observed actively eroding and releasing significant amounts of fine gravel, sand, and silt into Loomis Creek on July 17, 2024. Over time, this has resulted in deposits of fine gravel in the stream channel immediately downstream (Online Map Site ID ER03). An additional slump on the South bank 100 m downstream has also recently occurred (Online Map Site ID ER07), covering the path of the historical logging road and existing trail along Loomis Creek. Ongoing sediment inputs from this slump are less because the toe of the slump on the banks of Loomis Creek remains vegetated.

The average size of the mobile bedload (D90) in the mid-reach of Loomis Creek is relatively consistent, showing some variability but increasing in the downstream direction (Online Map Site IDs CM11 = 6.0 cm, CM16 = 8.8 cm, CM19 = 12.2 cm, CM25 = 10.2 cm, CM29 = 9.4 cm, CM31 = 9.2 cm; **Table IV- 2**).

iii. Channel morphology of Loomis Creek in the lower reach

Downstream of the Low Gradient Crossing to the mouth, the channel gradient of Loomis Creek steepens and step pool and cascade boulder channel morphology predominate (Online Map Site IDs CM32, CM34, CM35, CM36). The average gradient measured on the four lower-reach sites was 4.25% compared to just 2.2% at the six sites within the mid-reach of Loomis Creek (**Table IV- 1).**

). Pools are smaller, but more frequent, and the channel is again more confined than on the mid-reach. The typical 1-2 year high flow events do not cover the floodplain. Channel banks are either sediment terraces from large but infrequent flood events like the 2013 event or localized bedrock outcrops or escarpments. Boulders are either randomly distributed throughout the channel in cascades, or form lines perpendicular to the channel in step pools.

Relatively little functional LWD remains in the lower reaches of the Loomis Creek channel due to the 2013 flood event sweeping it parallel to the channel or downstream or pushing it up onto the banks.

One large, forced step in the stream channel was observed in this reach downstream of the Blowout Crossing where a logjam has created an approximately 1 m vertical drop in the stream bed that is likely a barrier to upstream passage for most sizes of fish during most levels of flows (**Photo IV- 5**, Online Map Site ID FB10).

Sediment delivery to the lower reaches of Loomis Creek is primarily from the upstream channel and local bank erosion. There are some occasional point source inputs of colluvial material ranging in size from silt and sand up to boulders from localized bedrock outcrops or escarpments (**Photo IV- 6**, Online Map Site IDs ER05, ER06). In addition to this, the historical logging road has slid into Loomis Creek approximately 650 m upstream from the Blowout Crossing (Online Map Site ID ER01). The landslide likely resulted from the roadbed being saturated with groundwater associated with the wet area that the Road Slide Tributary drains. Silt, clay, gravel, and larger cobble and boulder material was deposited into Loomis Creek, and some limited amounts of this material are continuing to enter the creek from the slide.

The average size of the mobile bedload (D90) in the mid-reach of Loomis Creek is relatively consistent between the four sites that were assessed and slightly higher than on mainstem sites further upstream (Online Map Site IDs CM32 = 16.4 cm, CM34 = 10.4 cm, CM35 = 10.6 cm, CM36 = 14.4 cm; **Table IV- 2**). One particularly large (D90 ~60 cm) piece of mobile colluvial bedload (**Photo IV- 7**) was noted that was perched in a logjam above the level of bankfull flows at the site closest to the mouth of Loomis Creek (CM36), highlighting the erosive power of Loomis Creek. A photograph of the estimated high watermark at another site on the lower reaches of Loomis Creek (CM34), further illustrates how high flows can be during flood events (**Photo IV- 8**).

iv. Channel morphology of Loomis Creek headwater tributaries

Channel morphology was assessed at one site on each of the four headwater tributaries that form Loomis Creek (**Figure 13**). The channels are steep (average 23% slope), have a colluvial or bedrock form, and are in deeply incised colluvial valleys lacking floodplains.

Sites on the western and eastern tributaries (Online Map Site IDs CM01, CM03) show signs of avalanche disturbance with the accumulation of small woody debris and bank scour from slush avalanches, respectively (**Photo IV- 9**). These watersheds are more hydrologically reactive due to heavy snowpacks that can melt quickly during rain events.

Photo IV- 5. Forced step on lower Loomis Creek is a 1 m high barrier to upstream fish passage.

Photo IV- 6. Eroding bank escarpment on lower reaches of Loomis Creek.

Photo IV- 7. 2013 mobile bedload with intermediate axis ~60 cm near mouth of Loomis Creek.

Photo IV- 8. Flood sign height on the lower reaches of Loomis Creek at CM34.

Photo IV- 9. Headwater tributary avalanche sign with woody debris (CM03, western) and slush-caused bank scour (CM01, eastern).

The headwaters west subwatershed has more south facing (SE, S, SW) aspect than the other headwater tributaries (**Figure 11**), which can result in faster snow melt due to greater solar radiation.

The average size of the mobile bedload (D90, cm) varies for each of the tributaries (Online Map Site IDs CM01 = 3.2 cm, CM02 = 11.2 cm, CM03 = 4.6 cm, CM04 = 5.6 cm; **Table IV- 3**), being largest in the southern tributary (Online Map Site IDs CM02) which may accumulate the greatest amount of snow in the headwaters and have the highest spring peak flows.

There are no obvious signs of a significant ongoing supply of sediment to any of the headwater tributaries other than local bank erosion. Despite signs of avalanches on two of the channels, these have not resulted in significant sediment inputs.

v. Channel morphology of Loomis Creek south side tributaries

Three tributaries flowing into Loomis Creek from the south side were assessed for channel morphology: Bishop Creek, LSBS2-3, and LSBS6.

Bishop Creek channel morphology

Bishop Creek is the largest tributary to Loomis Creek and channel morphology was assessed on two sites (**Figure 13**). One site was upstream of the planned logging (Online Map Site ID CM27) and one was at the mouth near Loomis Creek (Online Map Site ID CM26). Over this reach, the gradient of Bishop Creek is relatively consistent and measured as 6% at the mouth and 4% at the upper site (**Table IV- 2**). Most of the reach of Bishop Creek between the two sites had a riffle pool morphology type. There is no sign of frequent flood disturbance at either of the channel morphology sites on Bishop Creek, and while there were some mid-channel and side-channel gravel bars observed between the sites (**Photo IV- 10**; Online Map Site IDs CO47, CO49, FS06), these deposits are not recent and likely from the 2013 flood event. There is no sign of any large and ongoing inputs of sediment to Bishop Creek. The diameter of the largest mobile bedload material (D90, cm) on the two sites on Bishop Creek averaged 8.4 cm at the mouth and 5.6 cm at the upper site (**Table IV- 2**). Much of the Bishop Creek watershed appears burned in 1949 areal imagery, and signs of historical fire were observed throughout the watershed adjacent to the channel morphology sites (Online Map Site IDs HF03-06, HF15-23). No signs of historical riparian logging were observed.

LSBS2-3 channel morphology

The channel morphology site on LSBS2-3 (Online Map Site ID CM30) was located approximately 150 m upstream from Loomis Creek, downstream from the confluence of LSBS2 and LSBS3 (**Figure 13**). This site was classified as a cascade with boulders with a gradient of 6% (**Table IV- 1**, **Table IV- 2**). The gradient of the stream decreases slightly further upstream, and a riffle pool morphology is present in some locations (Online Map Site IDs CO010, CO011). Observations at the site, and for approximately 675 m further upstream, showed no recent signs of flood or channel forming flows. The average diameter

Photo IV- 10. Bishop Creek mid channel gravel bar deposits from past flood events.

of the largest mobile bedload material (D90) is 1.0 cm (**Table IV- 3**), and there were no signs of any significant sediment sources to this tributary or flood disturbance. The riparian area showed no clear signs of wildfire or logging disturbance, although imagery from 1949 shows that while the location of Online Map Site ID CM30 near Loomis Creek had not burned, almost the entire LSBS2-3 subwatershed burned in the 1936 fire. However, effects of this fire on LSBS2-3 channel morphology are not clearly apparent now.

<u>LSBS6 channel morphology</u>

The channel morphology site on LSBS6 was located approximately 175 m upstream from Loomis Creek (Online Map Site ID CM20). This site was classified as a forced step pool with a gradient of 8% (**Table IV- 1, Table IV- 2**). The channel shows signs of incisement, and the steps in the stream bed have formed from exposed root networks and LWD. The average diameter of the largest mobile bedload material (D90) was 11.0 cm (**Table IV- 2**), indicating the stream has significant erosive power, possibly due to the alpine headwaters accumulating a heavy snowpack and some of the forest burning in the 1936 wildfire. Both factors could make this tributary be more hydrologically reactive during spring freshet. The tributary was walked from the headwaters to Loomis Creek, and there were no recent and significant signs of flood disturbance, channel forming flows, or significant sediment sources. Roughly the lower quarter of the LSBS6 watershed burned in 1936, with signs of this observed (Online Map Site IDs HF7, HF9, HF10, HF13), but none of the LSBS6 subwatershed was historically logged (**Photo IV- 11**).

vi. Channel morphology of Loomis Creek north side tributaries

The channel morphology classification of tributaries flowing into Loomis Creek from the North is presented in groups of adjacent tributaries.

<u>LSBN8 and LSBN9 channel morphology</u>

LSBN8 and LSBN9 are the two largest tributaries flowing into Loomis Creek from the North and the furthest upstream tributaries other than the headwater tributaries. LSBN9 has a larger sub-basin area (1.6 km^2 vs. 0.6 km^2) and has a large area of south facing alpine slopes above tree line (**Figure 7**, **Figure 11**) that accumulates a large snowpack and can produce high flows during spring melt. In contrast, the LSBN8 sub-basin is entirely below tree line, so it does not accumulate as large a snowpack or produce as high flows during spring melt.

Channel morphology sites were placed on each tributary upstream and downstream of where historical logging occurred in each of LSBN8 and LSBN9 sub-basins (**Figure 11**). Two sites were placed on LSBN9 downstream of the historical logging road because channel avulsion upstream of the road within the logged area has resulted in a new channel forming. Channel avulsion may be the result of the snowpack-related hydrologic effects of historical logging causing higher flows, which could have resulted in increased bedload movement. LWD left behind in the channel after the logging may have also played a role. Review of historical areal imagery and assessment on the ground shows no sign that LSBN8 and LSBN9 subwatersheds have been affected by wildfire.

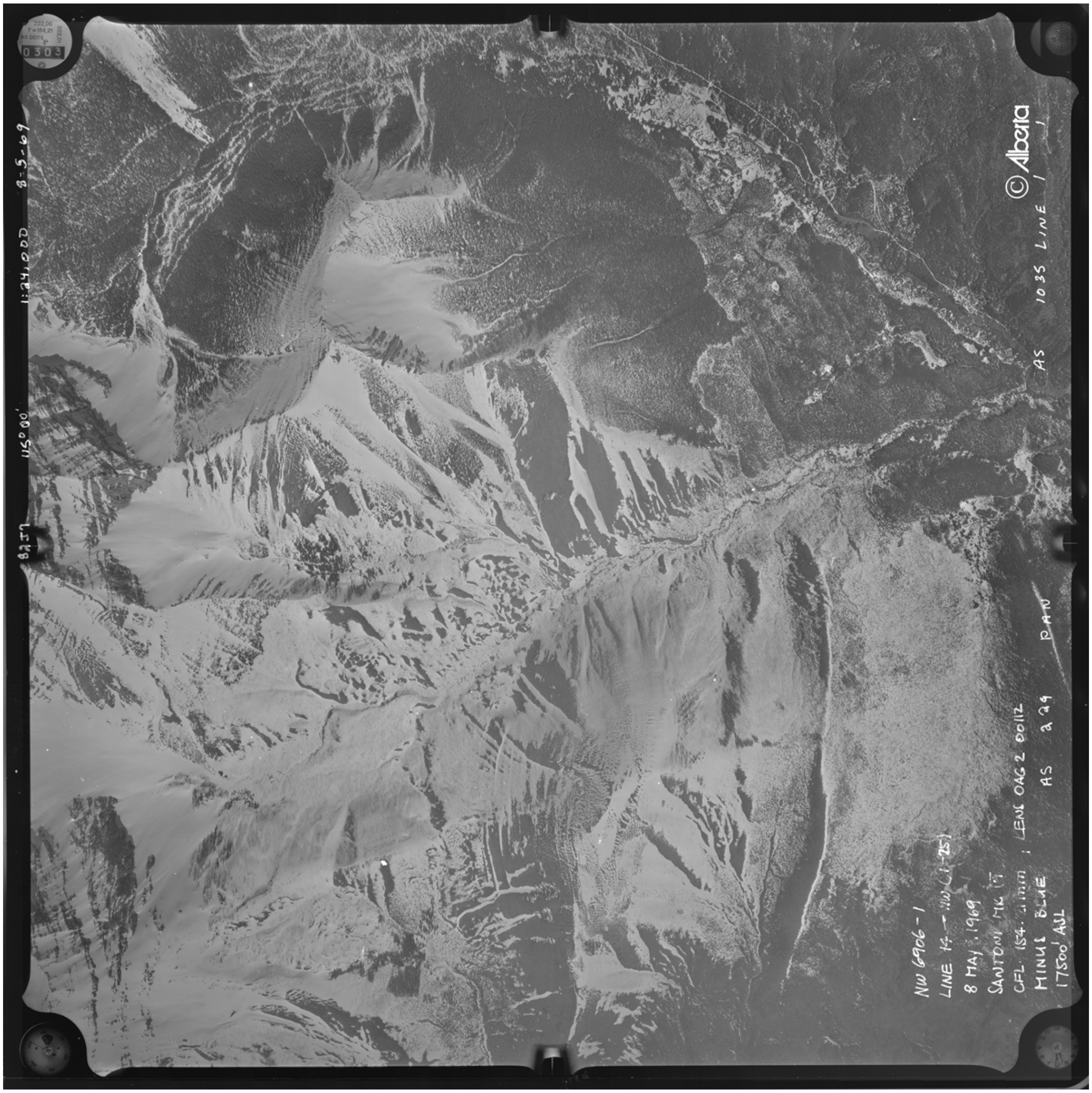


Photo IV- 11. Air photo (1969) showing Bishop Creek, LSBS6, and Loomis Creek headwaters.

The LSBN9 tributary upstream of the road is a steep cascade with boulders (16% gradient, **Table IV- 2**). There is evidence that the bedload is moving because the boulders are rounded and most of the bedload is not covered with moss (D90 = 9.6 cm, **Table IV- 3**). The channel morphology site (Online Map Site ID CM08) is upstream from historical logging.

On the original LSBN9 channel downstream of the historical logging road within the area that was historically logged the channel has become aggraded with the deposition of alluvial material, likely during the 2013 flood event (Online Map Site ID CM07). There has been no recent bedload movement (D90 = 1.6 cm, **Table IV- 3**), and channel gradient is lower that at CM08 (5%, **Table IV- 2**). The channel may now only receive overflow from LSBN9 during floods, so it was classified as an overflow channel.

The other site on LNSB9 downstream of the historical logging road is also within a portion of the subwatershed that was historically logged. It is on a new, underdeveloped channel that is cutting around trees, down through root networks, and leaving fresh deposits of bedload material (Online Map Site ID CM06). This is more pronounced upstream and downstream of this site (Online Map Site IDs CO089, CO090-CO094). The gradient is steeper than the aggraded original channel (11% vs. 5%, **Table IV- 2**). CM06 has a forced step pool morphology, with intermediate sections of cascades with cobbles. Most of the bedload is mobile and the D90 is 8 cm (**Table IV- 3**).

One site upstream and downstream of the historical logging was assessed on LSBN8 (**Figure 13**). At the upper site (Online Map Site ID CM10) above the portion of the subwatershed that was logged there is a colluvial channel morphology with small forced step pool sections. The steep gradient (20%, **Table IV- 2**) in combination with lower flows due to a smaller subwatershed lacking an alpine basin, mean the bedload material is not as mobile as on LSBN9 (D90 = 5 cm, **Table IV- 3**). Within the portion of the subwatershed that was historically logged and downstream of the historical logging road (Online Map Site ID CM09), like LSBN9, LSBN8 has a forced step pool channel morphology with a lower gradient (13%, **Table IV- 2**). Mobile bedload accumulates upstream of LWD, creating steps. The average diameter of the largest mobile bedload material (D90) is 6.0 cm (**Table IV- 3**). LSBN8 was walked from a point 265 m upstream of Online Map Site ID CM10 to Loomis Creek, and there were no significant signs of flood disturbance or channel forming flows. One small slump of the valley wall was observed upstream of Online Map Site ID CM10 that could be a source of sediment (Online Map Site ID CO128).

<u>LSBN4, LSBN5, LSBN6, and LSBN7 channel morphology</u>

Further to the East, four other tributaries flowing into Loomis Creek from the North have channel morphology sites placed upstream and downstream of the historical logging and/or the historical logging road: LSBN4, LSBN5, LSBN6, and LSBN7 (**Figure 13**).

On LSBN5 the upper site was located approximately 10 m downslope of the upper limit of historical logging (**Photo IV- 12**), while on LSBN4 no evidence of historical logging was observed upstream of the historical logging road but a site was placed upstream of the road.

Like LSBN8, which lacks an alpine basin, LSBN4, LSBN5, LSBN6, and LSBN7 are the same. Flows in LSBN8 are highest, while LSBN5 produces flashy runoff and can have substantial discharges, as evidenced by channelization, downcutting, and incisement through parts of the subwatershed that were historically logged without any riparian buffer (Online Map Site IDs CO105, CO106, CO108, CO109, CO115).

A colluvial channel morphology form was assessed on LSBN7, LSBN6, and LSBN5 at the sites upstream of the historical logging (**Figure 13**, **Photo IV- 12**; see Online Map Site IDs CM13, CM15, CM18, respectively). At these upper sites on LSBN7 and LSBN6, steep

Photo IV- 12. LSBN5, LSBN6, LSBN7 channels upstream of or within unbuffered clearcuts.

gradients (**Table IV- 2**; 29% and 22% at Online Map Site IDs CM13 and CM15, respectively), in combination with limited flows at these sites, resulted in only small gravel and silt being mobile (**Table IV- 3**; D90 ranges from 0.1-1.0 cm). At the upper site on LSBN5 (Online Map Site ID CM18) the gradient is lower (**Table IV- 2**; 5%), and only silt is mobile (**Table IV- 3**; D90 = 0.1 cm).

LSBN7 and LSBN6 flow on the surface of the forest floor from the sites above the historical logging into historically logged areas, but downstream of the historical logging road these tributaries start to flow subsurface, beneath the forest floor, with no visible channel except for short reaches approximately 50-100 m long near Loomis Creek. Where surface flow reemerged is where channel morphology sites downstream of the historical logging were placed. In contrast, LSBN5 has a visible channel on the surface of the forest floor most of the way between the upper site (Online Map Site ID CM18) and Loomis Creek.

Historical logging occurred over top of the LSBN7, LSBN6, and LSBN5 stream channels without leaving a riparian buffer, and is more extensive in the LSBN5 subwatershed. Channel incisement and channelization are apparent along most of the LSBN5 channel, while the other two channels remain subsurface throughout much of the historically logged portion of the LSBN7 and LSBN6 subwatersheds.

Flows are intermittent on LSBN7, LSBN6, and LSBN5, and the lower sites on LSBN7 (Online Map Site ID CM12) and LSBN6 (Online Map Site ID CM14) were assigned a channel morphology class of intermittent (**Figure 13**). Channel morphology at the lower site on LSBN5 (Online Map Site ID CM17) is a combination of a forced step pool morphology resulting from the exposed root networks of riparian trees that were logged, and incised and channelized morphology resulting from the stream downcutting through loose material.

Like the upper sites, only small gravel or organic fines and silt are mobile on LSBN7, LSBN6, and LSBN5 downstream of the historical logging near Loomis Creek (D90 ranges from 0.1-1.8 cm). Channel gradients at these sites (**Table IV- 2**) were 1% on LSBN7 and LSBN6 (Online Map Site IDs CM12 and CM14, respectively), while slightly greater on LSBN5 (5%, Online Map Site ID CM17). The flashy runoff and channelization, downcutting, and incisement on LSBN5 is resulting in ongoing erosion and downcutting, but this was not observed on LSBN7 and LSBN6.

As described above for the mainstem site on Loomis Creek immediately upstream from the beaver meadows (Online Map Site ID CM16), the lower site on LSBN6 near Loomis Creek (Online Map Site ID CM14) is also deeply incised into a paleo-floodplain that was deposited following the last glacial retreat. The position of the channel that LSBN6 flows in at Online Map Site ID CM14 has not changed since glacial retreat, but the stream is now undersized for the channel it lies in. At this location, LSBN6 may be flowing in what was a historic side channel of Loomis Creek.

Channel morphology on LSBN4 was not assessed as high up in the subwatershed as on LSBN7, LSBN6, and LSBN5 because no signs of historical logging were observed above the historical logging road. Instead, there were clear signs this area had historically burned

(**Photo IV- 13**, Online Map Site ID HF12). A forced step pool morphology, with unforced steps in sections, was assessed at this location (Online Map Site ID CM22; Table IV- 1). Channel gradient is low (5%) compared to the upper sites on LSBN7 and LSBN6 but increases at the lower site downstream of the road (Online Map Site ID CM21, 8%; **Table IV- 2**). The lower site also has forced step pool channel morphology. At both sites, mobile bedload (D90 = 3 cm) gets caught behind debris, roots, and rocks, but there are also colluvial sections of mossy immobile material. LSBN4 flowed throughout the summer and fall of 2024, and the channel remains visible from Online Map Site ID CM22 to Loomis Creek. Like LSBN5, LSBN4 is incised and downcutting downstream of the historical logging road. This was the only sign of channel forming flows and ongoing erosion on LSBN4.

<u>LSBN1, LSBN2, LSBN3 channel morphology</u>

East of LSBN4, just one channel morphology site was assessed on each of the next three tributaries (LSBN1-3; **Figure 13**).

The site on LSBN3 (Online Map Site ID CM23) is downstream of the historical logging road and has an intermittent channel morphology class (**Table IV- 1**), with forced step pools further upstream closer to the road that are capturing the mobile bedload of sediment (Online Map Site ID CO030, D90 = 0.1 cm; Table IV-2). The gradient is locally steep (19%; **Table IV- 2**)) as the channel follows a gully down to the edge of the beaver meadow on Loomis Creek. While not assessed on the ground, the channel further upstream above the road likely becomes colluvial as gradient increases. No significant signs of erosion or channel forming flood events were observed on LSBN3.

The site on LSBN2 (Online Map Site ID CM24) is upstream of the historical logging road. This is because from the point where the tributary intersects the road, it flows along the ditch line towards the East and then crosses the road and disappears into a vegetated draw that drains down to the beaver meadows. Therefore, natural channel morphology could only be assessed upstream of the road. Here at Online Map Site ID CM24, a colluvial morphology classification with occasional forced steps exists (**Figure 13**). Mobile bedload is sediment only (D90 = 0.1 cm; **Table IV- 3**) and gets caught behind debris and roots. There are sections of mossy immobile material as well. High flows have not resulted in recent erosion or channel forming flows at the site, but downstream of the site there is some evidence of recent channel incisement in the ditch line along the road (Online Map Site ID LI14). Channel gradient is 12% at Online Map Site ID CM24 (**Table IV- 2**).

The site on LSBN1 (Online Map Site ID CM28) is also upstream of the historical logging road because the channel reaches the Loomis Creek floodplain immediately downstream of the road. The site is approximately 165 m upstream from Loomis Creek where the channel is a forced step pool morphology, with a mobile bedload of small gravel (D90 = 1.8 cm; **Table IV- 3**). There are no signs of recent flood disturbance, channel forming flows, or erosion and sources of sedimentation on the channel upstream of the road. However, downstream of the road there has been some scour during past flood events (Online Map Site ID CO023).

Photo IV- 13. Evidence of historical fire in LSBN4 showing small size of regenerating stand.

No signs of historical logging or wildfire were observed anywhere near LSBN1, LSBN2, LSBN3, but historical imagery from 1949 suggest this part of the Loomis Creek watershed burned in the large 1936 wildfire that burned much of upper Highwood River valley.

Road Slide Tributary channel morphology

The last remaining tributary that was assessed for channel morphology that flows into Loomis Creek from the North was the Road Slide Tributary. This is a groundwater fed stream that flows perennially. It is named as such because it is within 10 m of where the tributary crosses the historical logging road a landslide of the roadbed was triggered by saturated soils. Although the slide occurred decades ago, the soil on the face of the slide is still saturated with groundwater and has not revegetated. It is not known when this slide occurred, but the road is visible in 1949 imagery and the slide may not have occurred until after the logging in the headwaters was completed in the 1960s.

The Road Slide Tributary channel morphology site was upstream of the historical logging road (Online Map Site ID CM33), because downstream of the road the tributary enters a steep gully that joins the landslide path down to Loomis Creek (Online Map Site ID ER01). Upstream of the road, stream gradient is steep (19%; **Table IV- 2**). Bedload material accumulates in forced steps (D90 = 2.6 cm; **Table IV- 1**, **Table IV- 3**). Flows appear to be stable, although the tributary flows subsurface in sections under moss and logs, and over exposed soil where a tree was uprooted. There are no signs of recent flood disturbance, channel forming flows, or erosion and sources of sedimentation on the Road Slide Tributary. No signs of historical logging or wildfire were observed anywhere nearby, although burned stumps were observed in the Loomis Creek valley downstream of the nearby mainstem channel morphology site (Online Map Site ID CM32). Historical imagery from 1949 shows the lower portion of the Loomis Creek watershed burned, with fire disturbance being patchy near the Road Slide Tributary.