

Motorized Access Management: Recommendations to Protect Grizzly Bears in the Upper Lillooet River Area


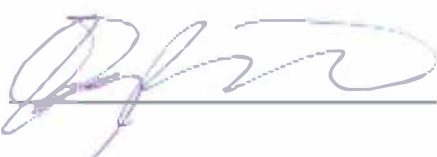




Sponsor & Partners Statement

This report, "Motorized Access Management: Recommendations to Protect Grizzly Bears in the Upper Lillooet River Area", was completed in collaboration with the project sponsor and partners listed below.

Other community stakeholders participated in wider planning meetings and helped inform the process with detailed information and local knowledge.

By signing this page, the sponsor and partners agree that the report information is an accurate representation of the issues, and that they support the recommended implementation and monitoring tasks.

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Front cover photo courtesy of Steve Rochetta (from Upper Lillooet hair snag (DNA collection) station camera, 2015)

Executive Summary

Land and resource issues within the Sea to Sky Natural Resource District (the District) and the traditional territory of the Lil'wat Nation are complex, with many overlapping values, including wildlife, recreation, and industrial tenures. Threatened grizzly bear populations in the District are affected by ongoing habitat fragmentation, displacement, and mortality risk associated with resource roads that enable dispersed public access. In addition, mountainous terrain consisting of steep slopes and volcanic landslide hazards contribute to backcountry risks to public safety. Effectively addressing these components is the purpose of this report.

In October 2017, the Office of the Auditor General of British Columbia released the report “An Independent Audit of Grizzly Bear Management” that focused on the Ministry of Environment and the Ministry of Forests, Lands and Natural Resource Operations and their roles in meeting government’s objective of ensuring healthy grizzly bear populations throughout BC¹. It also looked at government’s planning, activities and reporting as to the effectiveness of grizzly bear management. “Reducing Illegal Activities” and “Reducing grizzly bear/human conflicts” are two of the four key areas for managing human threats to grizzly bears identified in this report, and is the main objective of the planning process facilitated by the Sea to Sky Natural Resource District, resulting in this recommendations report.

The 2008 Coordinated Access Management Plan (CAMP) provides the most recent and comprehensive example of planning in the Sea to Sky Natural Resource District to address specific issues around wildlife, recreation, and roads, and resulted in seasonal road closures through the *Wildlife Act* to prevent conflict between grizzly bears and humans². This report builds on the CAMP and provides new access management control point locations that are intended to address and resolve considerations of public safety and grizzly bear conservation.

The Upper Lillooet River planning area is comprised of sensitive grizzly bear habitat, located mainly in the South Chilcotin Ranges Grizzly Bear Population Unit (GBPU), adjacent to the Squamish-Lillooet, Stein-Nahatlatch, and the Garbaldi-Pitt GBPUs. All of these GBPUs are classed as ‘Threatened’. To the west of the Squamish-Lillooet GBPU lies the ‘Viable’ Toba-Bute GBPU. The region east of the South Chilcotin Ranges GBPU is an area where grizzly bears have been extirpated.

Research, inventory and monitoring grizzly bear populations in the planning area has been ongoing since 2004, including: live trapping and GPS collaring and tracking of individual bears, hair snag sampling for DNA analysis, remote camera monitoring and incidental reporting of grizzly bear sightings. This report includes data interpretation to enable a management decision consistent with grizzly bear recovery in the planning area.

A core planning team, included representatives from FLNRORD, MOE, Lil'wat Nation, the Pemberton Wildlife Association and the Coast to Cascades Grizzly Bear Initiative, met to discuss access management issues and develop this report. Broader consultations with a wider range of stakeholders with

¹ <http://www.bcauditor.com/pubs/2017/independent-audit-grizzly-bear-management>

² http://www.bclaws.ca/civix/document/id/loo78/loo78/196_99

strong interests in the planning area provided further perspectives, and ensure all key interests are represented to improve the likelihood of implementation success.

Natural resource roads developed primarily by *Forest Act* and *Land Act* licensees frequently become high-use public corridors to access recreation features. Motorized activities associated with these roads can negatively impact grizzly bears by affecting: 1) fidelity to established home ranges; 2) triggering incremental mortality risk through exposure to garbage or other human foods that create conflict between bears and humans, 3) the likelihood of displacement of bears from seasonally important habitats by traffic or the humans themselves; or 4) by enabling the deliberate poaching of bears or the incidental killing of bears in conflict with poorly managed, hunter-killed ungulates. Construction of the roads themselves may result in small scale habitat loss under the road footprint, but research across North America has clearly demonstrated that it is the use of roads away from settlements that can significantly affect grizzly bear conservation and management.

Proposed public motorized access closures would be implemented through Section 109 of the *Wildlife Act* with the Motor Vehicle Prohibition Regulation (196/99), while closures for public safety are implemented, when required, through the *Forest and Range Practices Act*.

Contents

| | | |
|-------|--|----|
| 1 | Introduction..... | 1 |
| 1.1 | Background..... | 1 |
| 1.2 | Purpose..... | 2 |
| 1.3 | General Management Objectives..... | 3 |
| 2 | Planning Scope and Process..... | 5 |
| 2.1 | Scope..... | 5 |
| 2.2 | Project Charter Development..... | 5 |
| 2.3 | First Nations..... | 5 |
| 2.4 | Stakeholder Consultation..... | 6 |
| 2.5 | Legal Tools..... | 7 |
| 2.6 | Other Issues..... | 7 |
| 3 | Resource Values: Management Objectives, Goals, and Tactics..... | 8 |
| 3.1 | Grizzly Bears..... | 8 |
| 3.1.1 | Resource Management Objective..... | 8 |
| 3.1.2 | Resource Management Goal and Implementation Tactics..... | 8 |
| 3.1.3 | Current Understanding of Grizzly Bears in the Planning Area..... | 9 |
| 3.2 | First Nations Values..... | 15 |
| 3.2.1 | Resource Management Objective..... | 15 |
| 3.2.2 | Resource Management Goals and Implementation Tactics..... | 15 |
| 3.2.3 | First Nations traditional use in the planning area..... | 15 |
| 3.3 | Recreation..... | 16 |
| 3.3.1 | Resource Management Objective..... | 16 |
| 3.3.2 | Resource Management Goals and Implementation Tactics..... | 16 |
| 3.3.3 | Current status of recreation in the planning area..... | 16 |
| 3.4 | Motorized (Road) Access..... | 17 |
| 3.4.1 | Resource Management Objective..... | 17 |
| 3.4.2 | Resource Management Goals and Implementation Tactics..... | 17 |
| 3.4.3 | Current status of resource road access in the planning area..... | 17 |
| 4 | Recommendations for Access Management..... | 19 |
| 4.1 | Motorized Access Controls..... | 19 |
| 4.2 | Implementation Responsibility..... | 26 |

| | | |
|-----|---|----|
| 4.3 | Implementation Limitations..... | 26 |
| 4.4 | Communication Planning..... | 27 |
| 4.5 | Adaptive Management to Improve Effectiveness..... | 27 |
| 5 | Appendices..... | 28 |

Tables

| | | |
|----------|---|----|
| Table 1. | General Management Objectives and Goals..... | 4 |
| Table 2. | First Nations with specific interest in access management planning..... | 6 |
| Table 3. | Stakeholders with specific interest in access management planning..... | 6 |
| Table 4. | Recommended Motorized Access Controls..... | 19 |
| Table 5. | Implementation responsibility | 26 |

Figures

| | | |
|------------|---|----|
| Figure 1. | Key map of project area: Upper Lillooet, Meager, Railroad, Birkenhead, Ryan and Soo Landscape Units. Grizzly Bear Population Units are included for reference. | 3 |
| Figure 2. | Spring Season (April 1 - June 15) Grizzly Bear Collared GPS Locations (Consolidated) and Habitat Suitability | 11 |
| Figure 3. | Summer Season (June 15 - Sept 15) Grizzly Bear Collared GPS Locations (consolidated)..... | 13 |
| Figure 4. | Fall Season (Sept. 16 - Nov. 30) Grizzly Bear Collared GPS Locations (Consolidated)..... | 14 |
| Figure 5. | Traffic counter information for the Lillooet South FSR at 0 km..... | 18 |
| Figure 6. | Traffic counter information for the Lillooet FSR at 8.5 km..... | 19 |
| Figure 7. | Recommended Access Control Locations, with road counter locations and ‘current motor vehicle closure points’ (April 1 to June 15). | 21 |
| Figure 8. | Detail of Lillooet South FSR, access control point at 2 km, for Motor Vehicle Prohibition Regulation (S. 109 <i>Wildlife Act</i>). | 22 |
| Figure 9. | Detail of Lillooet South FSR, access control point at approximately Perkins Creek, for public safety when necessary..... | 23 |
| Figure 10. | Detail of Birkenhead Lake FSR, access control point at approximately 14 km, for Motor Vehicle Prohibition Regulation (S. 109 <i>Wildlife Act</i>). | 24 |
| Figure 11. | Example of the scenario evaluation, showing analysis of the negative impacts and positive benefits to each value from potential closures. | 25 |
| Figure 12. | Overview image of the MMVC with major peaks labelled..... | 31 |
| Figure 13. | Travel distance along Lillooet River of selected volcanic landslides originating in Job Creek (after Simpson et al 2006). Job Creek, Devastation Creek, Angel Creek and Capricorn Creek were modeled..... | 32 |
| Figure 14. | Model results for debris flows initiated in Devastation Creek near the Meager Creek hotspots. Source: Simpson et al (2006), Cordilleran Geoscience..... | 33 |
| Figure 15. | Volcanic Landslide Hazard Zones – Upper Lillooet Valley. Cordilleran Geoscience (2012; updated 2017)..... | 34 |

Appendices

| | |
|--|----|
| Appendix 1 – Grizzly Bear GPS Collar Summary | 29 |
| Appendix 2 - Public Safety Information for the Upper Lillooet Watershed..... | 31 |
| Appendix 3 – Excerpts from the 2017 report for the Meager and Pebble Creek Hot springs | 35 |

1 Introduction

1.1 Background

The grizzly bear population located in the Upper Lillooet River portion of the Sea to Sky Natural Resource District (the District) and within the traditional territory of the Lil'wat Nation is threatened by habitat fragmentation, displacement, and mortality risks. There is scientific evidence to suggest that this threatened population unit is growing, and ongoing research will continue to inform government and the Lil'wat Nation. The safety of visiting recreationalists is also a concern for the province in the same area due to extensive landslides and volcanic activity. Risks to both of these values – grizzly bears and public safety – can be mitigated to a certain extent by providing specific access controls on resource roads. Access controls within this report are targeted specifically to public motorized use of roads. First Nations motorized access would continue pursuant to Aboriginal rights to carry out traditional use activities. Furthermore, commercial users would continue to have motorized access pursuant to their rights as tenure holders. The access management controls would restrict public access to non-motorized use. Lil'wat Nation holds high value to wildlife and protecting wildlife habitat within its traditional territory. This is highlighted in the Lil'wat Land Use Plan (2006) on p. 25 where it states, "*Maintaining wildlife habitat is an important component of supporting healthy wildlife populations, and in turn, a healthy Lil'wat culture.*" Lil'wat Nation's interest in protecting grizzly bear habitat has led to working in partnership with provincial government and the Coast to Cascade Grizzly Bear Initiative to develop this report.

Improvements to existing roads and creation of new roads in areas previously inaccessible by road has occurred in the Upper Lillooet River area to enable sustainable resource extraction. The effect of these road developments has been an increase of motorized public access for backcountry recreation. This increased access challenges resource management attempts to both reduce the negative influences on grizzly bear populations and to consider public safety. In the Upper Lillooet River area, increased open road density is likely to negatively impact the natural recovery of the District's threatened grizzly bear populations³. The objective of this report is to address local factors and propose solutions to avoid or prevent further impacts to grizzly bear populations. The measures proposed in this report will also support efforts to address public safety concerns in the area.

The Upper Lillooet River watershed is a lynchpin for regional grizzly bear conservation and recovery because in addition to its inherently high natural productivity of high-energy food (specifically huckleberries and salmon), it provides multi-season core habitats for female bears and their cubs. The Upper Lillooet is also a natural movement corridor and linkage for grizzly bears and other wildlife to other, more remote areas. As such, it is critical that motorized access be managed so that it does not threaten the security of grizzly bears, their ability to access foods like spawning salmon and huckleberries, to enable the recolonization of areas with low grizzly bear numbers, and to allow for the genetic and demographic exchange necessary for the long-term persistence of grizzly bears in the four threatened Grizzly Bear Population Units (GBPUs) that overlap the District. There is abundant science that demonstrates the correlation of high road densities with declining grizzly bear habitat effectiveness, increasing mortality risk and the potential for exacerbated levels of human-

³ <http://www.env.gov.bc.ca/wld/grzz/>

bear conflict. This knowledge, in addition to recommendations from professional biologists, supports the recommendations for further motorized closures in the Upper Lillooet.

The Coordinated Access Management Plan (CAMP) that was completed for the District in 2009⁴ identifies a number of key access control points and strategies for grizzly bear management (e.g. spring closures), and also acknowledges many challenges and dependencies associated with implementation. The CAMP states that the plan “...*should be reviewed and revised as necessary in response to changes in access related factors such as ... land use issues.*” In the years following completion of the CAMP, new information from grizzly bear monitoring data and other land and resource circumstances, e.g. 2010 Capricorn land slide, construction of the Upper Lillooet Hydro Project (ULHP), 2015 Boulder Complex Wildfire, recreation use of the Pebble and Meager Hot springs, suggest that additional strategies are required to meet the LRMP’s objectives for grizzly bear conservation and related social, cultural and First Nation values.

In addition, the BC Environmental Assessment Office (EAO) November, 2012 “ULHP Assessment Report” recognizes the need for detailed access management planning in order to mitigate the magnitude of cumulative effects of the Upper Lillooet hydroelectric project on wildlife. This report and the CAMP state that more localized planning would address the cumulative pressures of activity in the Upper Lillooet area⁵. The ULHP proponent is actively engaged with Provincial scientists to help to enable adaptive management by providing ongoing funding for grizzly bear collaring, and hair-snag and camera monitoring even as the construction phase comes to an end and operations begin.

1.2 Purpose

The purpose of this report is to provide specific recommendations to address grizzly bear recovery and wildlife protection, while also considering public safety, dispersed recreation, industrial use, and Lil’wat Nation’s right to have ongoing access to its traditional territory for traditional use. This report supplements earlier access management efforts, i.e. the 2008 Sea-to-Sky Land and Resource Management Plan (S2S LRMP⁶) and the associated CAMP, which resulted in thirteen spring closure areas across the Sea to Sky District, established through Section 109 of the *Wildlife Act*. Spring closures focus on maintaining demographic and genetic linkages and providing habitat security among the Grizzly Bear Population Units (GBPU) that overlap the S2S LRMP, and are intended to support the recovery of threatened grizzly bears in southwest BC.

Recommendations made through this report are also intended to be implemented through Section 109 of the *Wildlife Act*.

The report recognizes and accommodates the ongoing access rights of Lil’wat Nation, and the sustainable industrial, commercial and recreational access needs while also addressing motor vehicle and off-road vehicle (ORV) traffic and their corresponding use of roads and trails that can negatively impact grizzly bear movements (as well as other valued wildlife), mortality risk, habitat security and habitat effectiveness.

Managing access for industrial use and public safety is considered in part by the district manager policy that

⁴ <https://www.for.gov.bc.ca/tasb/slrp/plan79.html>

⁵ http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_doc_list_357_a_waa.html

⁶ https://www.for.gov.bc.ca/tasb/slrp/lrmp/surrey/s2s/docs/S2S_LRMP_Final/S2SLRMP_Final_April2008.pdf

addresses specific terrain stability concerns in the Upper Lillooet, allowing for road shutdown to protect public safety⁷.

The Office of the Auditor General of BC released ‘An Independent Audit of Grizzly Bear Management’ on October 24, 2017⁸, which spoke to threats to grizzly bears and the authority of FLNRORD and MOE to address activities that impact grizzly bear populations with effective management practices. The Auditor General specifically identifies the expansion of resource roads that allows greater human access into wilderness areas, which results in increased illegal killing of grizzly bears and greater human-bear conflicts. The purpose of this access recommendations report is clearly linked to the Auditor General’s recommendations.

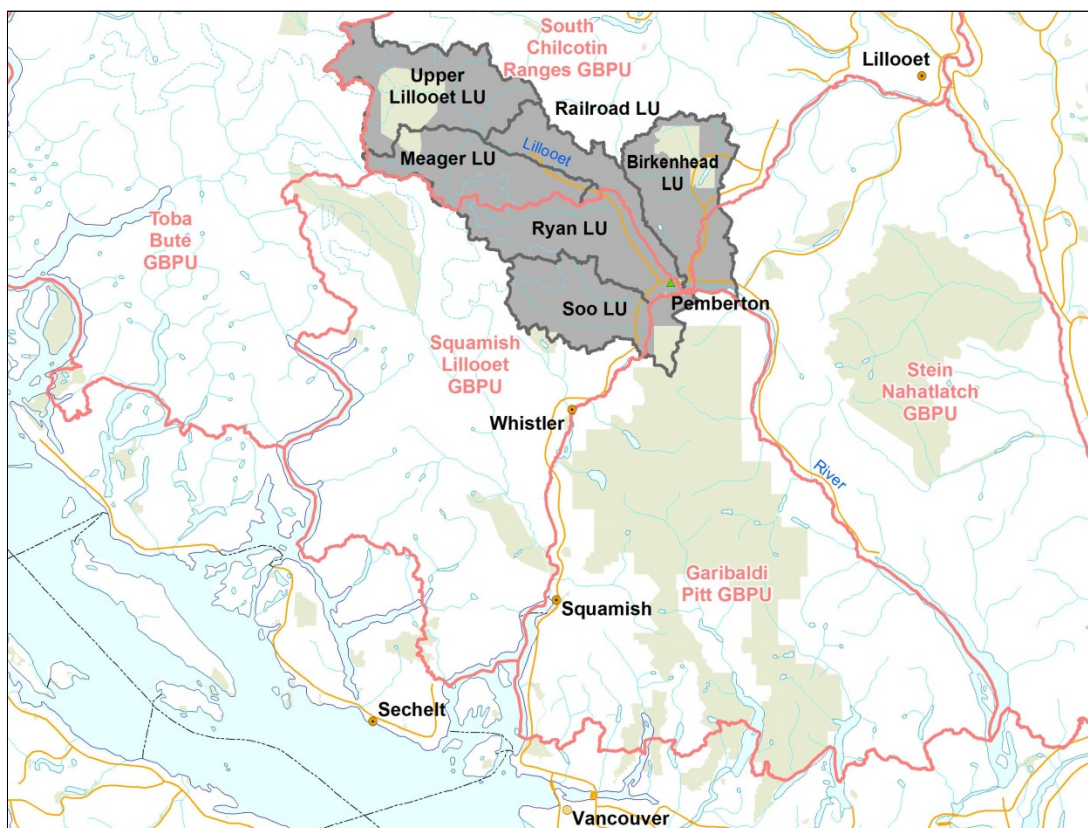


Figure 1. Key map of project area: Upper Lillooet, Meager, Railroad, Birkenhead, Ryan and Soo Landscape Units. Grizzly Bear Population Units are included for reference.

1.3 General Management Objectives

The general management objectives and tactical goals described for each resource value in Table 1 are to be considered in light of the objective to reduce the mortality risk to grizzly bears. General objectives and tactical goals are described for each value that has a significant social, environmental, economic or cultural role, and are considered in resource management planning to provide direction for timely implementation action.

⁷ <https://www.for.gov.bc.ca/dsq/Engineering/VolcanicLandslideRiskManagement.pdf>

⁸ <http://www.bcauditor.com/pubs/2017/independent-audit-grizzly-bear-management>

Table 1. General Management Objectives and Goals

| Resource Values and General Objectives | Tactical Goals |
|--|--|
| <p>Grizzly bear. Through research and observation by wildlife professionals, understand and describe grizzly bear populations, habitat, movements, and other factors influencing these components.</p> | <p>MOE and FLNRORD to lead research and monitoring in collaboration with the Lil’wat Nation, and provide analysis and report summary information in a timely manner to inform resource management planning and relevant management decisions.</p> |
| <p>First Nations Values. Through strong collaborative working relationship with Lil’wat Nation (and other First Nations where applicable), recognize and protect First Nation values for wildlife, and land and resources uses and future interests in their traditional territory.</p> | <p>Lil’wat Nation (and other First Nations, where relevant) participate in planning and provide input and support for the process with the project group, and clarify their preferred tactics that support their interests and values.</p> |
| <p>Resource Roads. Through appropriate engineering principles, understand and describe industrial road access requirements, user patterns and environmental conditions to consider road requirements while reducing density levels and improving public safety.</p> | <p>FLNRORD and MOE to collect current data and forecast future road use. <i>Forest Act</i> licensees and other participating legal tenure holders to provide input to planning on future access needs. Provide all data and information in a timely manner to support planning, and reduce road density.</p> |
| <p>Recreation. Through experience and knowledge by recreation professionals, understand and describe public and commercial recreation user patterns, and the need to safely locate recreation sites and trails while enabling appropriate access.</p> | <p>FLNRORD Recreation Sites & Trails Branch to share data and represent interests to maintain, expand, or reduce public recreation with the project group in a timely manner.</p> |

Objectives and goals for resource management values are further described in Section 3.

2 Planning Scope and Process

2.1 Scope

The scope of the project includes all information that collectively describes key components to reasonably achieve the ecological and security needs of grizzly bears.

The scope of the project is described by the following key components:

- The Upper Lillooet River watershed that includes resource roads accessing Crown land within the following Landscape Unit (LU) boundaries: Upper Lillooet LU, Meager LU, Railroad LU, Ryan LU, Soo LU, and the Birkenhead LU.
- Key seasonal grizzly bear core and connectivity habitat effectiveness in the Upper Lillooet River watershed, and an evaluation of habitat effectiveness supported by a scientific rationale. grizzly bear habitat effectiveness is understood to mean undisturbed use of seasonal food sources, including grizzly bear movements that are unimpeded by conflicts with humans.
- Roads, bridges and trails providing motorized access that encroaches on grizzly bear core security areas and limits connectivity between security areas.
- Lil'wat Nation's interests to protect grizzly bear habitat within the Lil'wat Nation traditional territory.
- Stakeholders with representative interests who can speak to their shared values, with an emphasis on those with legal authority to access Crown land, e.g. those awarded Crown land tenures through the *Land Act, Forest Act, Water Act, Wildlife Act, Mineral Tenures Act*).
- Install access controls such as locked gates or through deactivating roads that when implemented will reduce grizzly bear conflict with humans (i.e. reduce mortality risk and habitat alienation).
- Implementation and monitoring of recommended strategies and options, as developed by the project partners and resource professionals, and implemented by the project sponsor and applicable legislative tools.

2.2 Project Charter Development

The project charter defined the project in terms of objectives, scope, stakeholders and major deliverables. The project sponsor and partners all contributed to the project charter development during and between regular planning meetings. Approval of the project charter document in the fall of 2016 allowed detailed project planning to begin.

2.3 First Nations

Lil'wat Nation supported the initiation of this project in partnership with the Coast to Cascade grizzly Bear Initiative and the Province. Other First Nations with traditional territory within the planning area, the Squamish Nation and N'Quatqau Nation, were requested to define their level of engagement in the process to ensure that their interests were heard and considered during the planning process. The Squamish Nation and N'Quatqau Nation chose to be notified of the process rather than to be directly engaged in planning.

Formal consultation with First Nations will be conducted prior to implementation in order to meet Provincial requirements and other agreements, to assure legal requirements are met and to ensure there are no unnecessary impacts to First Nations rights and title.

Table 2. First Nations with specific interest in access management planning

| <i>First Nations</i> | <i>Interest</i> |
|----------------------|--|
| Lil'wat Nation | Partner, and participant in planning |
| Squamish Nation | Observer, to be notified of final report |
| N'Quatqua Nation | Observer, to be notified of final report |

2.4 Stakeholder Consultation

A range of specific individuals known to represent stakeholder groups were contacted by the District about the project and asked to confirm their level of interest and preferred engagement method. Response by stakeholders was good, and those with an interest in access management or aspects of the planning process were invited to attend specific meetings, comment on draft materials, and confirm their interest when the partners sought to resolve issues.

Table 3. Stakeholders with specific interest in access management planning

| <i>Stakeholders</i> | <i>Interests</i> |
|---|---|
| Ministry of Environment – Environmental Sustainability and Strategic Policy Division ⁹ | Support grizzly bear recovery, enhance and maintain habitat conditions |
| Ministry of Environment - BC Parks ¹⁰ | Maintain access to parks, advocate for protection of wildlife and environmental values |
| Innergex Renewable Energy Inc. ¹¹ | Maintain access to hydro-electric facilities, adhere to Environmental Assessment conditions |
| Pebble Creek Timber Ltd. | Maintain access to Forest License chart area |
| Squamish Lillooet Regional District ¹² | Advocate and manage public safety |
| Village of Pemberton ¹³ | Advocate tourism, recreation opportunities |

⁹ <http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/grizzly-bear>

¹⁰ http://www.env.gov.bc.ca/bcparks/explore/parkpgs/up_lillooet/

¹¹ <https://projects.eao.gov.bc.ca/p/upper-lillooet-hydro/detail>

¹² <http://www.slrld.bc.ca/>

¹³ <http://www.pemberton.ca/>

| | |
|--|--|
| Pemberton Wildlife Association ¹⁴ | Advocate wildlife management and protection |
| Trap line holders | Access to trap lines, wildlife habitat protection |
| UBC Varsity Outdoor Club ¹⁵ | Maintain non-motorized access to the Harrison Hut |
| Garibaldi Pumice Ltd. | Maintain access to mineral tenures |
| Copper Cayuse Outfitters ¹⁶ | Maintain access to trailhead |
| Meager Creek Development Corporation | Maintain access to geothermal wells in tenure area |

The stakeholders listed in Table 3 have specific interests in access control decisions. Some were requested to directly participate in working group sessions to help resolve issues, while others considered implementation measures and provided input to support access implementation measures.

Other stakeholders that did not participate in the development of the report will be informed of the report during implementation to ensure adequate communication of management objectives. A communications strategy developed in consultation with Government Communications and Public Engagement (GCPE) will inform the general public of the project by information bulletins and media releases. Section 4.4 provides more information on this topic.

2.5 Legal Tools

Recommendations to protect grizzly bear populations are to be implemented by regulation made by the Minister of Forests, Lands, Natural Resource Operations and Rural Development through Section 109 (1) (b) of the *Wildlife Act*, for the Motor Vehicle Prohibition Regulation (196/99).

2.6 Other Issues

Issues and constraints that could impact implementation success include:

- The public’s ability to access Crown land will continue; however restrictions on public motorized access during specified times of the year will be an issue for certain segments of the population. A communications strategy will improve compliance and mitigate public complaints.
- Access to legal tenure areas will continue; however better tracking and monitoring by tenure holders will improve implementation and monitoring effectiveness. Restrictions are to be followed by all employees, with impacts from restrictions avoided or mitigated through advance planning and stakeholder agreement.

¹⁴ <http://www.pembertonwildlifeassociation.com/>

¹⁵ <http://www.ubc-voc.com/>

¹⁶ <https://coppercayuseoutfitters.ca/>

- Resource availability to support project development and implementation delivery and monitoring may be a constraint, and will be more thoroughly addressed following project completion (e.g. funds for gate construction and maintenance, resources for compliance and enforcement)
- Economic and social pressure to maintain recreation opportunities, while making balanced land and resource use decisions that may significantly impact some of those opportunities.
- The effectiveness of managing and maintaining access controls and ongoing resources.
- Lil'wat Nation will be required to take a lead role to ensure Lil'wat citizens can continue to access gated areas.

3 Resource Values: Management Objectives, Goals, and Tactics

The management objectives, goals, and tactics for the resource values considered in this report are described below, and are intended to provide context and to confirm the shared understanding of the background information and data that was considered to support the recommendations in this report. The descriptions here are not intended to be exhaustive, detailed, or to represent a complete understanding of each value.

Each of the resource values below are intended for consideration together to support principles of shared management. This approach is expected to achieve the greatest positive net benefit to these values, to avoid, reduce or mitigate the potential for negative impacts.

3.1 Grizzly Bears

Grizzly bears are an important wildlife value that is very sensitive to human interactions, that requires special or specific management objectives and strategies to maintain or recover populations and habitats.

This recommendations report is not intended to summarize all the existing science, research or background knowledge on grizzly bear habitat requirements or population impacts. Rather, area-specific information is provided on grizzly bear density, movements and habitat that is appropriate and sufficient to support decision-making for the purposes of this report.

3.1.1 Resource Management Objective

- To ensure that resource management decisions consider all potential land and resource activities and relevant information to support Grizzly bear recovery, consistent with the Sea to Sky LRMP's grizzly bear objectives and Lil'wat Nation Land Use Plan¹⁷.

3.1.2 Resource Management Goal and Implementation Tactics

- Significantly reduce or eliminate human-bear interactions that may result in higher mortality risk, conflict, and displacement of grizzly bears from their preferred seasonal habitats.
- Identify key access control points, and legally establish closures to implement motorized access restrictions in important habitat areas during specific periods.

¹⁷ Lil'wat Land Use Plan, 2006, p. 26, Management Direction for Wildlife

- Support any closures with corresponding public education and information.
- Ensure compliance with closures through ongoing enforcement
- Continue to monitor results and adapt implementation measures where necessary.

3.1.3 Current Understanding of Grizzly Bears in the Planning Area

The data collection supporting this report was initiated by the Province in 2004 to help inform resource management decisions, and was instrumental in supporting spring closures through the Wildlife Act, as recommended by the Coordinated Access Management Plan (CAMP), completed in 2008. Grizzly bear inventory, monitoring and research in the Upper Lillooet River to better understand grizzly bear population and habitats are ongoing¹⁸. Some of the key findings that support the need for access management are explained below.

Population Movement and Location Density

Grizzly bears tracked with global positioning system (GPS) collars provided detailed movement information that was illustrated by location density mapping using geographic information systems (GIS). Although these collars depend on satellite availability and connection to satellites while under dense canopy cover, the data received is reliable and sufficiently accurate for the purposes of this report. See Appendix I for a summary of the GPS collar data.

Habitat Suitability Data

Terrestrial Ecosystem Modelling (TEM) data for the planning area was completed from 2006 to 2010 by Timberline Natural Resources Group for the Soo Timber Supply Area. This base layer of information was then rated by Ecofish Research Ltd. The TEM was combined with the Vegetation Resource Inventory (VRI) data to generate non-forested buffers and associated habitat suitability and habitat capability ratings, which were provided to FLNRORD by Innergex Renewable Energy Inc. in support of this report, GPS collar location data were intersected with the rated TEM map provided by Innergex.

Spring seasonal habitat utilization density (April 1 to June 15)

During the early spring, most grizzly bears seek out lush vegetation. In the Upper Lillooet River watershed these areas are located in valley bottoms adjacent to the river where the first new growth begins to appear following winter snow melt. An exception to this migration includes female grizzly bears with cubs that may delay den emergence to avoid aggressive males and give more time for the cubs to mature. Wildlife Habitat Areas (WHAs) for grizzly bears were established across the entire natural resource district in 2006 in order to protect these important riparian area locations from further development¹⁹.

The map shown in Figure 2 illustrates grizzly bear location density during the spring time period of April 1 to June 15. This is the time period that corresponds to grizzly bear emergence from dens,

¹⁸ South Coast Grizzly Bear Space-Use & Movements Relative to Habitat & Humans, 2016/2017, Apps et al.

¹⁹ http://www.env.gov.bc.ca/cgi-bin/apps/faw/wharesult.cgi?search=show_approved

located at higher elevations, and movement to lower elevations where snow has melted. Based on consolidated GPS data collected from 13 bears for this period from 2007 to 2015, the grizzly bear habitat utilization density during the spring is clearly much higher within the riparian areas.

Also located in valley bottoms are important motorized access corridors (roads and floodplains), specifically the Lillooet Forest Service Road (FSR) on the north side of the Lillooet River, and the Lillooet South Forest Service Road on the south side. *Forest Act* tenure holders and other industrial users with legal tenure (e.g. forestry, mining) located within the Upper Lillooet River area require road access to enable ongoing management of their tenure areas.

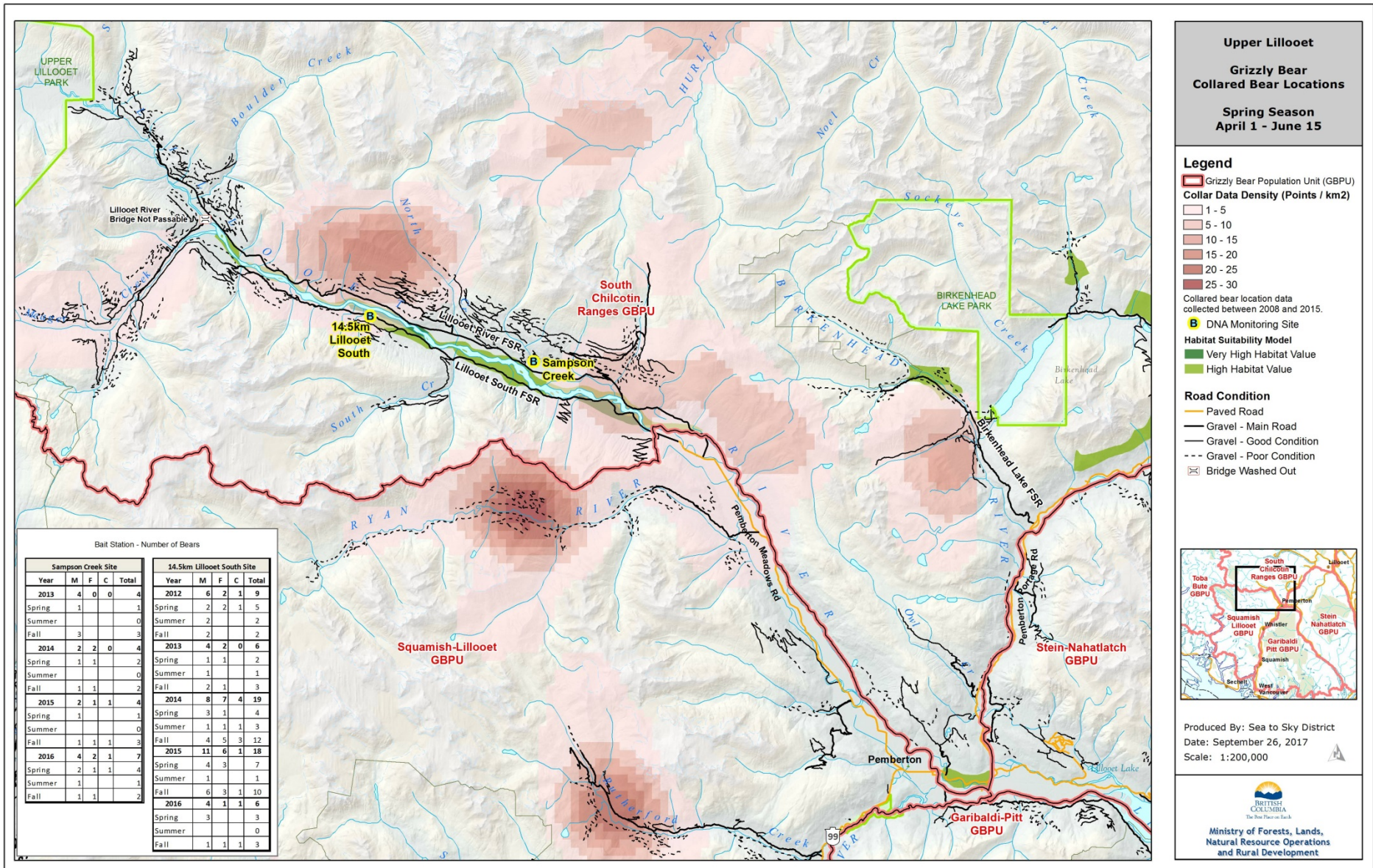


Figure 2. Spring Season (April 1 - June 15) Grizzly Bear Collared GPS Locations (Consolidated) and Habitat Suitability

Summer Seasonal habitat utilization (June 16 to September 15)

After the June 15 spring period, grizzly bears typically move into higher elevations as the temperatures increase and snowline rises in order to take advantage of new vegetation growth, to utilize other food sources such as huckleberries, and for other reasons such as mating. Movement may also result from disturbance by ongoing or continuous human activities, including noise, smoke and smells that are typical of camp sites and garbage. Though grizzly bears typically avoid humans, in some instances grizzly bears are known to protect important feeding habitats, or alternatively investigate human activities, sometimes to the disturbance or detriment of both humans and grizzly bears.

The map shown in Figure 3 illustrates the grizzly bear location density during the summer time period of June 16 to September 15. Based on GPS data collected during this 91 day period for the years 2007 to 2015, grizzly bear density is observed to be highest in mid to higher elevations, with greater density in the Meager watershed, overlapping the Meager hot springs location.

Fall seasonal habitat utilization (September 16 to November 30)

During this fall time period, grizzly bears begin to seek out high-energy food sources, which mainly consist of salmon as they begin to appear in rivers and side channels. Some grizzly bears have been observed to alternate between feeding on salmon and on huckleberries during peak crop periods, depending on the timing and abundance of the salmon run. In many instances, these fall salmon feeding areas correspond to the same riparian locations established through legal WHAs.

The map shown in Figure 4 illustrates grizzly bear location density and habitat suitability for the 76 day period during the years 2007 to 2015, showing greater location density in riparian locations and mid-elevation berry habitats.

Huckleberry seasonal habitat utilization (July 15 – October 31)

The Tenquille Creek burn is a grizzly bear subpopulation driver, un-paralleled anywhere else in south west BC. The study team have collared 9 females and 7 males that frequented the Tenquille burn during huckleberry season since 2007 (from July 1st to October 31st each year). In addition, there have been at least 4 uncollared mature females with cubs in the last 3 years at DNA hair snag sites in the burn. The importance of huckleberries (*Vaccinium membranaceum*) to the short and long-term trajectory of grizzly bear populations has been repeatedly demonstrated by research elsewhere in BC (e.g. McLellan 2015, Lamb et al. 2017) and the same is true in southwest BC (McLellan and McLellan 2015). Managing the security of the grizzly bears using the Tenquille Creek burn through effective restriction of public motorized access is essential to achieving grizzly bear recovery in southwest BC. By closing the Tenquille FSR at a suitable location close to kilometer 14 on the Birkenhead Lake FSR, bears, particularly females with cubs, using the burn to forage on berries will be far less likely to encounter humans. Restricting public access will minimize grizzly bear mortality risk and protect the ability of the population to remain productive. Such measures will eventually help enable the population to expand into currently vacant but suitable habitats nearby.

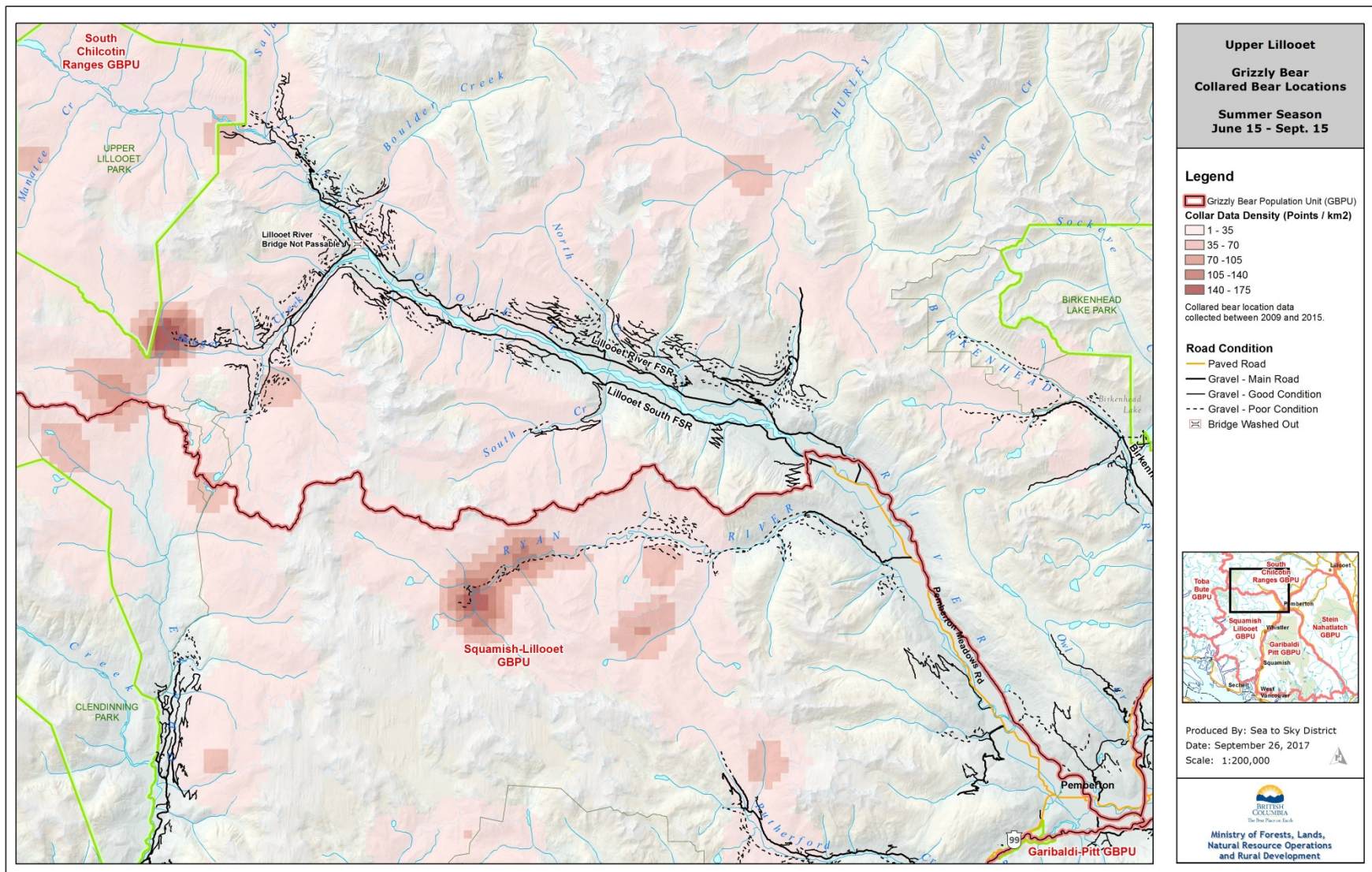


Figure 3. Summer Season (June 15 - Sept 15) Grizzly Bear Collared GPS Locations (consolidated)

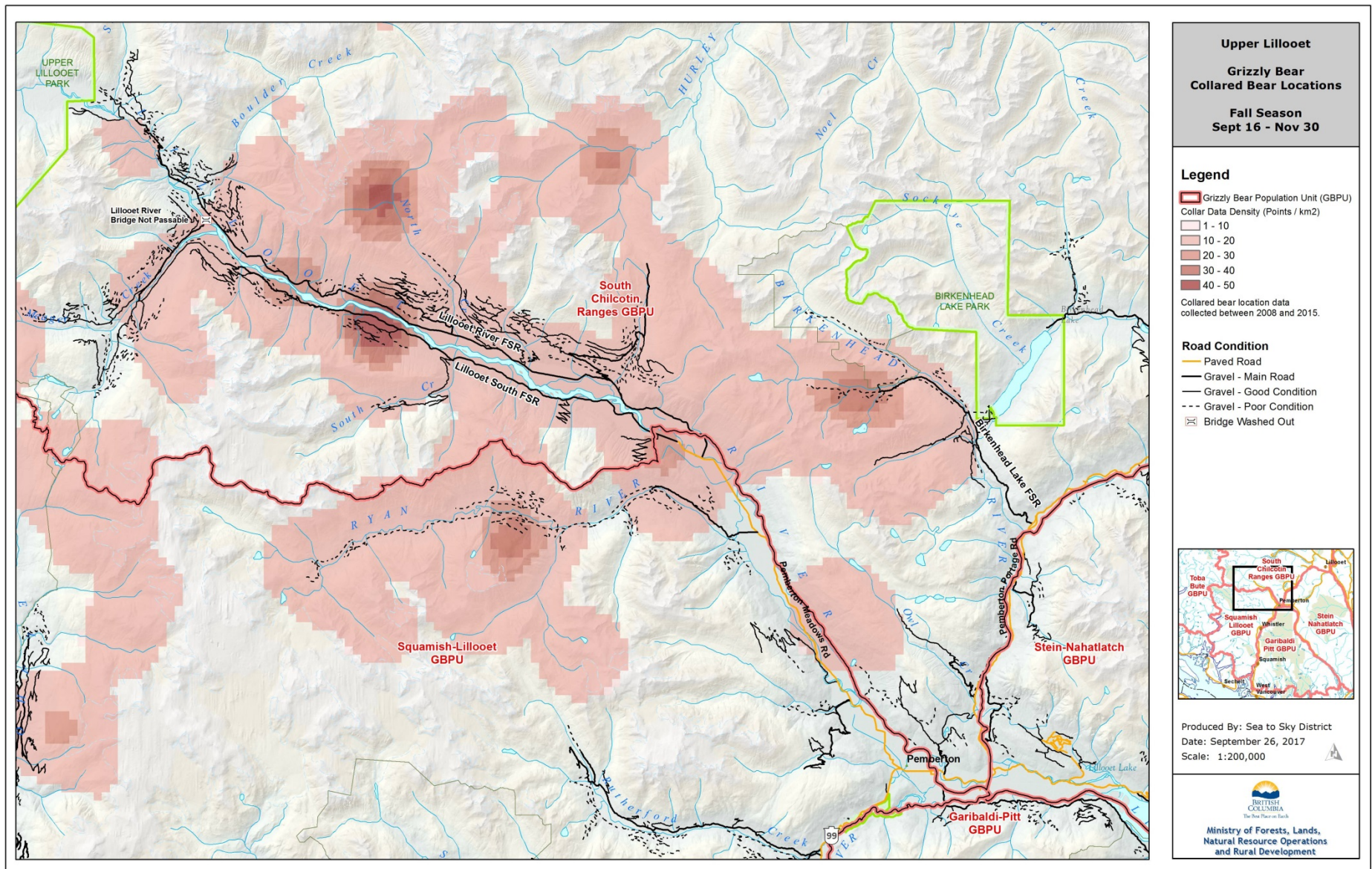


Figure 4. Fall Season (Sept. 16 - Nov. 30) Grizzly Bear Collared GPS Locations (Consolidated)

3.2 First Nations Values

The planning area is comprised of core traditional territory of the Lil'wat Nation. Lil'wat Nation has been involved in the initiative to develop this access management plan. This report began through a partnership approach between Lil'wat Nation, the province and Coast to Cascade Grizzly Bear Initiative to address common concerns and values for protecting wildlife and wildlife habitat. This approach is also consistent with Lil'wat Nation's assertion of title and rights, and reflects the stewardship role Lil'wat Nation is actively taking over its traditional territory. Other First Nations also have territory, whether shared or not, either within or adjacent to the planning area; specifically the Squamish Nation and N'Quatqua Nation. These First Nations have been notified of this project, and have provided direction to government that 'notification' is the level of involvement they want at this time on this issue.

3.2.1 Resource Management Objective

As expressed in the Land Use Planning Agreement between the Lil'wat Nation and the Province of British Columbia, "the Lil'wat Nation seeks the ability to participate meaningfully in decisions relating the land and resource planning and management in Lil'wat territory²⁰". This statement serves to describe an overall objective that is considered valuable for the purpose of this report.

3.2.2 Resource Management Goals and Implementation Tactics

The aforementioned land use planning agreement contains recommendations to guide the relationship between the Province and the Lil'wat Nation, as well as specific items of agreement for land use planning and management. Further goals and implementation tactics for recommendations in this report are not provided or assumed, provided that bilateral discussions between the Province and Lil'wat Nation continue to seek to foster a cooperative relationship related to land and resource management planning.

3.2.3 First Nations traditional use in the planning area

Lil'wat Nation traditional use within the planning area includes spiritual places, vision questing, food and material gathering, hunting, and ceremonial sites. These uses and cultural values are articulated in the Lil'wat Land Use Plan (2006), which provides vision for land use and management strategies for the entire Lil'wat Nation traditional territory. The Lil'wat Land Use Plan visions for land use over the planning area includes the St'uqa'ts (Upper Lillooet) Stewardship Area, the Upper Lillooet Provincial Park Collaborative Management Area, the Nqw'elqw'elústen (Meager) Conditional Economic Development Area, and the Lilwatátkwa (Lillooet River), Úll'us (Ryan River) Managed Resource Use Areas. The Lil'wat Land Use Plan management direction for each of these areas reflects Lil'wat cultural values and protection of Lil'wat interests.

A number of significant outcomes resulted from the land use planning agreement between the Province and the Lil'wat Nation, not least of which is recognition of the Meager A7x7úlmechw (spirited ground) area in the Meager Creek watershed, which is protected from further land and resource development that may impact cultural values associated with the area as determined through the appropriate assessment and consultation with the Lil'wat Nation. The recommendations in this report to restrict public motorized access to protect grizzly bear habitat is also compatible with the interests of Lil'wat Nation to protect the sacred value of the Meager A7x7úlmechw area from impacts of high

²⁰ https://www.for.gov.bc.ca/tasb/slrp/lrmp/surrey/s2s/docs/S2SLRMP_G2G_Agreements/S2SG2G_Lilwat_BC_Agreement.pdf

recreational use. However, a permanent closure to public motorized access will be in place at Perkins Creek on an interim basis until a management plan is in place. This permanent interim closure is beyond the scope of this report and necessary to protect the significant cultural values of the Meager A7x7ūlńecw area. Clearly, the Lil'wat Nation greatly respects the land, water, wildlife and associated resources within their traditional territory. They value the sustainability of those resources and resource development and the safety of people, and FLNRORD will maintain their relationship with Lil'wat Nation to respect and implement its agreement with Lil'wat Nation on behalf of the Province.

3.3 Recreation

Recreation activities are enjoyed by an increasing amount of the public on many desirable Crown land features in the planning area. These activities are managed on specific designated sites, or are dispersed across the District, and accessed by resource roads that are shared by industrial users, and by established or dispersed trails. The District is a very popular location for many forms of recreation not only because of the variety and quality of the backcountry recreational experience, but also because of the large population base in the lower mainland, and other international travellers who wish to experience unique and spectacular recreation environments.

3.3.1 Resource Management Objective

- Develop, maintain and manage public opportunities for safe and quality recreation activities across the District, while considering the protection of grizzly bear habitat.

3.3.2 Resource Management Goals and Implementation Tactics

- Manage for safe public enjoyment of registered recreational features
- Manage public recreation use on Crown land

3.3.3 Current status of recreation in the planning area

Public recreational activities in the planning area are substantially increasing as more people learn about opportunities to enjoy features such as trails, campsites and hot springs. These features are distributed throughout the District, and some are supported by a modest allocation of District resources through the Recreation Sites and Trails Branch (RSTB), who conduct routine maintenance and provide guidance and advice to resource management activities. Public can learn about recreation opportunities on the appropriate RSTB website, though other social media tools such as Facebook, Twitter, Instagram or other blogs and website often share this information to a much wider audience.

Some of the challenges with meeting public expectations for recreation in the District includes recognising an urban demographic that is often identified as being inexperienced with appropriate camping and wilderness etiquette and safety practices. There have been many observations of recreationalists who do not appear to be educated to respect the many wilderness values, or who do not appear to respect the need to protect the natural resource environment, which is a potential threat to grizzly bear habitat and populations and a concern to the partners in this report. The main recreation features in the planning area include the Pebble Creek hot springs and associated trails including the Keyhole Falls trail and associated spectacular scenic values, which were closed in early 2017 due to conflicts with bears, and the Meager Creek hot springs, which is now permanently closed due to the 2010 landslide²¹.

²¹ For more information please see Appendix II – Public Safety Information for the Upper Lillooet Watershed

RSTB has reported a significant number of issues in the area caused by some recreational users who have not practiced appropriate garbage and waste management, resulting in concerns about grizzly bears and black bears within camping areas and subsequently managed by closing the Pebble Creek hot springs trail. RSTB reports that there are currently no plans to re-open the Meager Creek hot springs recreation site, regardless of the improved access to the site, due to the concerns of risks and challenges to maintain public safety. Lil'wat Nation also has concerns with the potential for increased recreational use at Meager Hot springs, given the spiritual and cultural significance of this area. An adventure tourism tenure located in the Tenquille area utilizes horses as a key feature of their business. A motorized closure supporting grizzly bear foraging proposed in that watershed is considered compatible with their operation.

In a 2016 memo from Innergex Renewable Energy Inc. (Innergex) to RSTB, information of public use collected on the Upper Lillooet FSR at the kilometer 37.5 checkpoint indicated a much greater number of recreational vehicles and campers than would normally be expected. For example, Easter weekend (March 25-28, 2016) observed 224 vehicles carrying 716 people, and the May long weekend (May 20-22, 2016) saw 350 vehicles carrying more than 700 people.

Despite intensive management actions by Innergex and RSTB staff, including increased signage and garbage collecting, the hot springs and trail areas were inundated by people who disregarded appropriate waste and food management, and elevated the risk to wildlife and themselves: *“Many posting on social media had indicated that there was an increase in bear sighting at the hot springs area. Bear attractants and mishandling of food at the camping area, along with the spike in use in the area, led to the bears becoming aggressive and charging people²²”*. RSTB and others are concerned that without sufficient access management, the Meager Creek area will experience similar challenges and that uncontrolled public motorized access is likely to result in public or bear mortality.

3.4 Motorized (Road) Access

Forest Service Roads (FSRs) and other resource roads are constructed and maintained to support ongoing industrial activities on Crown land, however the vast majority of roads in the District are open for public use without controls or restrictions. Road access issues were examined from the context of supporting grizzly bear survival.

3.4.1 Resource Management Objective

- Effectively manage roads and motorized traffic levels to ensure sustainable and safe use, and compatibility with other resource values such as grizzly bears and public safety.

3.4.2 Resource Management Goals and Implementation Tactics

- Consider and implement access controls where appropriate to manage other resource objectives, including public safety, recreation, and grizzly bear management.

3.4.3 Current status of resource road access in the planning area

Resource roads have an extensive footprint throughout the planning area, with most of the operable forest accessible by roads that are in various stages of accessibility. Main access roads along valley bottoms are active and legally registered for industrial users, with public use allowed for activities such as camping, hiking, and hunting or fishing. This is certainly true in the Upper Lillooet, where a well-travelled FSR is located on each side of the Lillooet River, directly

²² Innergex Memorandum, September 28, 2016.

adjacent to sensitive riparian areas. A number of other forestry roads adjacent to the FSRs are deactivated or infrequently used and may be overgrown but are used by off-road vehicles, mountain bikes, or hikers. Shared use of resource roads is common in BC, and road closures to restrict public motorized use are considered where the risks to other values including public safety are serious enough to warrant access controls.

The design and construction of resource roads in the District is often challenging and expensive, due to the majority of terrain located on steep slopes and rocky conditions typical of the coastal mountains. When roads are no longer immediately needed, the road owner may implement a number of deactivation actions to reduce their potential legal liability and maintenance costs, such as cross ditching, removing bridges, culverts, and re-contouring the road surface. These actions are intended to prevent environmental degradation associated with erosion, to prevent water quality impacts, and also to improve public safety.

In order to enable appropriate resource road management and to account for road maintenance needs, traffic counters are located at several strategic points around the District. These assist in monitoring road traffic and can inform where additional resources may be required. From an analysis of recent traffic counter reports, the traffic counter statistics are summarized by season in order to develop a better understanding of traffic in the planning area.

Figure 5 provides five full years of data, from 2013 to 2017 for the Lillooet FSR on the south side of the Lillooet River. This result is typical for most areas in the District and reflects the ongoing increased traffic for this road, since industrial use on this road is very low and most traffic is related to vehicles travelling to the trailhead to the Harrison Hut. A slowdown in the 2017 traffic counts on the Lillooet South FSR reflects the completion of the Upper Lillooet Hydro-electric project. This result can be compared to Figure 6 showing the amount of traffic on the Lillooet FSR (Railroad location) slowing in 2017, almost back to 2013 levels.

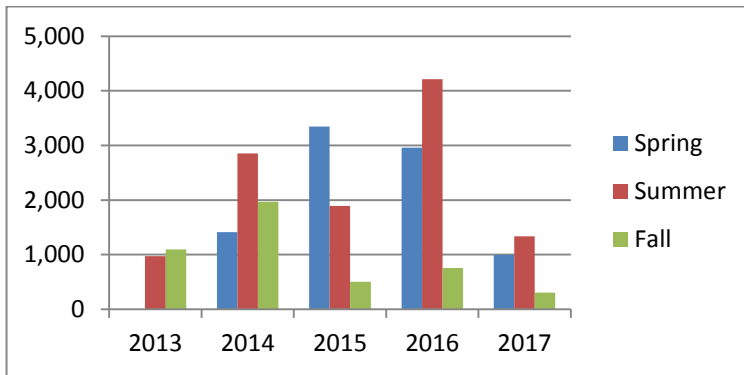


Figure 5. Traffic counter information for the Lillooet South FSR at 0 km

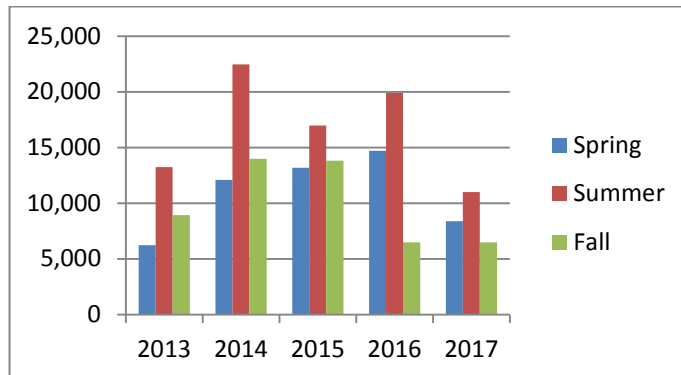


Figure 6. Traffic counter information for the Lillooet FSR at 8.5 km

The above traffic counter information reporting the steady increase of traffic on resource roads corresponds with similar traffic counts provided by the BC Ministry of Transportation and Infrastructure (MOTI) for Highway 99, with comparisons available at several locations from Lions Bay to Whistler and Pemberton. For example, MOTI statistics for the location at the Cheekeye River bridge (10 km north of Squamish) shows that the annual average daily traffic has increased from 3,000 in 1997 to over 10,000 in 2015²³. The purpose of this comparison is intended to support the resource road findings and confirm the trend of increasing public presence in the District and the planning area.

4 Recommendations for Access Management

Access management is the key focus in this report due to a forestry road being constructed on the south side of the Lillooet River that will soon re-establish motorized access into the Meager Creek drainage, containing the Meager Creek hot springs that have been closed since 2010. In this circumstance it is the public recreation that is cause for concern, owing to the observations on the north side of the Lillooet River FSR, and activities in the Pebble Creek hot springs that frequently require action by Conservation Officers and FLNRORD Compliance and Enforcement personnel.

Aside from the road maintenance and deactivation actions described in the Motorized (Road) Access section, other access controls on resource roads are intended to restrict the entry and passage of motorized vehicles, including road deconstruction and installing gates. Gates allow for continued industrial and First Nations use while restricting public recreational or other unauthorized use. Public non-motorized access into the Meager Creek watershed is permitted, however continued use of the Meager Creek hot springs is not permitted as the site remains closed due to terrain stability concerns.

4.1 Motorized Access Controls

The following motorized access controls listed in Table 4 will apply to all road users, except authorized tenure holders and First Nations. First Nations access will be managed through the Lil'wat Nation Land and Resources Department. Safety closures will be communicated with the Lil'wat Nation Land and Resources Department so that appropriate measure can be taken to ensure the safety of Lil'wat Nation and other First Nation citizens. Figure 7 provides a map showing the location of the access control points, and Figure 8, Figure 9 and Figure 10 provide a more detailed view. The table in Figure 11 provides an example showing how various access control scenarios were considered in relation to the potential impacts to the values described in this report.

Table 4. Recommended Motorized Access Controls

²³ <http://www.th.gov.bc.ca/trafficdata/tradas/mainmap.asp>

| Control Point Location | Management Objectives | Implementation Goal | Closure Tools²⁴ | Closure Timing | Responsibility |
|--|---|---|-----------------------------------|---|---|
| Lillooet South FSR at approx. 2 km. | Grizzly bear: Protect spring forage areas and fall salmon feeding areas | Prevent grizzly bear disturbance or mortality during sensitive feeding periods. | Locked gate | April 1 to June 15 and September 16 to Nov 30 (access exceptions for industrial users and other registered users including Lil'wat Nation) | FLNRORD will be responsible to coordinate installation, management and enforcement of closure periods with industrial and other users, including lock key registration and addressing issues with compliance and enforcement. Lil'wat Nation will be responsible for managing access for Lil'wat and other First Nation citizens. |
| Birkenhead Lake FSR at approx. 14 km. | Grizzly bear: Protect summer and fall Huckleberry forage areas. | Prevent grizzly bear disturbance or mortality during sensitive feeding periods. | Locked gate | July 15 to October 31 st (access exceptions for industrial users and other registered users including Lil'wat Nation) | |

²⁴ Type and Location of this closure may change based on compliance effectiveness, as determined by Conservation Officers and Compliance and Enforcement personnel.

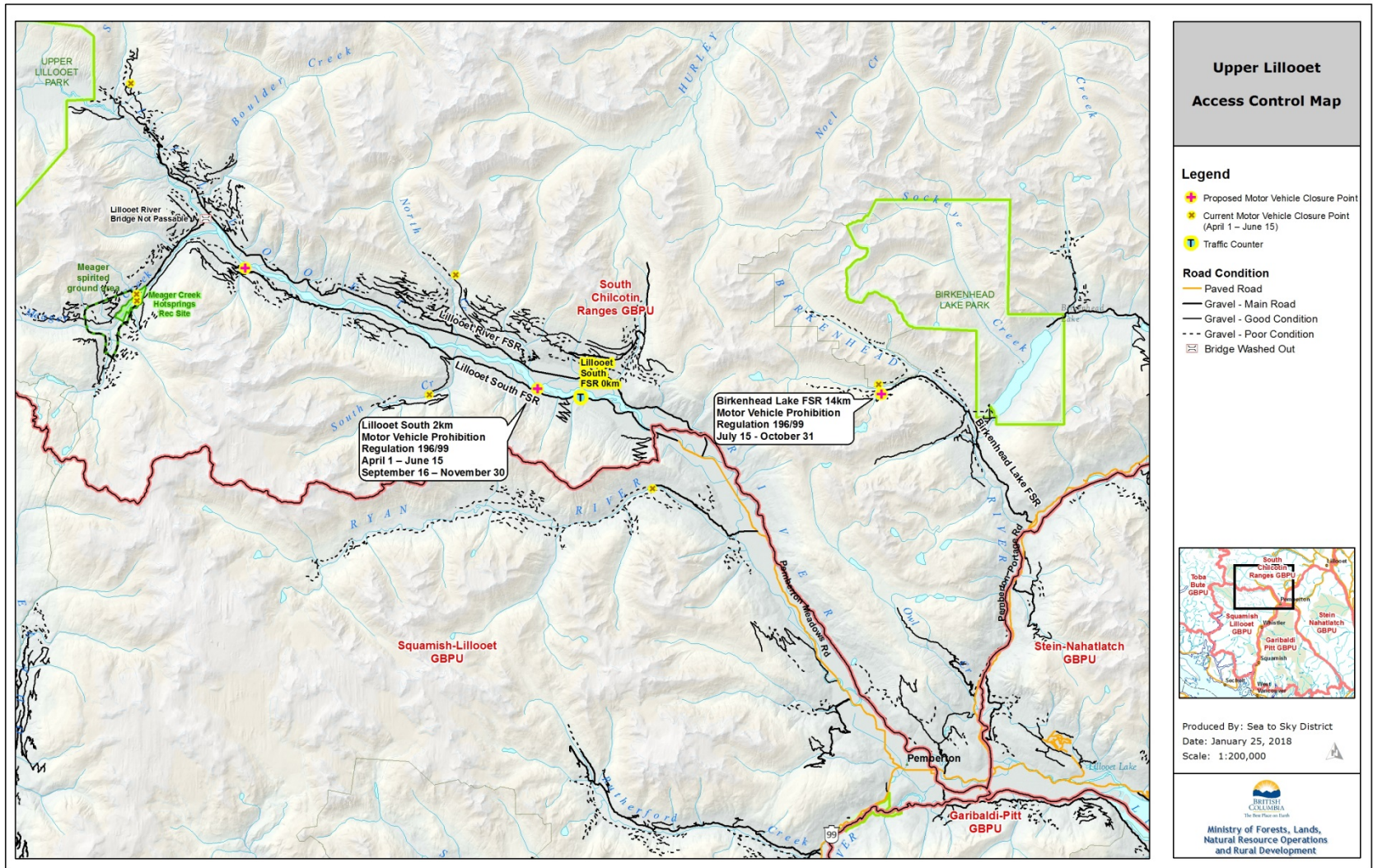


Figure 7. Recommended Access Control Locations, with road counter locations and ‘current motor vehicle closure points’ (April 1 to June 15)²⁵.

²⁵ The access control point noted for Perkins Creek is noted here for additional clarity. See Appendix II and Appendix III for more information.



Figure 8. Detail of Lillooet South FSR, access control point at 2 km, for Motor Vehicle Prohibition Regulation (S. 109 Wildlife Act).

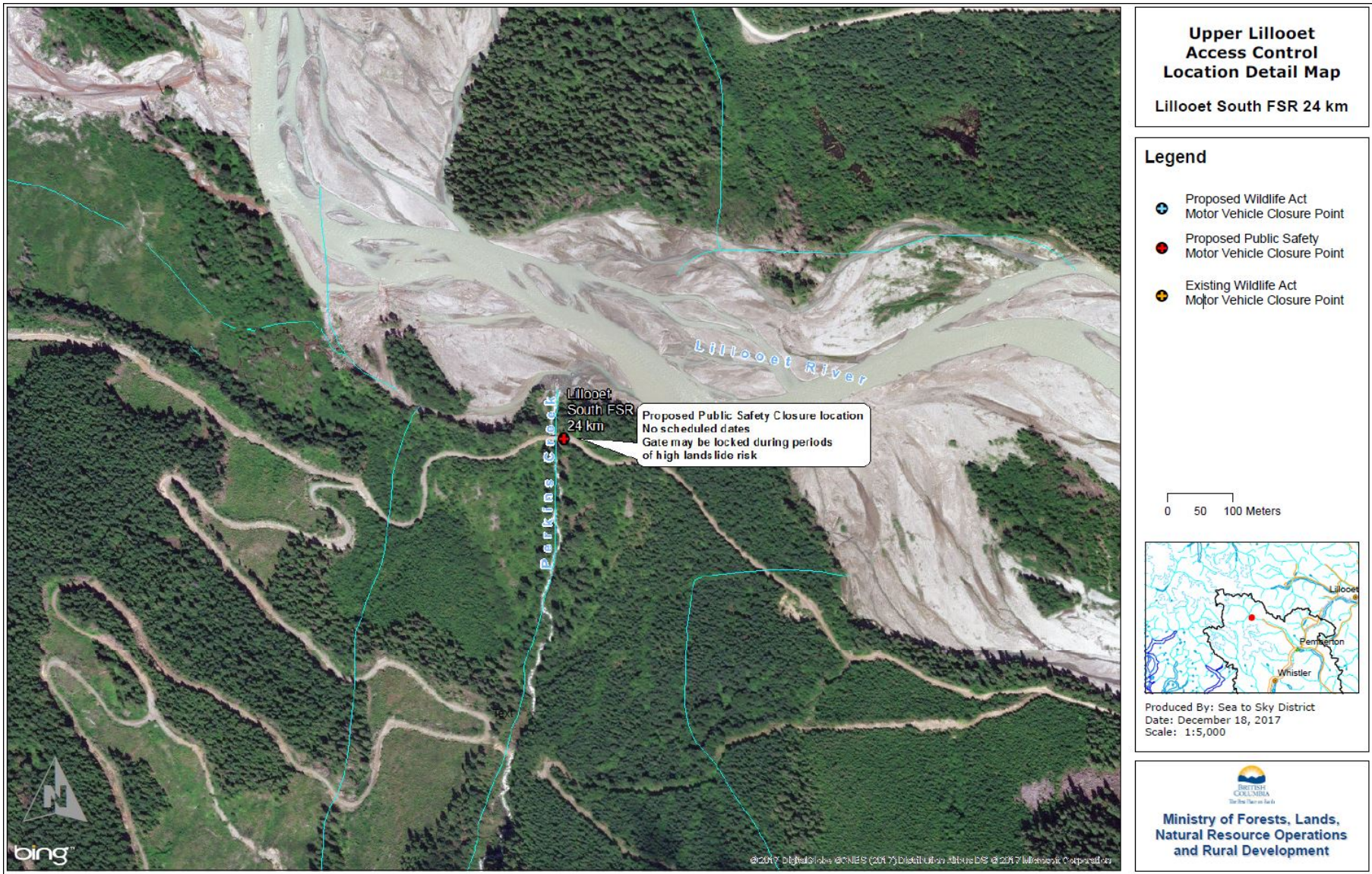


Figure 9. Detail of Lillooet South FSR, access control point at approximately Perkins Creek, for public safety when necessary.

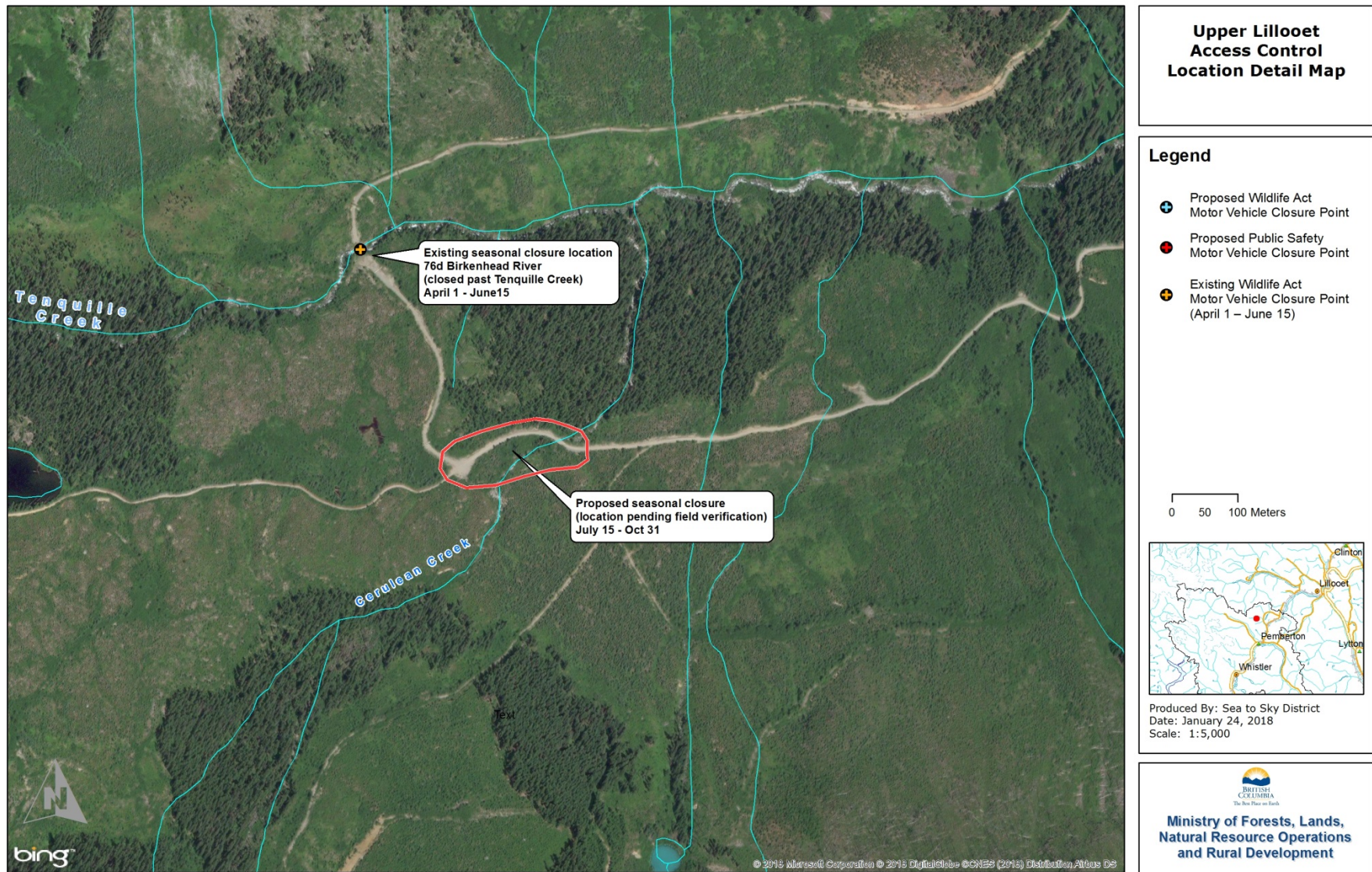


Figure 10. Detail of Birkenhead Lake FSR, access control point at approximately 14 km, for Motor Vehicle Prohibition Regulation (S. 109 Wildlife Act).

Interest area: Lillooet South FSR - No Closure

| | | | | | Impact/Benefit of Tool to Values (-3/0/+3) | | | | | | |
|-------------------------|----------------|--------------------|-----------------|----------------|--|----------------|-------------------|---------------|----------|-------|--|
| Tool | Responsibility | Est. Cost (0 to 5) | Effort (0 to 5) | Timing | Grizzly Bear | Other Wildlife | Public Recreation | Public Safety | Industry | Total | Comments on implementation |
| Sign Program | FLNRO | 1 | 1 | Permanent | 1 | 1 | 1 | 1 | 0 | 1 | Manage damaged signs |
| Social Media | Shared/FLNRO | 2 | 3 | Ongoing | 2 | 2 | 2 | 2 | 0 | 2 | Requires ongoing and timely updates and engagement |
| Website | FLRNO | 1 | 1 | As needed | 1 | 1 | 1 | 1 | 0 | 1 | Requires timely updates |
| No Closure | | | | | -3 | -3 | 3 | -3 | -1 | -1 | |
| Landslide Risk Closures | FLNRO | 1 | 3 | High Risk Time | 1 | 1 | -2 | 2 | -2 | 0 | Unpredictable timing. Immediate response. |
| | | 1 | 2 | | 0 | 0 | 1 | 1 | -1 | 0 | AVERAGED |

Interest area: Lillooet South FSR - Annual Closure at 2km

| | | | | | Impact/Benefit of Tool to Values (-3/0/+3) | | | | | | |
|-------------------------|----------------|--------------------|-----------------|----------------|--|----------------|-------------------|---------------|----------|-------|--|
| Tool | Responsibility | Est. Cost (0 to 5) | Effort (0 to 5) | Timing | Grizzly Bear | Other Wildlife | Public Recreation | Public Safety | Industry | Total | Comments on implementation |
| Sign Program | FLNRO | 1 | 1 | Permanent | 1 | 1 | 1 | 1 | 0 | 1 | Manage damaged signs |
| Social Media | Shared/FLNRO | 2 | 3 | Ongoing | 2 | 2 | 2 | 2 | 0 | 2 | Requires ongoing and timely updates and engagement |
| Website | FLRNO | 1 | 1 | As needed | 1 | 1 | 1 | 1 | 0 | 1 | Requires timely updates |
| Gate @ 2 kms | Licensee/FLNRO | 2 | 4 | Annual Closure | 3 | 3 | -3 | 3 | 1 | 1 | Not manned |
| Landslide Risk Closures | FLNRO | 1 | 3 | High Risk Time | 1 | 1 | -1 | 1 | -2 | 0 | |
| | | 1 | 2 | | 2 | 2 | 0 | 2 | 0 | 1 | AVERAGED |

Interest area: Lillooet South FSR - Spring closure at 2 km

| | | | | | Impact/Benefit of Tool to Values (-3/0/+3) | | | | | | |
|-------------------------|----------------|--------------------|-----------------|----------------|--|----------------|-------------------|---------------|----------|-------|--|
| Tool | Responsibility | Est. Cost (0 to 5) | Effort (0 to 5) | Timing | Grizzly Bear | Other Wildlife | Public Recreation | Public Safety | Industry | Total | Comments on implementation |
| Sign Program | FLNRO | 1 | 1 | Permanent | 1 | 1 | 1 | 1 | 0 | 1 | Manage damaged signs |
| Social Media | Shared/FLNRO | 2 | 3 | Ongoing | 2 | 2 | 2 | 2 | 0 | 2 | Requires ongoing and timely updates and engagement |
| Website | FLRNO | 1 | 1 | As needed | 1 | 1 | 1 | 1 | 0 | 1 | Requires timely updates |
| Gate @ 2 kms | Licensee/FLNRO | 2 | 4 | Spring | 2 | 2 | -1 | 1 | -1 | 1 | Not manned |
| Landslide Risk Closures | FLNRO | 1 | 3 | High Risk Time | 1 | 1 | -2 | 2 | -2 | 0 | |
| | | 7 | 12 | | 1 | 1 | 0 | 1 | -1 | 1 | AVERAGED |

Figure 11. Example of the scenario evaluation, showing analysis of the negative impacts and positive benefits to each value from potential closures.

4.2 Implementation Responsibility

As sponsor, FLNRORD is the planning lead and will coordinate implementation actions with other agencies, industry, and any other relevant group to ensure that all activities are consistent with this report. Conservation officers and other compliance and enforcement personnel responsible for monitoring should report the effectiveness of implementation to FLNRORD for improvements if necessary for alternative locations or management activities. Any important issues should be discussed and resolved with the involvement of the other project partners.

Table 5. Implementation responsibility

| Agency/Organization | Responsibility |
|--|--|
| FLNRORD – Sea to Sky Natural Resource District | <ul style="list-style-type: none"> • Engineering details, including access control design, installation, maintenance • Notification to other stakeholders • Public communication (through GCPE) • Advising Compliance & Enforcement staff (C&E) • Ecological monitoring of grizzly bear populations |
| MOE | <ul style="list-style-type: none"> • Enforcing Wildlife Act Closures • Providing advice to FLNRORD District Ecologist |
| Coast to Cascades Grizzly Bear Initiative | <ul style="list-style-type: none"> • Supporting implementation and participating in ongoing meetings to review monitoring reports • Communicating results to members |
| Lil'wat Nation | <ul style="list-style-type: none"> • Supporting implementation through on-site monitoring, reporting of compliance issues and participating in ongoing meetings to review monitoring reports • Providing field support for ecological monitoring of grizzly bear populations • Communicating closures and managing ongoing access for Lil'wat Nation citizens and other First Nations as may be applicable. |
| Pemberton Wildlife Association | <ul style="list-style-type: none"> • Supporting implementation and participating in ongoing meetings to review monitoring reports • Communicating results to members |
| Existing Crown land tenure holders | <ul style="list-style-type: none"> • Implement a safety management plan, if operations require access into closure areas |

4.3 Implementation Limitations

Although FLNRORD is responsible for recommendation implementation, other unforeseen circumstances may influence effective implementation. Any unexpected issues that may arise during implementation should be communicated to FLNRORD, for discussion and resolution with the other project partners.

Examples of possible implementation limitations may include:

- Changes in wildlife values

- Change to environmental conditions impacting the access area (e.g. landslide)
- Vandalism impacting the access controls
- Change to the industrial use, or to the Crown land status
- Poor communication of access controls, and poor compliance of closures; and
- Issues from recreation users (non-motorized and motorized)

4.4 Communication Planning

Sharing information on closures with a wide audience is more likely to improve compliance simply because more people will know about the closures than those who will not. Utilizing a greater number of communication tools and more frequent communication will also improve compliance.

Communication may include specific efforts to communicate through local communication outlets, social media tools and web applications, road signs and notices placed on appropriate road locations, and posting legal notices where required, such as the annual Hunting and Trapping Regulations Synopsis²⁶.

4.5 Adaptive Management to Improve Effectiveness

The access recommendations put forward here are to be implemented through an adaptive management approach. Where ongoing monitoring indicates that the above resource value objectives are not being met or, conversely, recovery is achieved, the expectation is that access management implementation would be adjusted accordingly.

²⁶ <https://www2.gov.bc.ca/gov/content/sports-culture/recreation/fishing-hunting/hunting/regulations-synopsis>

5 Appendices

I – Grizzly Bear GPS collar summary

II – Public Safety Information for the Upper Lillooet Watershed

III – Excerpts from the 2017 Cordilleran Geoscience report for the Meager and Pebble Creek Hot springs

Appendix 1 – Grizzly Bear GPS Collar Summary

The following table lists the number of GPS collar location confirmations for each grizzly bear, by year and season.

| Bear / Year | Spring | Summer | Fall | Winter | Total | First Date | Last Date |
|-----------------|-------------|-------------|-------------|------------|-------------|-----------------------------------|-------------------------------------|
| Bruno | 64 | 2050 | 1622 | | 3736 | Sunday, June 13, 2010 | Monday, November 28, 2011 |
| 2010 | 64 | 2050 | 1621 | | 3735 | Sunday, June 13, 2010 | Sunday, November 28, 2010 |
| 2011 | | | 1 | | 1 | Monday, November 28, 2011 | Monday, November 28, 2011 |
| Grey | 896 | 1343 | 962 | | 3201 | Tuesday, July 24, 2012 | Tuesday, August 6, 2013 |
| 2012 | | 1199 | 962 | | 2161 | Tuesday, July 24, 2012 | Tuesday, November 6, 2012 |
| 2013 | 896 | 144 | | | 1040 | Friday, April 26, 2013 | Tuesday, August 6, 2013 |
| Hank | 1092 | 3361 | 1031 | | 5484 | Sunday, July 27, 2014 | Friday, September 25, 2015 |
| 2014 | | 1187 | 807 | | 1994 | Sunday, July 27, 2014 | Monday, October 20, 2014 |
| 2015 | 1092 | 2174 | 224 | | 3490 | Tuesday, April 21, 2015 | Friday, September 25, 2015 |
| Madeline | | 909 | | | 909 | Sunday, July 27, 2014 | Tuesday, September 9, 2014 |
| 2014 | | 909 | | | 909 | Sunday, July 27, 2014 | Tuesday, September 9, 2014 |
| Mattias | 1078 | 3089 | 854 | | 5021 | Monday, July 21, 2014 | Friday, September 4, 2015 |
| 2014 | | 1234 | 854 | | 2088 | Monday, July 21, 2014 | Tuesday, November 18, 2014 |
| 2015 | 1078 | 1855 | | | 2933 | Thursday, April 23, 2015 | Friday, September 4, 2015 |
| Melanie | 1446 | 3271 | 2335 | | 7052 | Sunday, July 29, 2012 | Saturday, May 17, 2014 |
| 2012 | | 1135 | 1263 | | 2398 | Sunday, July 29, 2012 | Thursday, November 29, 2012 |
| 2013 | 1052 | 2136 | 1072 | | 4260 | Wednesday, May 1, 2013 | Wednesday, November 13, 2013 |
| 2014 | 394 | | | | 394 | Sunday, April 20, 2014 | Saturday, May 17, 2014 |
| Mercury | 716 | 1669 | 908 | 12 | 3305 | Monday, January 8, 2007 | Monday, June 15, 2009 |
| 2007 | | 8 | | 12 | 20 | Monday, January 8, 2007 | Tuesday, July 31, 2007 |
| 2008 | | 1661 | 908 | | 2569 | Wednesday, June 25, 2008 | Wednesday, October 29, 2008 |
| 2009 | 716 | | | | 716 | Friday, May 8, 2009 | Monday, June 15, 2009 |
| Natasha | 630 | 2042 | 686 | | 3358 | Sunday, September 16, 2012 | Sunday, September 15, 2013 |
| 2012 | | | 686 | | 686 | Sunday, September 16, 2012 | Saturday, October 27, 2012 |
| 2013 | 630 | 2042 | | | 2672 | Thursday, May 16, 2013 | Sunday, September 15, 2013 |
| Pebbles | | | 1741 | 158 | 1899 | Monday, September 17, 2012 | Wednesday, February 13, 2013 |
| 2012 | | | 1741 | 70 | 1811 | Monday, September 17, 2012 | Sunday, December 30, 2012 |
| 2013 | | | | 88 | 88 | Wednesday, January 2, 2013 | Wednesday, February 13, 2013 |
| Serena | 569 | 1256 | 1385 | 211 | 3421 | Friday, July 25, 2014 | Thursday, May 21, 2015 |
| 2014 | | 1256 | 1385 | 18 | 2659 | Friday, July 25, 2014 | Monday, December 29, 2014 |

| Bear / Year | Spring | Summer | Fall | Winter | Total | First Date | Last Date |
|--------------------|-------------|--------------|--------------|------------|--------------|---------------------------------|--------------------------------------|
| 2015 | 569 | | | 193 | 762 | Thursday, January 1, 2015 | Thursday, May 21, 2015 |
| Silt | | 221 | | | 221 | Friday, July 20, 2012 | Saturday, August 11, 2012 |
| 2012 | | 221 | | | 221 | Friday, July 20, 2012 | Saturday, August 11, 2012 |
| Skid | 773 | 1389 | 1801 | 24 | 3987 | Tuesday, July 24, 2012 | Friday, June 21, 2013 |
| 2012 | | 1254 | 1801 | | 3055 | Tuesday, July 24, 2012 | Friday, November 30, 2012 |
| 2013 | 773 | 135 | | 24 | 932 | Sunday, January 6, 2013 | Friday, June 21, 2013 |
| Titus | 975 | 998 | 1330 | 1 | 3304 | Thursday, August 4, 2011 | Wednesday, September 19, 2012 |
| 2011 | | 935 | 1312 | 1 | 2248 | Thursday, August 4, 2011 | Saturday, December 24, 2011 |
| 2012 | 975 | 63 | 18 | | 1056 | Saturday, April 21, 2012 | Wednesday, September 19, 2012 |
| Grand Total | 8239 | 21598 | 14655 | 406 | 44898 | Monday, January 8, 2007 | Friday, September 25, 2015 |

Appendix 2 - Public Safety Information for the Upper Lillooet Watershed

Public safety is a shared responsibility between the public and other government agencies. While government is responsible to ensure infrastructure such as roads and recreation sites are assessed for hazards, the public must take personal responsibility for their own safety when travelling on Crown land by following direction for legal closures, reviewing posted signs for safety information, and respecting gates that are established to restrict access for their protection, in addition to making preparations with appropriate personal safety equipment for hiking and camping. For clarification, the ‘public safety’ responsibilities provided by the Ministry of Public Safety and Solicitor General are beyond the scope of this report²⁷. The Province may consider public safety in making other land use decisions where issues may exist, in order to ensure that resource management objectives, activities or tenures do not conflict with maintaining public safety.

In the context of this report, the greatest risk to public safety is the Mount Meager Volcanic Complex (MMVC), a potentially active volcano in the Garibaldi volcanic belt. Debris flows are a common hazard at volcanoes with steep unstable slopes, especially those that are snow and ice capped and located in areas of high precipitation²⁸.



Figure 12. Overview image of the MMVC with major peaks labelled.

Volcanic activities including catastrophic debris flows originating from the MMVC have been studied over many years, and provided a foundation for identifying known hazard areas, risk levels and closure criteria that were established to inform access closures to protect the public. Research and observations from historic and recent events enable confident estimates of total volume and distance that a potential debris flow may travel, with variation based on proximity to the potential source of debris flow. Figure 6 illustrates an example of the hazard inundation zones for a volcanic debris flow originating from the MMVC.

²⁷ <http://www2.gov.bc.ca/gov/content/governments/organizational-structure/ministries-organizations/ministries/public-safety-solicitor-general>

²⁸ Simpson, et al (2006)

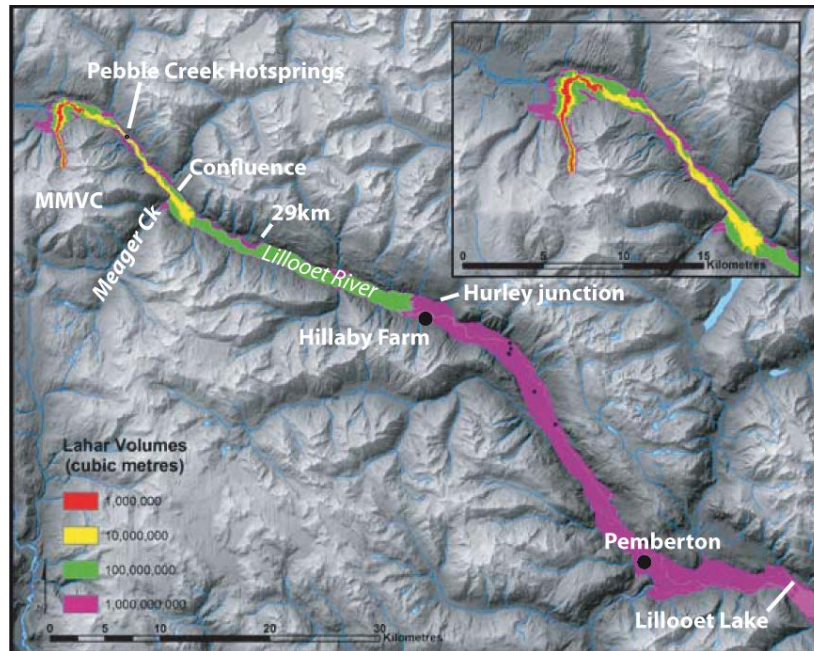


Figure 13. Travel distance along Lillooet River of selected volcanic landslides originating in Job Creek (after Simpson et al 2006). Job Creek, Devastation Creek, Angel Creek and Capricorn Creek were modeled.

A number of reports describe the catastrophic hazards to humans in the planning area, mainly associated with flooding, landslides, debris flows, avalanches and volcanic activity. Wildfire is yet another public safety concern that is gaining prominence in the planning area, mainly due to the recent 2015 Boulder complex wildfires that burned over 3,000 hectares of Crown forest; however, this component is not discussed in the report.

In order to address the above hazards, a formal protocol informs the risk for public safety in the planning area, based on rainfall amount and temperature²⁹. The risk to public safety from snow avalanches is also provided by Avalanche Canada³⁰. When maximum amounts of rainfall or temperature are triggered, the likelihood of landslides increase and in response to these conditions the industrial road users will shut down activities and leave the area, or activate their own industrial safety protocols according to Workers Compensation Board requirements. This may include evacuating the area, sweeping the area for members of the public, and then locking a gate behind them as they leave. In the case of wildfire, the BC Wildfire Service will advise local governments, who then initiate evacuation alerts and evacuation orders to inform the public of a closure and then patrol the area to instruct members of the public to evacuate from the area.

Recreation site closures may also be necessary to prevent risk of public harm when aggressive bears are reported during camping season. In many instances the conflict with bears is caused by recreationalists, with poor food management or garbage attractants being the main instigator. This is a clear example

²⁹ <https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/resource-roads/local-road-safety-information/sea-to-sky/volcaniclandslideriskmanagement.pdf>

³⁰ <http://www.avalanche.ca/map>

where the Province takes extra steps to protect public safety and important wildlife values to protect wildlife and people.

There is a long history of studying and analyzing the Upper Lillooet landslide hazards, both to understand the volcanic and terrain dynamics and to provide recommendations to government for appropriate management and emergency planning. More recently, Cordilleran Geoscience was contracted by BC Recreation Sites and Trails Branch in 2017 to review hazards associated with landslides. Figure 7 shows modeling results for volcanic debris flow of various magnitudes initiated from Devastation Creek (Simpson et al 2006). Following a slide, the model results indicate that significant amounts of material could be swept downstream, which would impact the hot springs site and roads, similar to past events that altered the location and nature of the hot springs, and would be detrimental to any values in the path of such a slide. See Appendix I for excerpts from this report that describing the hazards affecting the MMVC in more detail.

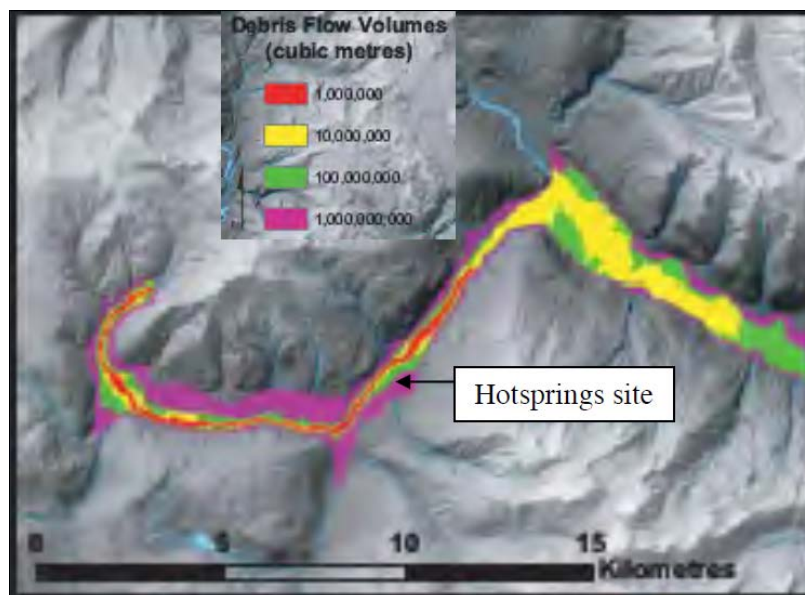


Figure 14. Model results for debris flows initiated in Devastation Creek near the Meager Creek hot springs. Source: Simpson et al (2006), Cordilleran Geoscience.

In spring 2010 an automated weather station was installed near the Mouth of Meager creek to inform the aforementioned shutdown policy linked to precipitation levels and daily temperatures. This policy was updated in 2012. Figure 8 illustrates the volcanic landslide hazard zones that relate to the initiation zones from Mount Meager and Capricorn Peak, as well as other avalanche zones and known debris flows. See Appendix I for excerpts from the Cordilleran Geoscience report describing the operational shutdown and landslide risk management procedures.

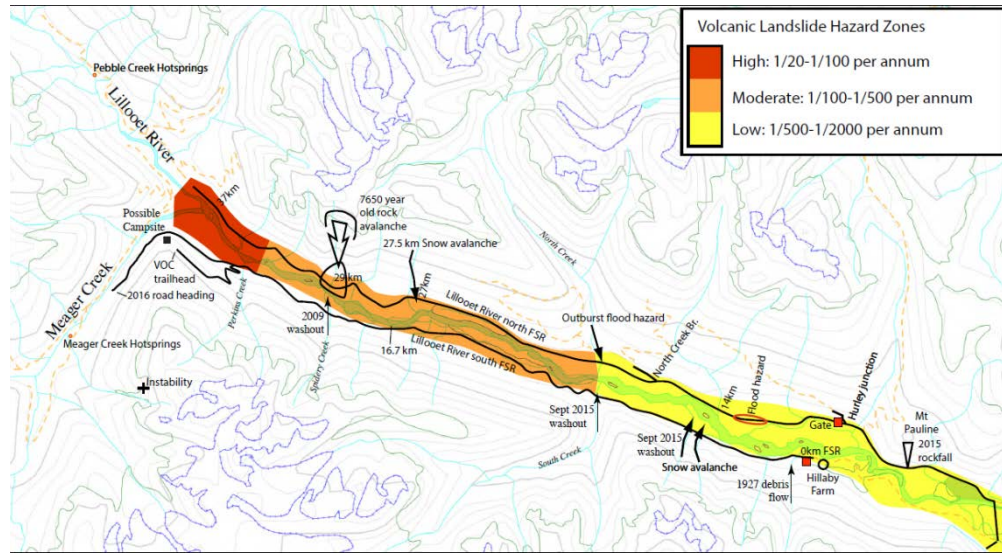


Figure 15. Volcanic Landslide Hazard Zones – Upper Lillooet Valley. Cordilleran Geoscience (2012; updated 2017³¹)

Access closures in the Upper Lillooet river valley due to the hazard conditions being triggered in the shutdown policies is becoming more common and is occurring on a more frequent basis. Lives have not been lost since 1974 when four geologists died at Devastation Creek when they were buried in a debris flow, though other recorded events include stranded infrastructure and vehicles. Logging equipment was buried by the 2010 slide that also destroyed roads, bridges, and temporarily blocked both Meager Creek and Lillooet River. Pemberton meadows residents were evacuated when the debris flow deposited materials forming an earth dam, and temporarily blocked both the Meager Creek and Lillooet River.

As concluded by Cordilleran Geoscience (2017), “Due to the high frequency of large destructive landslides, there is a high landslide risk to infrastructure and use groups and Meager Creek and Upper Lillooet River, including both industrial users and recreationists.” While industrial users have established safety protocols and emergency evacuation plans, daily and hourly access to weather station information and use of radios and communications equipment, recreationists largely do not, and the Province must consider other means that are practical and economically feasible to effectively protect public safety given the risks and hazards described above.

³¹ For more information on this report, please contact the Sea to Sky Natural Resource District

Appendix 3 – Excerpts from the 2017 report for the Meager and Pebble Creek Hot springs³²

³² 2017 Cordilleran Geoscience report for the Meager and Pebble Creek Hot springs. For more information on this report, please contact the Sea to Sky Natural Resource District.

4.0 Hazards Affecting Mount Meager Volcanic Complex

4.1 Non-eruption Related Landslide Hazard Overview

The first documented instability at Mount Meager was the 1931 landslide from Devastation Creek (Carter 1932). To support BC Hydro geothermal exploration, geological mapping was conducted by Read (1978), who first identified many of the unstable areas. In July 1975 four BC Hydro geologists were killed by another Devastation Creek landslide (Mokievsky-Zubok 1977). In the 1980s, Dr Mike Bovis (UBC) began his research on landslide processes at Meager with monitoring of the Affliction Creek sacking slope (Bovis 1989), and he first related the progressive slope distress to glacier retreat. Evans (1987) described a 500,000 m³ rock avalanche that initiated in 1986 on the north flank of Mount Meager and reached upper Lillooet River, forming a temporary blockage. Evans highlighted the landslide risk to human activities. Jordan (1987) mapped, differentiated and dated several valley bottom landslide deposits in Meager Creek and upper Lillooet River valleys in his study of landslide-river interaction in Squamish Lillooet Regional District. Read (1990), in a summary of Meager geology, commented that the massif was likely the most unstable region in Canada. In the 1990s two significant PhD studies supervised by Bovis focussed on volcanic landslide processes: Jordan's (1994) study of debris flow mobility; and Jakob's (1996) reconstruction of the 200 year long debris flow record for tributary basins based on dendrochronology. Bovis and Evans (1996) mapped numerous sites of gravitational slope distress in an about Mount Meager. A large landslide from Capricorn Creek in July 1998 was documented by Bovis and Jakob (1998). Baumann Engineering/EBA (1999) compiled and summarized all previous work as background for the landslide risk Management Plan for Meager Creek Hotsprings. Van der Kooij and Lambert (2002) used InSar to document settlement rates of 1.0 cm/yr of a 1km by 1km area on the east side of Devastation Creek. The last student of Bovis to work at Meager, Holm et al (2004) completed a detailed analyses of landslide response to glacier retreat from Little Ice Age moraines. First recognition that large edifice collapse at Pylon Peak had spawned debris flows large enough to travel 10s of kilometers downstream to Pemberton Meadows was reported by Friele and Clague (2004) and confirmed by a subsurface drilling program in Pemberton Meadows 30-50 km downstream from the massif (Friele et al 2005). Simpson et al (2006) conducted debris flow runout modeling (LaHarz) to investigate the potential impacts of future large clay-rich debris flows on Pemberton Meadows; while Friele et al., (2008) conducted a Quantitative Risk Assessment (QRA) concluding that the non-eruptive volcanic landslide risk affecting Pemberton Meadows was unacceptable by international safety standards.

Since the occurrence of the August 6, 2010 Mount Meager Landslide at Capricorn Creek, there has been considerable research paid to that event (Guthrie et al 2012; Allstadt 2013; Moretti 2014; Roberti et al., 2017, in press), and Mount Meager has again become the focus for graduate research. Hetherington (2014) conducted numerical analysis of slope stability across a North-South transect of the massif from Meager Creek to Lillooet River. She demonstrated that large edifice collapses (10⁸ m³) are still possible, with five main areas currently having a greater likelihood of failure: West Devastation Creek, the southern flank of Pylon Peak, the bulge at Job Creek, Affliction Creek and the eastern flank of Plinth Peak (Figure 1). The first four of these locations have clearly visible unstable features and the fifth is a steep cliff, which failed during the last volcanic



eruption. Hetherington noted that instability was sensitive to annual water infiltration, and minor changes could trigger failure. If failure occurred along a deep failure plane, volumes greater than 10^8 m^3 could be delivered to Lillooet River, which would inundate the entire valley, and could reach Pemberton. As part of initial stages of a Ph.D. program, Giochino Roberti has been conducting slope movement monitoring using sequential air photo and satellite imagery (Roberti et al., 2015), and has confirmed several areas of movement and identified others. In summer of 2016, gas vents, or fumaroles, were noted for the first time, and GSC issued a situation report on the status of Mount Meager volcanic activity, suggesting that at this time there was no concern about an explosive eruption (NRCan 2016).

The main conclusions regarding future slope hazards are summarized nicely in the abstract to Holm et al (2004), cited below:

“The bedrock landslide response to glacial retreat varies appreciably according to rock type and the extent of glacial scour below the Little Ice Age (LIA) trimline. Valleys carved in weak Quaternary volcanics show significant erosional oversteepening and contain deep-seated slope movement features, active rock fall, rock slides, and rock avalanches near glacial trimlines. Basins in stronger granitic rock rarely show increased bedrock instability resulting from post-LIA retreat, except for shallow-seated rock slides along some trimlines and failures on previously unstable slopes. In surficial materials, landslides associated with post-LIA retreat originate in till or colluvium, as debris slides or debris avalanches, and are concentrated along lateral moraines or glacial trimlines.

Significant spatial association was also observed between recent catastrophic failures, gravitational slope deformation, and slopes that were oversteepened then debutressed by glacial erosion. Eight out of nine catastrophic rock slope failures occurred just above glacial trimlines and all occurred in areas with a previous history of deep-seated gravitational slope movement, implying that this type of deformation is a precursor to catastrophic detachment.”

Holm’s latter statement was borne out by the August 6, 2010 Mount Meager landslide which has been shown to be directly related to progressive slope distress resulting from glacier retreat and debuttreasing (Roberti et al., in press).

4.2 Incidents Involving Risk to Human Life

Due to the high frequency of large destructive landslides, there is a high landslide risk to infrastructure and user groups at Meager Creek and upper Lillooet River, including both industrial users and recreationists. Local history includes such recorded events as the 1931 Devastation debris flow nearly washing Bert Perkins away while at his trappers cabin at South Creek (Decker et al., 1977). In July 1975, four geologists lives were lost while waiting for a helicopter pickup at Devastation Creek (Mokievsky-Zubok, 1977). A debris flow on Hotsprings Creek in 1984 stranded vehicles and recreationists; while the CRB watchman’s camp and repair shop at Canyon Creek were partly buried a couple of times in the late 1980s and early 1990s. After the 2003 regional flood, the Meager Creek



bridge to the Hotsprings was washed out. The site remained inaccessible till the bridge was finally replaced in 2008. With the upgraded Hotsprings Recreation site open for business, a recreation site manager set up camp for the summer season. The task was to open and close the Br 3 gate daily and to monitor weather. The camp location for two seasons was at the mouth of Meager Creek on the floodplain, and was eventually deemed unsafe (Cordilleran 2009), and for the 2010 season was relocated to the 36 km campsite. Had the operator been in camp at the time, the move would have saved his life, as the previous seasons camp was completely destroyed by the 2010 Meager landslide. The 2010 Meager landslide resulted in two other close calls. Weather shutdown employed by Squamish Mills (Cordilleran, 2010), who were rebuilding the Capricorn Creek crossing after the 2009 landslide resulted in a heatwave triggered shutdown, such that on the day of the 2010 landslide there was no work occurring at the Capricorn Creek crossing. Again, had the landslide occurred during working hours, this would have spared lives. Finally, the 36 km public campsite was occupied on the night of August 6, 2010, and one group was just arriving at 3am; they were in the midst of setting up camp when they heard the loud reports of the initial release, and as they attempted to flee northward in their vehicle they were turned around and nearly overwhelmed by the wet front of the debris that had overtopped the river terrace (Guthrie et al. 2012).

4.3 Hazards Affecting the Meager Creek Hotsprings Recreation Site

The contributing basin area upstream of the Meager Creek Hotsprings Recreation site is 215 km² and extends from Canyon Creek to Devastation Creek, including the watersheds of Devastation, Boundary, No Good, Angel, Pylon, Canyon, and Hotsprings Creeks, and the lower reaches of Barr and South Meager Creeks.

In the study area, Meager Creek is narrowly confined with 2000 m of relief to glaciated summits. Upstream of Angel Creek, large debris fans from the north force the river against the south valley wall. Between Angel and Canyon creek, Meager Creek is incised 60-140 m in rock avalanche deposits from Pylon Peak. Downstream of these rock avalanche deposits the creek is confined between alluvial fans on Hotsprings and Canyon creeks. Capricorn Creek is 4 km downstream of the Hotsprings and landslides from this basin would likely not directly impact the site, although 2010 was close call reaching with 300 m of the site, but landslides from Capricorn Creek do sever access and/or cause upstream inundation.

4.3.1 Hydrologic Clear Water Floods

Based on a basin size of 215 km² for the Hotsprings site, the 100-year peak discharge was estimated to be 275 m³/s (DWB Forestry Services Ltd., 2005). Using Creager's equation, applied to Lillooet and Bridge river records, Baumann Engineering/EBA (1999) suggested a value of 290 m³/s. Based on a Gumbel distribution applied to data from Cheakamus River at Millar Creek (1982-2004), the 10-year and 50-year floods would be on the order of 165 m³/s and 250 m³/s, respectively. Hydrologic floods in the range up to about 50-year return appear not to affect the Hotsprings pools (Photo 1).



4.3.2 Coarse Woody Debris and Sediment Loading

Upstream of the Hotsprings site, Meager Creek is incised up to 60-140 m in landslide deposits (Photo 2). The steep slopes to the creek are mostly forested, but local slumping is common. Slumps may be tens of metres wide and extend the full height of the scarp, and may introduce abundant coarse woody debris and sediment into the channel. Sediment introduced by bank slumps and from debris flows from tributary basins results in high sediment loads that may lead to cycles of bed aggradation and degradation, which could make the pools more or less vulnerable to flooding.

4.3.3 Outburst floods

Debris flows, rockslides from tributary basins, or bank collapses could all lead to blockage along Meager Creek, and potential dam break flooding. Impoundment volumes and potential instantaneous discharges from blockages at No Good Creek were calculated by Jordan (1987). The calculated outburst flood discharges ranged from 130-6000 m³/s, with the largest likely debris flow producing an outburst flood with a discharge of 360-1800 m³/s, for most-likely and maximum cases, respectively. Given an instantaneous discharge of 2000 m³/s with a velocity of 5 m/s the flood wave would occupy an area of about 400 m². This would inundate the Meager Creek hotsprings terrace (Figure 2).

According to former CRB woods boss, Terry Ross (personal communication), the original Meager Creek bridge was destroyed by a small outburst flood due to damming of Meager Creek by a small debris flow on Canyon Creek in 1984. Further, Jordan (1987) described a potential outburst flood resulting from a blockage of Meager Creek by a debris flow on Hotsprings Creek in the mid 1950s. This event washed out the Hotsprings site to a level at least 3-m higher than low water level. The blockage from the 1975 Devastation Creek event persists to this day, with the lake completely infilled by sand; while the blockage of Meager Creek by landslides on Capricorn Creek in 1998 & 2009 drained slowly over the course of one year. In contrast, the Meager Creek blockage caused by the 2010 Mount Meager landslide drained catastrophically after 18 hours (Guthrie et al 2012). The stability and outburst potential of a landslide dam is a function of its geometry and composition. Since there is no lengthy record of historic outburst flooding in the study area, a magnitude-frequency distribution is not possible, but the potential for flood surges on the order of 10² m³/s to 10³ m³/s is likely high (Table 1).

4.3.4 Volcanic debris flows along Meager Creek

Volcanic debris flows are probably the most significant hazard affecting the Meager Creek Hotsprings site. Not all landslides will evolve into debris flows, as illustrated by the difference in behaviour between the 1931 and 1975 events: both initiated in the same general area with similar magnitudes (10⁶-10⁷ m³); however, the 1975 event stopped at the mouth of Devastation Creek, forming a dam on Meager Creek; while the 1931 event, transformed into a debris flow that traveled the length of Meager Creek, and caused surging on Lillooet River as far as South Creek (Decker et al 1977). Landslides from downstream sources may affect the site as well, as indicated by the near miss of the upstream surge of the 2010 Mount Meager landslide.



A large rock avalanche has been recently documented on the Lillooet Valley floor at about 29 km. Exposures at river level have been dated (Friele and Clague, unpublished) indicating that this event occurred 7650 years ago, or earlier.

6.0 Operational Shutdown & Landslide Risk Management

In response to the landslide risk, District of Squamish (MoFLRO) contracted Baumann/EBA (1999) to provide a management strategy for the Meager Creek drainage. As a result of this work, Meager Creek hazards and risk management measures were described by signage at several key locations along Pemberton Meadows Road and Lillooet River FSR. For the Meager Creek hotsprings recreation site, only day use (8:00 am-8:00 pm) during the summer season (May-Sept) was permitted. For the fall/winter, access was prevented by a gate on Br 3 on the river right abutment of Lillooet River bridge at the mouth of the Meager Creek drainage.

Part of the summer use management strategy was a protocol for weather-based operational shutdown. Where long and detailed weather and stream flow records are absent, like at Meager Creek, linking landslide activity to climate and runoff triggers is problematic. The method used at Meager Creek is largely based on sparse data comparison of landslide occurrence and simple metrics for temperature and precipitation.

These methods are not without their detractors (Marquis 2001), largely because they are not considered accurate predictors of landslide activity. The phenomenon that extreme climate events sometimes fail to trigger landslides, while at other times apparently milder climate events do was noted by Church and Miles (1987), and this remains a problem in landslide forecasting. This is not to say that shutdown protocols should not be taken seriously. Clearly, with the potential for loss of life, especially in the valleys flanking the Meager massif, the best available method should be applied.

After Baumann Engineering/EBA (1999), summer season operational shutdown guidelines for Meager Creek drainage were established. When a trigger was indicated, then the valley was to be evacuated. The shutdown triggers were as follows:

- Instantaneous high flows to the various tributaries within the Meager Creek drainage during spring runoff;
- When average temperature for 6 days exceeds 25°C;
- Sudden drop in water flow or significant colour change of Meager Creek or its tributaries shall warrant immediate shutdown of Meager Creek hotsprings and restriction of vehicle access into drainage;
- An actual rainstorm or the forecast of a high intensity rainstorm (20mm/24 hour) in conjunction with 2 to 5 days of temperatures averaging more than 25°C warrants immediate shutdown of the drainage;
- Rainfall intensity exceeds 70mm/24 hour.



