Proposed Anahim Connector Road
Risk Assessment and Mitigation Reports

Contents

Summary and Results

The Ministry of Forests, Lands, Natural Resource Operations, and Rural Development has completed a risk assessment and has identified mitigation options for moose, grizzly, watershed health and caribou for the proposed Anahim Connector road project. The assessments are based on the guidelines set out in the Environmental Mitigation Policy for B.C. Potential impacts and recommended mitigations will be used to inform a decision on the project in early 2019.

The proposed project will have an impact on moose habitat and mortality risk. Overall, risk to moose is considered moderate. Mitigation measures are recommended to avoid or minimize impacts (Report 1, page 19). Existing disturbances are high and the addition of a road will increase the cumulative effects on moose. Deactivation and/or rehabilitation of roads will help to reduce cumulative effects.

The proposed project will have an impact on grizzly bear habitat and mortality risk. Overall, the risk to grizzly bear is considered low. Mitigations are recommended to avoid or minimize impacts on grizzly bears (Report 1, page 28). Cumulative impacts of the road and other disturbances will have some impact. Opportunities to deactivate and/or rehabilitate roads or reduce road densities will help to reduce the cumulative effects on grizzly bears.

The proposed project will have impacts on watershed health; however the overall risk is considered low. The watersheds in this area are undisturbed or not considered sensitive, therefore the cumulative effects of the road on watershed health is low. The construction of the road may however, have indirect effects on fisheries values within the area through increased recreational fisheries and potential exploitation of fisheries values in the area. Mitigation measures are recommended to avoid or minimize impacts to watershed health (Report 1, page 34).

The proposed project will have impacts on caribou and the risk to further caribou population declines is moderate to high. Cumulative effects on critical caribou habitat are significant and will occur on a landscape scale. Mitigation measures are unable to fully mitigate impacts to caribou, however, recommendations may partially mitigate impacts (Report 2, page 25).

1. Proposed Anahim Connector Road Risk Assessment and Mitigation Report

Moose, Grizzly, and Watershed Health

Prepared by:

Ministry of Forests, Lands, Natural Resource Operations

and Rural Development

11/19/2018

Contents

1. Introduction

1.1. Background

The Southern Dakelh Nation Alliance (SDNA) communities of Lhoosk'uz Dene Nation and Ulkatcho First Nation have requested secondary emergency evacuation routes from each of their communities, following the 2017 wildfire season which heightened community concerns over limited fire egress options.

In March 2017, MLA Coralee Oakes announced that the government had budgeted 7 million dollars for the Kluskus and Anahim Connector projects to support the regional economy and for First Nation fire egress. The 2017 fire season was the worst in recorded history and posed significant threats to both Kluskus and Ulkatcho First Nations, shifting government's priority towards constructing a connector road primarily for emergency egress.

The Anahim connector project (the Project) crosses two Natural Resource Regions and 3 Natural Resource Districts. Planning tools available within each of the regions differ, along with harvesting pressures within each district.

The Project is likely to impact woodland caribou, moose, grizzly bear and aquatic ecosystems. Woodland caribou are a threatened species under the federal *Species at Risk Act* (SARA). The following is provided as an assessment of the risk associated with the Project and potential risks to moose, grizzly bears and aquatic values specific to the proposed Project. Risks to caribou are assessed through a separate document (Cariboo Region Caribou Technical Committee, 2018). Other values may be impacted by the proposed development; however, they were not included as part of this assessment. The values selected, were based on social as well as ecological significance and availability of existing information.

2. Effects Assessment Methodology

This environmental risk assessment seeks to determine the nature and extent of environmental impacts from the Anahim Connector project and outlines what mitigation measures could be appropriate.The potential effects of the proposed Project have been assessed following the Procedures for Mitigation Impacts on Environmental Values (Environmental Mitigation Procedures) (Ministry of Environment, 2014).

2.1. Values Assessed

Values assessed are elements of the natural environment that the Province has identified as important for assuring the integrity and well-being of the province's ecological systems. Environmental components are attributes of the natural system that are measured and managed to maintain the environmental value.

Three environmental values have been selected for assessment (**Table 2-1**).

Table 2-1: Environmental Values and Components assessed for the Anahim Connector Road Project

Value	Component
Moose	• Moose Habitat • Mortality Risk
Grizzly Bear	• Grizzly Bear Habitat • Mortality Risk
Aquatic Ecosystems	• Fisheries Values • Sedimentation Risk • Stream flow Risk

2.2.Assessment Boundaries

The spatial boundaries used in the assessment of the proposed Project consider the following:

- Footprint: The land directly disturbed by the Project and includes temporary and permanent features of the Project.
- Local Study Area (LSA): The boundary of the LSA varies depending on the value assessed; however considers the direct and indirect effects of the Project.
- Regional Study Area (RSA): The boundary of the RSA varies depending on the value assessed. For each value assessed a separate RSA has been identified which considers the landscape context and cumulative effects.

Individual assessment boundaries are discussed in further detail within the appropriate values sections of the document.

Temporal boundaries for the proposed project include: construction and operation phases. The proposed project is considered permanent; therefore, decommissioning was not considered. The construction phase of the project includes: pre-clearing, surveying, clearing, grading and post-construction reclamation. Project construction is anticipated to begin spring of 2019 and is anticipated to take one field season. Operation would commence following construction.

2.3.Project Effects

Effects resulting from the Project were identified using existing information, from literature, Provincial and Regional cumulative effects work, and population and habitat monitoring. Section 3 identifies the potential effects, on the values identified in Section 2.1, resulting from the Project during construction and operation.

2.4.Mitigation

Mitigation is tangible conservation actions taken to avoid, minimize, restore on-site, or offset impacts on environmental values and associated components, resulting from a project or activity.

British Columbia's *Policy for Mitigating Impacts on Environmental Values*, identifies a mitigation hierarchy that is intended to improve the quality, transparency and consistency in mitigating impacts on environmental values. Within the policy, all feasible measures should be considered and applied at one level before moving to the next. Avoiding impacts on values is considered the first step. This is achieved most effectively during the planning stage, where impacts to the value or values may be avoided by choosing the most appropriate location or timing for the activity. The second level in the mitigation hierarchy is to minimize. Measures to minimize the effects consider the scope, scale and duration of the impacts. The final levels of the mitigation hierarchy are measures for restoration on-site and offsets to address direct or indirect impacts remaining after mitigation measures to avoid and minimize are applied.

Section 3 and Appendix A provides a list of mitigation measures recommended for the Project. Mitigation measures are based on the best available science and existing Best Management Practices.

2.5.Characterization of Potential Residual Effects

Residual effect means an impact that affects an environmental component, and remains, or is predicted to remain, following the application of all feasible measures to minimize and/or restore on-site.

Each residual effect was characterized based on the qualitative criteria provided within the Environmental Mitigation Procedures. The criteria are provided below in **Table 2-2**.

Table 2-2: Characterization of residual effects criteria, as per the Environmental Mitigation Procedures

Assessment Criteria	Characterization	Definition
Context		The specific ecological setting that the environmental component will be assessed within
Magnitude: The assessed size of severity of the impact.	Negligible	Residual effect is not detectable
	Low	Residual effect is detectable but below management or bench mark targets
	Medium	Residual effect is detectable and approaching management or bench mark targets
	High	Residual effect is detectable and exceeding management or bench mark targets
Duration: What is the duration of the impact?	Immediate	The residual effect dissipates within 1 to 2 days
	Short-term	The residual effect dissipates in more than 2 days but less than 1 year
	Medium-term	The residual effect dissipates after construction
	Long-term	The residual effect persists through operation
Frequency: How often will the impact occur?	Single Event	The impact is confined to a one-time event
	Occasional	The impact occurs intermittently and sporadically over the assessment period
	Regular	The impact occurs intermittently but repeatedly over the assessment period
	Continuous	The impact occurs continuously over the assessment period.
Reversibility	Reversible	The impact is not permanent if the impact is stopped
	Irreversible	The impact is permanent even if the impact stops
Consequence		Consideration of Context, Magnitude, Duration, Frequency and Reversibility to determine Consequence.
Probability of Occurrence: What is the likelihood of the impact?	High	Likely
	Low	Unlikely

2.6.Risk

A determination of risk was completed for each identified residual effect. Determination of risk considers consequence and likelihood to determine risk for each potential impact and impacts after mitigation measures to avoid, minimize and restore on-site have been applied. Risk is reported as Low, Moderate or High. Several factors are considered when determining risk. If a standard is established through legislation or regulation, the predicted effect is measured against the standard to determine risk. In the absence of a standard, a combination of criteria is used to determine is the risk is High:

- Have a high magnitude at the LSA and be long term or permanent in duration;
- Have a medium magnitude at the RSA and be long term or permanent in duration;

- Have a high magnitude at the RSA

For risk identified not as High, addition criteria are considered, such as context and frequency to characterize the risk as either Low or Moderate.

2.7. Cumulative Effects

Cumulative effects assessment evaluates the likelihood that residual effects from the proposed Project will contribute to residual effects of other impacts to the value from past and current projects.

Provincial and Regional cumulative effects assessments have been completed, which overlap the assessment area. The approach to cumulative effects varies between cumulative effects assessments. The information presented within this report highlights aspects that are consistent between the various cumulative effects work that has been completed throughout the assessment area. A detailed Cumulative Effects Assessment conducted for the Cariboo Region portion of the project can be found in Appendix B.

2.7.1. Methodology

The cumulative effect assessment for each value will consist of the following steps:

- Identification of residual effects from the Project
- Identification of spatial and temporal boundaries appropriate for each value where effects of other projects/activities may interact with effects from the Project
- Identification of potential cumulative residual effects
- Identification of additional mitigation measures
- Characterization of residual cumulative effects
- Determination of Risk

3. Risks Assessment

The proposed Anahim Connector Road would require the upgrading of existing road and construction of a new road into an area that is primarily undisturbed (Figure 3-1). Upgrades would be made to approximately 23 km of existing road, with new construction of approximately 8-12 km, depending on route selection. Two primary routes have been identified for further consideration. Route 1 is located west of Eliguk Lake, with alternatives to the route, including: an option to travel west of Basalt Lake and an alternative junction to the Kluskus FSR. Route 2 is located east of Eliguk Lake with alternatives that avoid potentially sensitive cultural sites and large wetlands. The upgraded and new road will allow for easier vehicle access into the area. This will result in new hunting, fishing and recreation opportunities in an area that currently has little access to vehicle traffic. Additionally the construction of the new access may facilitate increase resource extraction within the assessment area.

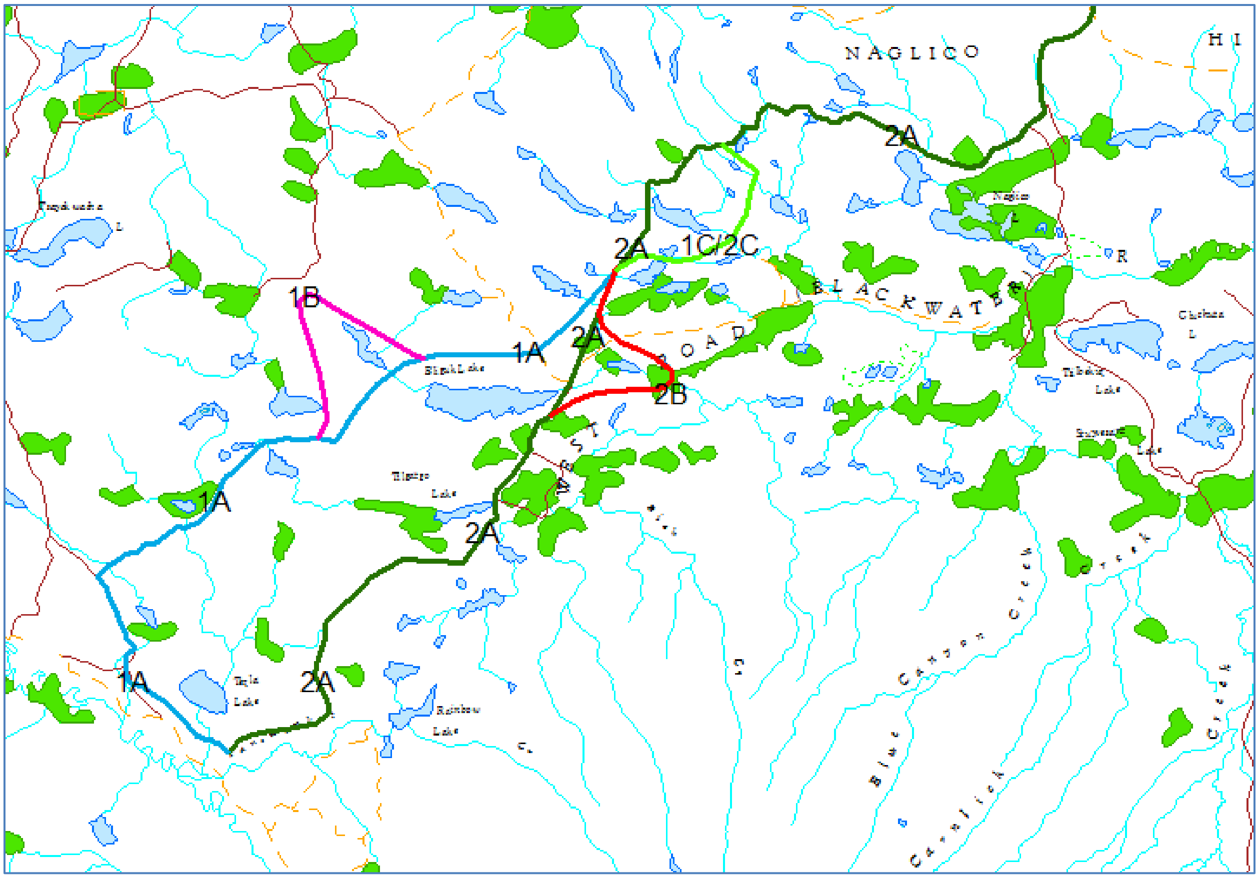

Figure 3-1. Route Options and alternatives for the proposed Anahim Connector Road

3.1.General Risks

Jalkotzy et al (1997) states, of all disturbance corridors humans create, roads potentially have the greatest impact on wildlife populations. Roads have the potential to result in multiple effects, through direct and indirect habitat loss, direct and indirect mortality and disruption in movement.

Undisturbed areas may function as a source habitat for species, and by creating access within these areas can shift habitat to become 'sink' habitat (Nielsen, 2011). Source habitat and populations are critical to the long term maintenance of self-sustaining populations. To achieve this, adequate, spatially appropriate, functioning habitat is required, allowing juveniles to disperse into areas of lower densities.

Direct and indirect mortality may be experienced through collisions with vehicles as well as improved hunter efficiency. Improved access has the potential to facilitate predator movement as well as provide access for potential unauthorized hunting and fishing. Risks associated with direct and indirect mortality can be minimized through careful planning to avoid constructing roads in areas of sensitive habitat or sensitive periods; however, residual effects would still persist that would require additional consideration.

Avoidance of linear features is well documented for multiple species. The degree of avoidance varies depending on species and characteristics of the feature. In some cases a linear disturbance can function as a barrier to species movement, disrupting: seasonal migration, species distribution and genetic connectivity.

Indirect effects on constructing new access may be experienced as well. The establishment of new access may result in increases in industrial activity within an area. Overall active, pending and retired forest authorizations are minimal across the assessment area in comparison to the higher harvesting rates to the east and north, which may be attributed to existing access. **Figure 3.1-1** shows current and historical forest authorization within the assessment area. The indirect effect may amplify the effects to habitat loss, mortality risk and species movement.

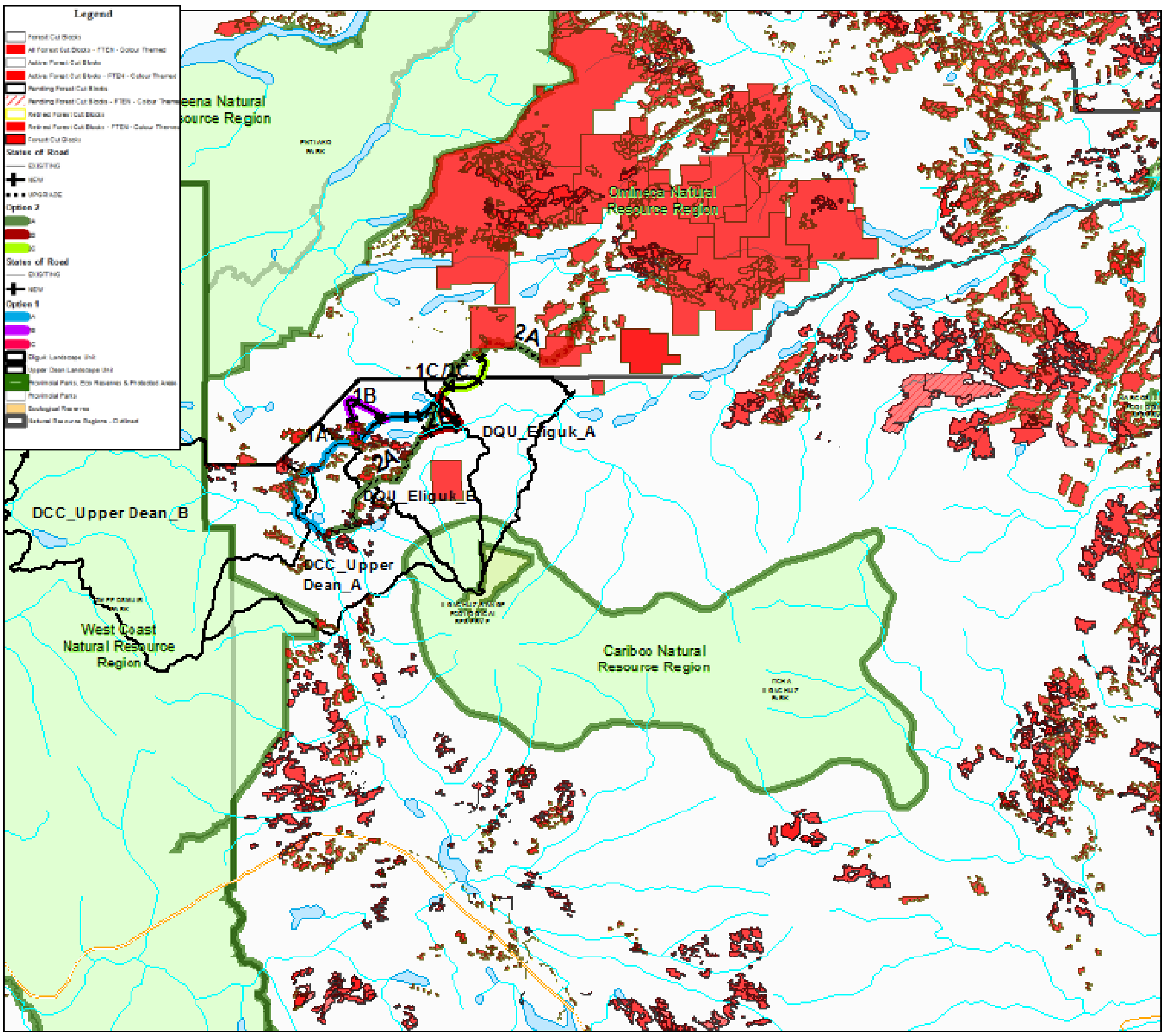

Figure 3.1-1: Current and historical forest authorizations in the assessment area.

3.2. Moose

Moose are the largest member of the deer family (Cervidae). Provincially, moose are Yellow-listed, or considered apparently secure and not at risk of extinction. However, across the assessment area populations of moose have experienced significant declines. In some cases the declines are expected as a result of landscape-level changes due to both human impacts and natural disturbance (FLNRORD, 2017).

The Vanderhoof Land and Resource Management Plan and the Cariboo Chilcotin Land Use Plan (CCLUP) identify moose as a highly valued species. Both plans identify objectives for the protection and maintenance of sufficient quantity and quality of habitat for moose to maintain healthy populations. Within the CCLUP, "High Value" wetlands are identified. "High Value" wetlands were identified through a preliminary list of high value wetlands for moose within the Cariboo Forest region and were determined by measuring the number of known moose-locations surrounding each wetland as they appear on maps that contained moose-locations and wetland polygons. Wetlands that were surrounded by a disproportionately large number of moose were described as "high value". Further field reconnaissance was completed to confirm the value of these wetlands for moose. These areas were mapped and are contained within map 11 of the CCLUP.

The high value wetlands that exist within the assessment area are limiting on the landbase. This highlights the importance of the wetland complex within the assessment area as these types of habitat are limited across the Chilcotin and surrounding areas and are important areas for moose.

Moose were selected as a value because they are year-round residents within the Project area and because of their ecological and social importance to both First Nations and residence for subsistence.

3.2.1. Assessment Boundary

Two geographic boundaries, as shown in **Figure 3.2-1**, were used to evaluate the effects of the Project on moose. The assessment boundary encompasses the LSA and the RSA.

The LSA includes a 1 kilometer buffer on either side of the road centerline, which accounts for both the direct and indirect effects of the project. The LSA is limited to the portions of the Project resulting in new or upgraded road, and does not include existing infrastructure that is not scheduled for upgrades.

The boundary of the RSA is identified as the affected Landscape Unit (LU) specified within the BC Data Catalogue (Government of BC, 2018). A landscape unit is generally based on ecologically similar areas and drainages in consideration of natural disturbance regimes. The LU range from about 30,000 to 70,000 ha in area, with larger units in the plateau areas and smaller units in more mountainous terrain. The range in size recognizes the natural variability among home range sizes for wildlife species.

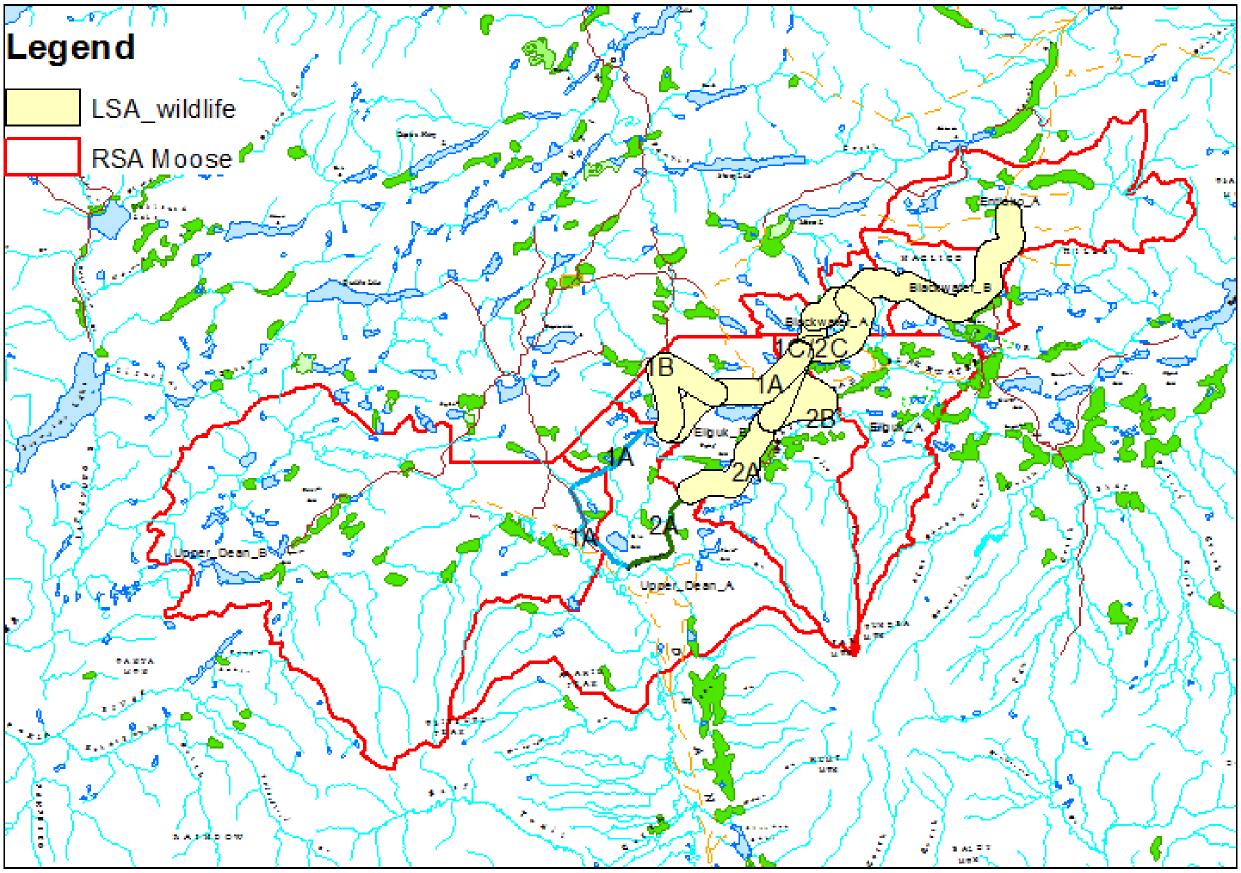

Figure 3.3-1: Local Assessment Area and Regional Assessment Area for assessing risk to moose.

3.2.2. Population

The Project area falls within the Entiako survey block in the Skeena region and Wildlife Management Unit (WMU) 5-12A and 5-12B in the Cariboo Region. The Entiako and WMU 5-12A were last surveyed in 2017 to assess the moose population. Within the Entiako, calf survival was measured based on radio-collared cow moose; revealing a ratio of 9 calves per 100 cows. A calf cow ratio of 25 to 30 calves to every 100 cows is desirable for a stable population. Higher ratios indicate potential increases in population, while ratios below this would indicate a decline in population.

The Entiako survey block is part of a provincial moose research project investigating causes and rates of cow moose mortality. The leading probably proximate causes of moose mortality have been identified as predation (50%), hunting (17%) and health (22%) (Kuzyk *et al.*, 2017).

The moose density estimate in WMU 5-12B increased significantly from 1997 to 2002 before decreasing significantly from 2002 to 2012 (Table 3.3-1). The survey results are consistent with anecdotal reports from First Nations and licensed hunters indicating that moose populations in the Anahim Lake area have decreased substantially through the late 2000s. Within WMU 5-12A, bull to cow ratios ranged from 33 to 56 bulls per 100 cows and calf tocow ratios ranging from 21 to 30 calves per 100 cows. A bull to cow ratio of 30 bulls to 100 cows is desirable (FLNRORD, 2017).

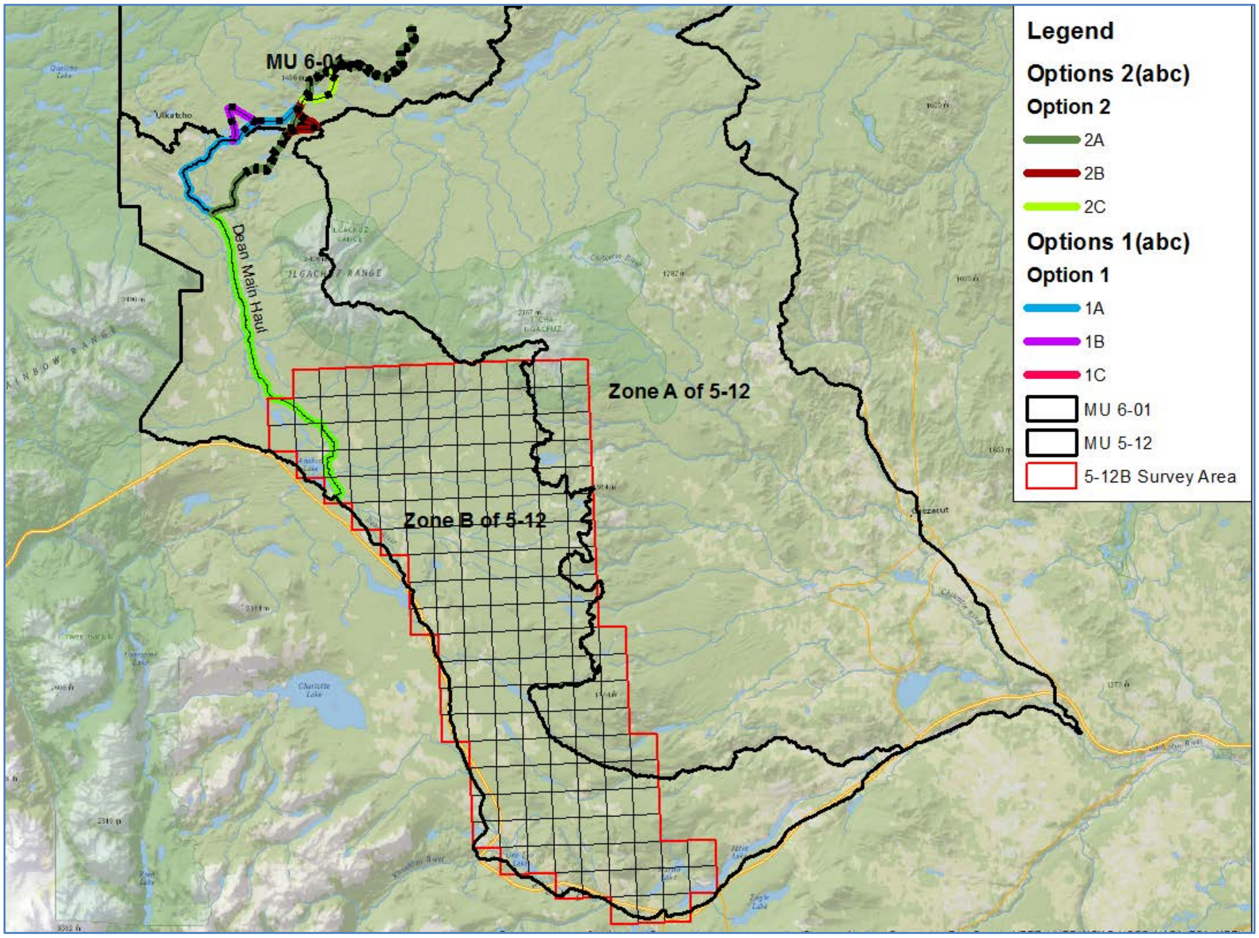

Figure3.3-2: Stratified Random Block survey area used during the 2002 and 2012 5-12B moose surveys.

Table 3.3-1: Moose Survey History within Limited Entry Hunting Zone 5-12B

Survey Year	Survey Type	Survey Area (km^2)	Corrected Density Estimate* ($moose/km^2$)	Sightability Correction Factor (SCF)	Bull/Cow Ratio (Bulls:100 Cows)	Calf/Cow Ratio (Claves:100 Cows)
1995	SRB	1,648	0.38 (±23%)	1.40	43	48
1997	SRB	1,648	0.35 (±15%)	1.40	39	40
2002	SRB	2,672	0.58 (±13%)	1.40	44	48
2012	SRB	2,672	0.23 (±17%)	1.21	70	40
2017	Comp	3,852	N/A	N/A	56	30

*Density estimates were corrected for sightability bias by applying a Sightability Correction Factor (SCF). The 1995, 1997, and 2002 SCFs were based on expert opinion, the 2012 SCF was calculated utilizing a sightability correction model based on vegetative cover observations made during the survey (See Quayle et al. 2001).

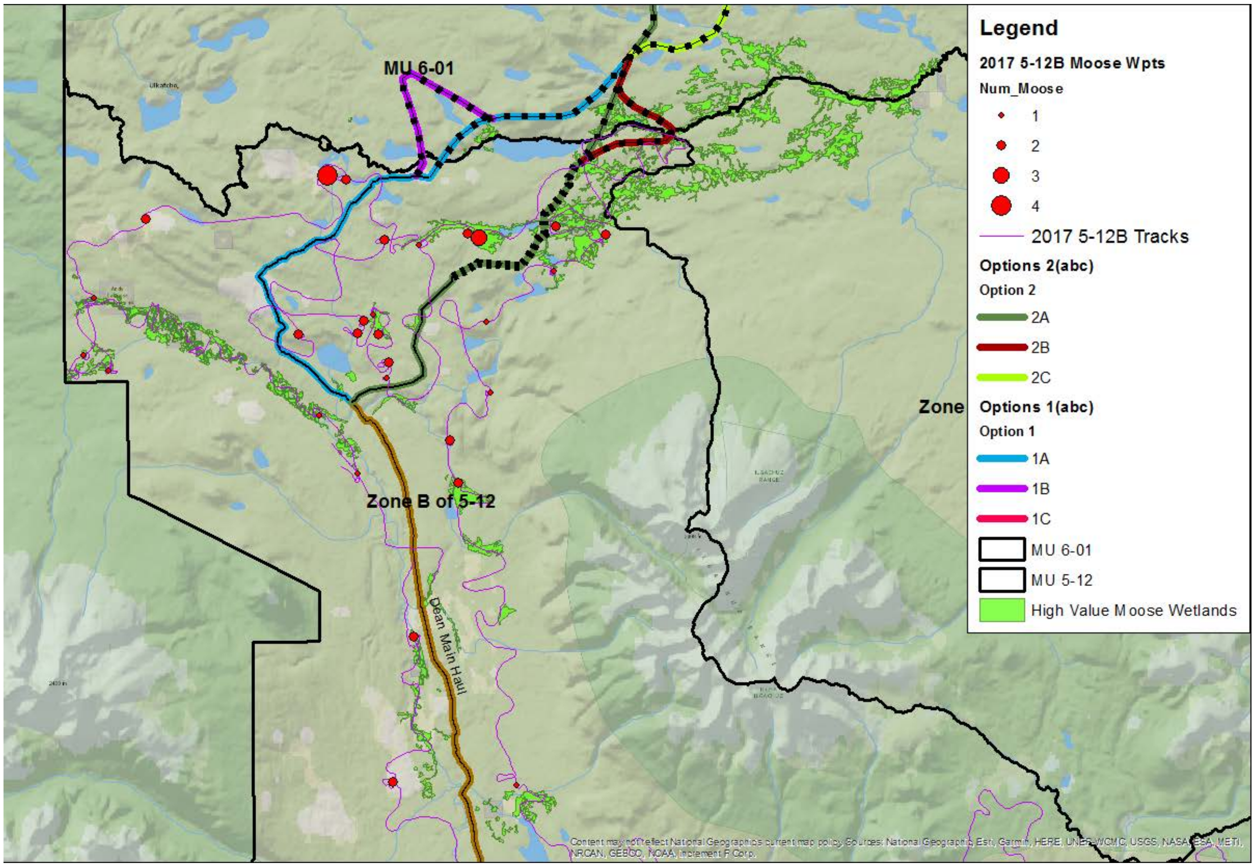

Figure 1.3-3: Moose locations and survey track from the 2017 5-12B composition survey.

Several moose surveys completed in the central interior of BC from 2010-2017, found significant declines in moose abundance. The decreased moose densities appeared to be associated with the mountain pine beetle epidemic and subsequent salvage operations. In response to the seemingly widespread declines, the Provincial government, in partnership with local First Nations, initiated several moose recovery initiatives.

The Province has reduced Limited Entry Hunting (LEH) authorizations in the Chilcotin by over 60% from 2011 to 2018 in response to moose population declines. In addition, the September and early October hunting seasons have been closed in LEH hunting zones in which moose population metrics are not meeting management targets. The reductions in licenced harvest and closure of the September and early October seasons were intended to facilitate population recovery, maintain and recover bull to cow ratios and facilitate First Nations shifting moose harvest from cows to bulls.

The Tsilhqot'in National Government (TNG) has also made efforts to reduce the Nation's harvest of cow and calf moose through support of the cow moose signage project and information sessions held at member communities. In September 2018, the TNG and Southern Dakelh National Alliance (SDNA) issued a joint media release banning all LEH moose hunting within their respective territories which includes both LEH Zones 5-12B and 6-01. The announced ban reflects the serious concern that TNG and SDNA share regarding current moose population status.

Based on the previous surveys within the project area, populations within the southern portion of the Project assessment area are potentially stable to slightly decreasing based on calf to cow and bull to cow ratios; however the longer term trend still reflect a significantly reduced population. Within the northern portion of the Project area moose populations continue to decline. Since the last surveys the Project area has been impacted by wildfire. The effects of the wildfires have not been fully assessed at the time of preparing this assessment.

Habitat and habitat conditions for moose within the Project area is characterized in the following sections as part of the assessment and cumulative effects assessment.

3.2.3. Potential Effects

The following section speaks to the potential effects of the Project on moose during construction and operation phases.

The assessment considers the following:

- Impacts to winter moose habitat, including forage habitat and adjacent cover,
- Impacts to moose populations, including direct mortality risk through increased access and indirect mortality of moose through increased hunting opportunity and improved predator movement.

3.2.3.1 Assessment Approach

A quantitative assessment was completed to determine the effects of the Project and associated risks.

Winter forage habitat was identified based on queries of Vegetation Resource Inventory (VRI) data available for the Project area. The assessment focused on static forage habitat, which does not move around the landscape and includes habitat such as wetlands, riparian and self-sustaining deciduous forests. Static habitat was identified based on area classified as wetlands or deciduous leading using land cover data in VRI and greater than 1000 metres from a road. Definition queries were developed based on attributes from identified “High Value” wetlands within the CCLUP. The effectiveness of winter forage habitat is influenced by the proximity of shelter habitat (i.e. forest cover) critical to moose. Shelter habitat, which provides snow interception and thermal cover, is required for moose to allow movement to conserve energy and relief from extreme winter temperatures (Wall *et al*., 2011). Shelter habitat was identified as areas classified as conifer stands, greater than 60 years of age, and greater than 1000 metres from a road.

Mortality risk to moose is influenced by road density and the amount of early seral habitat (Beazley *et al*., 2004). Roads provide access for hunters and predators and are known to correlate to hunter and predator efficiency. In addition to increased hunter and predator movement, roads increase risk of direct mortality through collision. Early seral habitat reduces visual screening, improving sightability for hunters and predators (Kuzyk and Heard, 2014). Road density was calculated based on km of road per km^2 of area. Amount of early seral habitat, vegetated areas less than 20 years of age, is reported based on percent.

3.2.3.2 Assessment Results

3.2.3.2.1 Winter Forage Habitat

The potential overlap of the Project with Static winter forage habitat is provided in **Table 3.2-2.** The potential overlap of the Project with Shelter habitat is provided in **Table 3.2-3.**

The amount of static winter forage habitat within the Project area varies depending on the route selected, ranging from 151 ha to 486 ha (**Figure 3.2-4**). The potential overlap equates to 1.64% to 5.25% loss of the available winter forage within the RSA (9254 ha). The impacts to static winter forage habitat are restricted to new development in only three of the Landscape Units that make up the RSA (Eliguk A, Eliguk B and Blackwater LU). The upgrades of existing roads do not result in further loss of static habitat as impacts are already realized through the existing development. The potential impact is more accurately represented by potential overlap with the Project within those affected Landscape Units. The potential overlap within affected Landscape Units ranges from 3.13% to 10.03% loss of the available static winter forage within the affected Landscape Units (4842 ha).

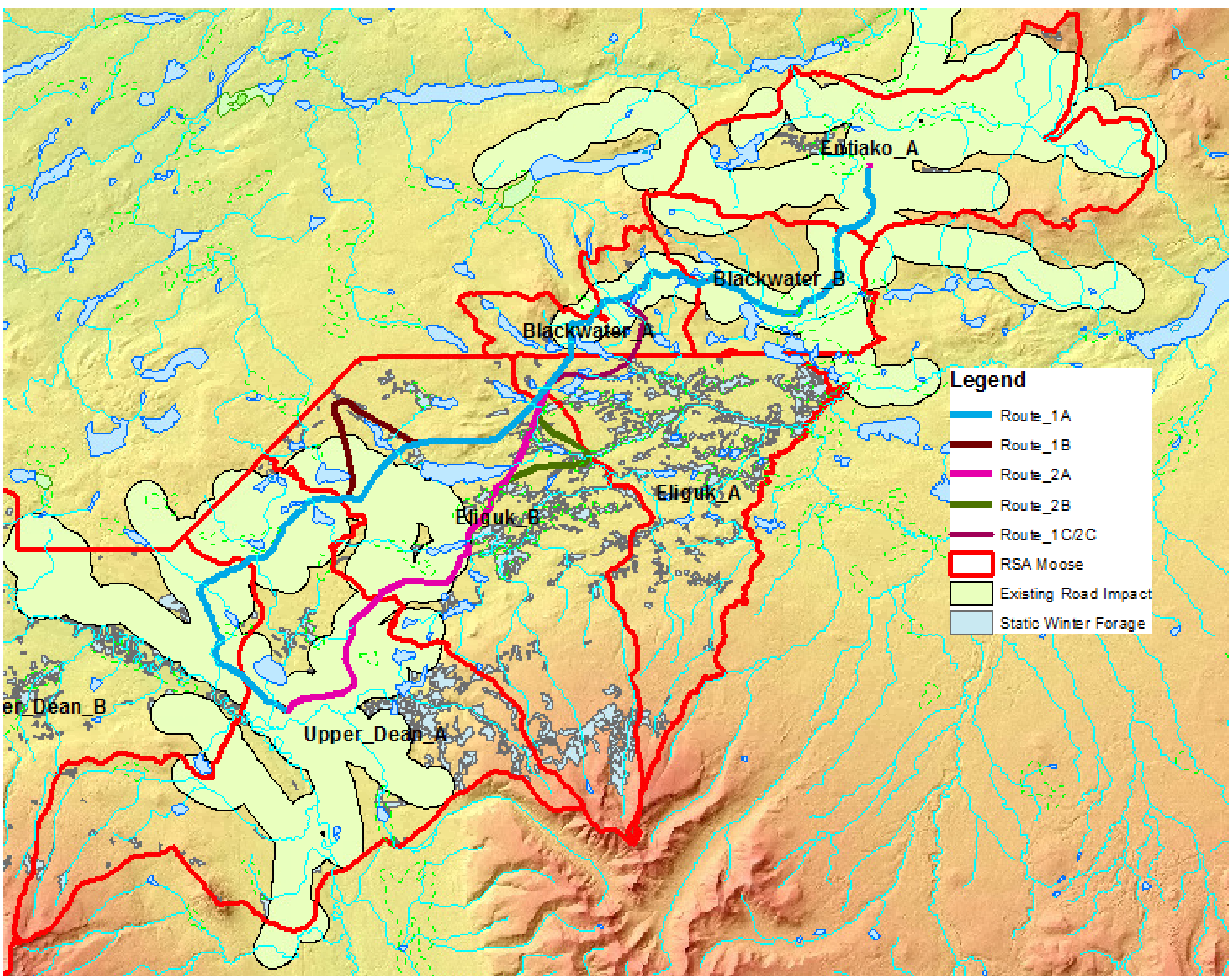

Figure 3.2-4: Static winter forage habitat available within the RSA. Figure illustrates areas previously impacted through existing road development.

Table 3.2-2: Overlap of project components with Static Winter Forage habitat.

	Project Component	Static Winter Forage Habitat Loss (ha)	% of Static Winter Forage Habitat impacted within the RSA	% Static Winter Forage Habitat impacted within Affect Landscape Units
LSA	1A	151.43	1.64	3.13
	1A + 1B	185.94	2.01	3.84
	1A + 1C	271.78	2.94	5.61
	2A	365.19	3.95	7.54
	2A + 2B	478.98	5.18	9.89
	2A + 2C	485.53	5.25	10.03

The amount of shelter habitat within the Project area varies depending on the route selected, ranging from 1804 ha to 2697 ha (**Figure 3.2-5**). The potential overlap equates to 2.19% to 3.35% loss of available shelter habitat within the RSA (82,268 ha). The impacts to shelter habitat are restricted to only 2 Landscape Units that make up the RSA. The upgrades of existing roads do not result in further loss of shelter habitat as impacts are already realized through the existing development. The potential impact is more accurately represented by the potential overlap with the Project within the affected Landscape Units. The potential overlap within the affected Landscape Units ranges from 6.73% to 10.3% loss of the available shelter habitat within the affected Landscape Units (26,789 ha).

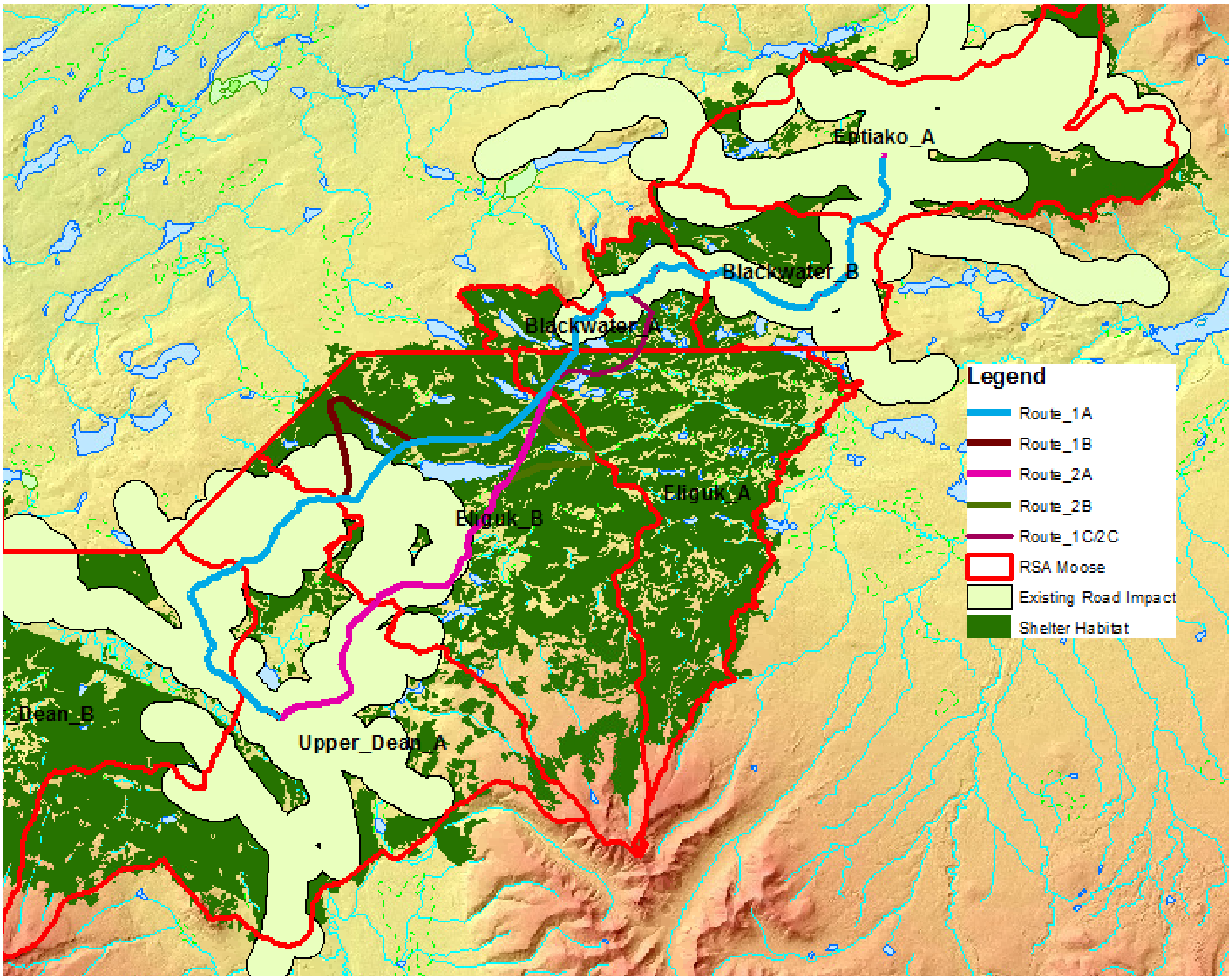

Figure 3.2-5: Shelter habitat available within the RSA. Figure illustrates areas previously impacted by road development.

Table 3.2-3: Overlap of project components with Shelter habitat.

	Project Component	Shelter Habitat Loss (ha)	% of Shelter Habitat impacted within the RSA	% of Shelter Habitat impacted within the Affected Landscape Units
LSA	1A	355.86	2.32	7.12
	1A + 1B	374.65	3.35	10.3
	1A + 1C	377.77	3.28	10.07
	2A	250.25	2.19	6.73
	2A + 2B	272.63	2.92	8.95
	2A + 2C	272.16	3.15	9.67

3.2.3.2.2 Mortality Risk

Mortality risk was assessed based on amount of early seral habitat and road density. Early seral habitat and road density were used a proxies for direct and indirect mortality. The risk assessment is limited by the information available. The effects of creating access into previously un-accessed may not be well represented by this assessment; therefore there remains a degree of uncertainty regarding mortality risk. Changes in early seral habitat and road density are provided in **Table 3.2-4** and **Table 3.2-5**, respectively.

The amount of early seral habitat within the affected Landscape Units ranges from 6.83% to 33.72% without the Project. All proposed routes considered for the Project will result in additional early seral habitat from the clearing of the right-of-way. In all scenarios, the increase in early seral directly attributed to the Project is a difference of <1% from baseline.

The Project will result in the construction of new road. The new road segments will contribute to increases in road density. Because of the length of the new potential segment, the increases in road density range from 0.01km/km^2 to 0.05km/km^2.

Table 3.2.4: Early seral habitat within the Project assessment area and potential change as a result of the Project

Landscape Unit	% Early Seral without the Project	% Early Seral with Route **1A**	% Early Seral with Route **1B**	% Early Seral with Route **1C**	% Early Seral with Route **2A**	% Early Seral with Route **2B**	% Early Seral with Route **2C**
Blackwater	8.65	9.43	9.43	9.41	9.43	9.43	9.41
Eliguk A	6.84	6.93	6.93	7.03	6.92	6.93	7.02
Eliguk B	8.96	9.17	9.28	9.17	9.26	9.34	9.26
Entiako	18.85	18.88	18.88	18.88	18.88	18.88	18.88
Upper Dean A	33.72	33.83	33.83	33.83	33.75	33.75	33.75
Upper Dean B	31.45	31.51	31.51	31.51	31.45	31.45	31.45

Table 3.2.5: Road Density within the Project assessment area and potential change as a result of the Project.

Landscape Unit	Road density without the Project Km/km^2	Road density with Route **1A** Km/km^2	Road density with Route **1B** Km/km^2	Road density with Route **1C** Km/km^2	Road density with Route **2A** Km/km^2	Road density with Route **2B** Km/km^2	Road density with Route **2C** Km/km^2
Blackwater	0.37	0.38	0.38	0.40	0.38	0.38	0.40
Eliguk A	0.33	0.35	0.35	0.37	0.35	0.35	0.37
Eliguk B	0.29	0.34	0.36	0.34	0.31	0.33	0.31
Entiako	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Upper Dean A	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Upper Dean B	0.29	0.29	0.29	0.29	0.29	0.29	0.29

3.2.4. Mitigation Measures

Potential measures that could be applied to avoid, minimize, or restore onsite that would attribute to a reduction in the residual effects are available within the *Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (MFLNRO, 2014) and are summarized in **Table 3.2-6**.

The Project will impact moose habitat and mortality risk. At a landscape level the impacts are unavoidable; however, route selection may mitigate some potential effects of the road at a site specific level by avoiding sensitive areas.

The second level in the mitigation hierarchy is to minimize. Measures to minimize the effects should consider the scope, scale and duration of the impacts. Mitigation measures include considerations for location and road design. Route 1A represents the greatest opportunity to minimize site specific impacts to moose forage habitat, while Route 2 impacts less shelter habitat. Other measures for minimizing impact may exist depending on road design. If the road is designed as fire egress only, narrower clearing width and slow speeds could be included in the design. Slower speeds would help reduce the potential direct and indirect mortality risks associated with the road from hunting and vehicle collision. Additionally, not ploughing the road during the winter would reduce the effects on moose. If the road is designed to higher standard and for year-round use, opportunities to minimize the effects through design are minimal and risks to all wildlife values are significantly higher.

The final levels of the mitigation hierarchy are measures for restoration on-site and offsets to address direct or indirect impacts remaining after mitigation measures to avoid and minimize are applied. Examples that may be considered include, planting of non-palatable species. As the road would be permanent, restoration opportunities are limited to areas disturbed to facilitate construction and will not fully mitigate the effects; therefore, offset would be the concluding measure for mitigating the effects of the road if deemed necessary.

Table 3.2-6: Recommended mitigation measures to reduce effects of the Project on habitat and mortality risk.

Phase	Mitigation		
	Avoid	**Minimize**	**Restore On-site**
Pre-Construction (pre-clearing, design. Surveying)	• During final route design avoid key features such as mineral licks, wallows and trails.	• Select the route that results in the least impact to forage and shelter habitat. • Select the route that results in the least impact to mortality risk. • Design crossings to avoid disrupting natural drainage patterns and ground water. • Minimize potential speeds and footprint to limit sensory disturbance	• Develop an Erosion and Sediment Control plan • Develop a Construction Environmental Management Plan with considerations for revegetation
Construction (Clearing, grading, post-construction reclamation)	• Avoid construction during the critical period of May 15th to July 15th.	• Maintain visual screening (forested cover) around key features and static forage habitat. • Minimize clearing of vegetation in areas adjacent to the footprint • Plant native, non-palatable species within disturbed area..	• Prevent the establishment of invasive species by re-vegetating disturbed areas.
Operation	• Restrict winter use	• Reduce speeds • Manage access to limit traffic and reduce sensory disturbance • Implement dust control,	

		including water roads and avoiding use of road salts for dust control during the summer and winter • Provide breaks in snow banks to allow wildlife escape • Establish a motor vehicle hunting closed area	

3.2.5. Characterization of the Residual Effects

With consideration of potential mitigation measures to avoid, minimize and restore on-site there will be a residual effect on moose. Residual effects on moose are characterized in terms of context, duration, frequency, reversibility, consequence and probability (**Table 2.2**). Characterization in terms of magnitude specific to moose is provided in **Table 3.2-7**.

Table 3.2-7: Characterization of magnitude for moose

Characterization	Description	Quantitative Measure
Magnitude	Assessed size or severity of the impact. Measured as the amount of change in a variable relative to baseline	Negligible – effects are not measurable Low – A measurable change but within the range of expected natural variation Medium – A measurable change but less than high High[1] – a >20% change from current condition

The risks of the proposed Project on moose habitat are rated as **low to moderate** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to moose experiencing decline within the assessment area and the species being affected by other landscape changes. The magnitude of the loss is rated as low to medium, depending on route selection, because additional high value forage and shelter habitat exist within the affected Landscape Units. The potential changes to forage and shelter habitat from baseline ranges in a loss of 3 to 10% of the available habitat within the affected Landscape Units. The loss of habitat will occur once during the Construction phase and the loss would be permanent. The probability of an effect is high.

The risks of the proposed Project on moose mortality risk are rated as **low** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to moose experiencing decline within the assessment area and the species being affected by other road development and landscape changes. The magnitude of the loss is rated as low because the potential changes to road density and the amount of early seral habitat. The potential change ranges from 1 to 3% change from baseline within the affect Landscape Units. The increase in road density will occur during the Construction phase but the effects will be persistent through Operation. The addition to road density will be permanent; however, roads within the affected Landscape Units may not be permanent. The probability of an effect is high. The increase in early seral

[1] A threshold of 20% change is a general approach supported in past Environmental Assessment under the *Environmental Assessment Act*.

habitat will occur during the Construction phase with effects persistent through Operation. The addition to early seral habitat will be permanent; however, the amount of early seral will change over time as a result of disturbed areas regenerating.

3.2.6. Cumulative Effect Assessment

The proposed Project would result in a residual effect to moose habitat and mortality risk. The effects of the project will interact with impacts from past and present projects.

At a landscape level, the effects assessment on moose is focused on ecological importance, hazards, and current mitigation. Ecological importance looks at the abundance of all capable moose winter habitat within the assessment area. Hazards looks at the level of impact by roads and forest cover reduction to highly suitable moose winter habitat (forage habitat and the adjacent shelter habitat). Current mitigation focuses on the amount of high suitability moose habitat with legal harvesting constraints as a measure of risk of future activity.

3.2.6.1 Assessment Results

The majority of the assessment area has some level of moose winter habitat, although areas of moderate and higher capability are limited to a few small areas. The Upper Dean sub-units are assessed as high for moose ecological importance as the unit has 85% and 76% capable moose winter habitat with small areas of moderate and high capability habitat. The Eliguk A and B, Blackwater and Entiako LUs are assessed as moderate for ecological importance with 82% and 72%, 74% and 45%, respectively, as capable habitat, with several areas of moderate capability habitat.

In the absence of the proposed Project, the hazards or likelihood of effects are considered low across portions of the assessment area, as a result of low harvesting and road construction rates. However, within a portion of the Upper Dean LU the road disturbance of suitable habitat is 44%. With the Blackwater and Entiako LUs the road disturbance of suitable habitat is 50% and 82% respectively. With additional consideration of natural disturbance across the assessment area, the likelihood of effects on moose habitat increases due to reductions of thermal and security cover and a lag in suitable habitat post-wildfire and impacts from Mountain Pine Beetle.

Mitigation is in place that influences future activities within the affected LUs. Tweedsmuir Provincial Park and Itcha Ilgachuz Provincial Park offers protection to moose habitat. Additionally some areas of caribou “no harvest” and “modified harvest” protections overlap with a portion of the Upper Dean LU, Eliguk LUs and Entiako LU; however, much of the mitigation does not overlap moose capable habitat as caribou utilize different ecosystems.

3.2.7. Characterization of Residual Cumulative Effects

Residual cumulative effects on moose are characterized in terms of context, duration, frequency, reversibility, consequence and probability (**Table 2.2**). Characterization in terms of magnitude specific to moose is provided in **Table 3.2-8**.

Table 3.2-8: Characterization of magnitude for moose

Characterization	Description	Quantitative Measure
Magnitude (habitat)	Assessed size or severity of the impact. Measured as the amount of change in a variable relative a undisturbed landscape	Negligible – effects are not measurable Low – A measurable change but within the range of expected natural variation Medium – A measurable change but less than high High – a >20% change from capable habitat

The risks of the cumulative effects on moose habitat are rated as **High** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to moose experiencing decline within the assessment area and the species being affected by other landscape changes. The magnitude of the loss is rated as medium to high because forage and shelter habitat, within the affected LUs, have experienced adverse impacts through previous road development, fire, insect and forest harvesting. The cumulative effect to winter forage habitat ranges in a loss of 2 to 82% impact of the suitable habitat from existing road disturbance within the affected LUs. The highest levels of cumulative effect occur in LUs with current road access and harvesting. The proposed alignment would utilize existing roads, where possible, within many of these affected LUs limiting the addition of new impacts to LUs with low existing impacts. The addition of new road will be permanent; however, roads within the affected LUs may not be permanent. The probability of an effect is high.

3.2.8. Conclusions

The potential site level risks of the project on moose is considered **Moderate** with the project's contribution to cumulative effects considered low; however, the existing cumulative effects from road disturbance are considered **High** in several of the LU. Additionally, the construction of new access will likely pose an increased risk of further development that would contribute to additional impacts. Future forest harvesting, facilitated by the new access, would increase the impacts to moose habitat and mortality risk, and contribute further to cumulative effects. Because of the existing cumulative effects, additional mitigation should be considered to mitigate existing impacts to moose. Deactivation and/or rehabilitation of roads within the affected LUs will contribute to reducing the cumulative effects on moose.

3.3. Grizzly Bear

Provincially, grizzly bear are Blue-listed, or considered to be of Special Concern. Species considered of Special Concern are sensitive or vulnerable to human activities or natural events. Grizzly bear are federally listed under Schedule 1 of the *Species at Risk Act* as Special Concern.

The Vanderhoof Land and Resource Management Plan and the Cariboo Chilcotin Land Use Plan identify grizzly bear as a highly valued species. Both plans identify objectives for the protection and maintenance of sufficient quantity and quality of habitat for grizzly bear to maintain healthy populations.

Grizzly bear were selected as a value because they are year-round residents within the Project area and because of their ecological and social importance.

3.3.1. Assessment Boundary

Two geographic boundaries, as shown in **Figure 3.3-1**, were used to evaluate the effects of the Project on grizzly bear. The assessment boundary encompasses a LSA and RSA.

The LSA includes a 1 kilometer buffer on either side of the road centerline, which accounts for both the direct and indirect effects of the project. The LSA is limited to the portions of the Project resulting in new or upgraded road, and does not include existing infrastructure.

The boundary of the RSA is identified as the affected Landscape Unit specified within the BC Data Catalogue (Government of BC, 2018). A landscape unit is generally based on ecologically similar areas and drainages in consideration of natural disturbance regimes. The LU range from about 30,000 to 70,000 ha in area, with larger units in the plateau areas and smaller units in more mountainous terrain. The range in size recognizes the natural variability among home range sizes for wildlife species.

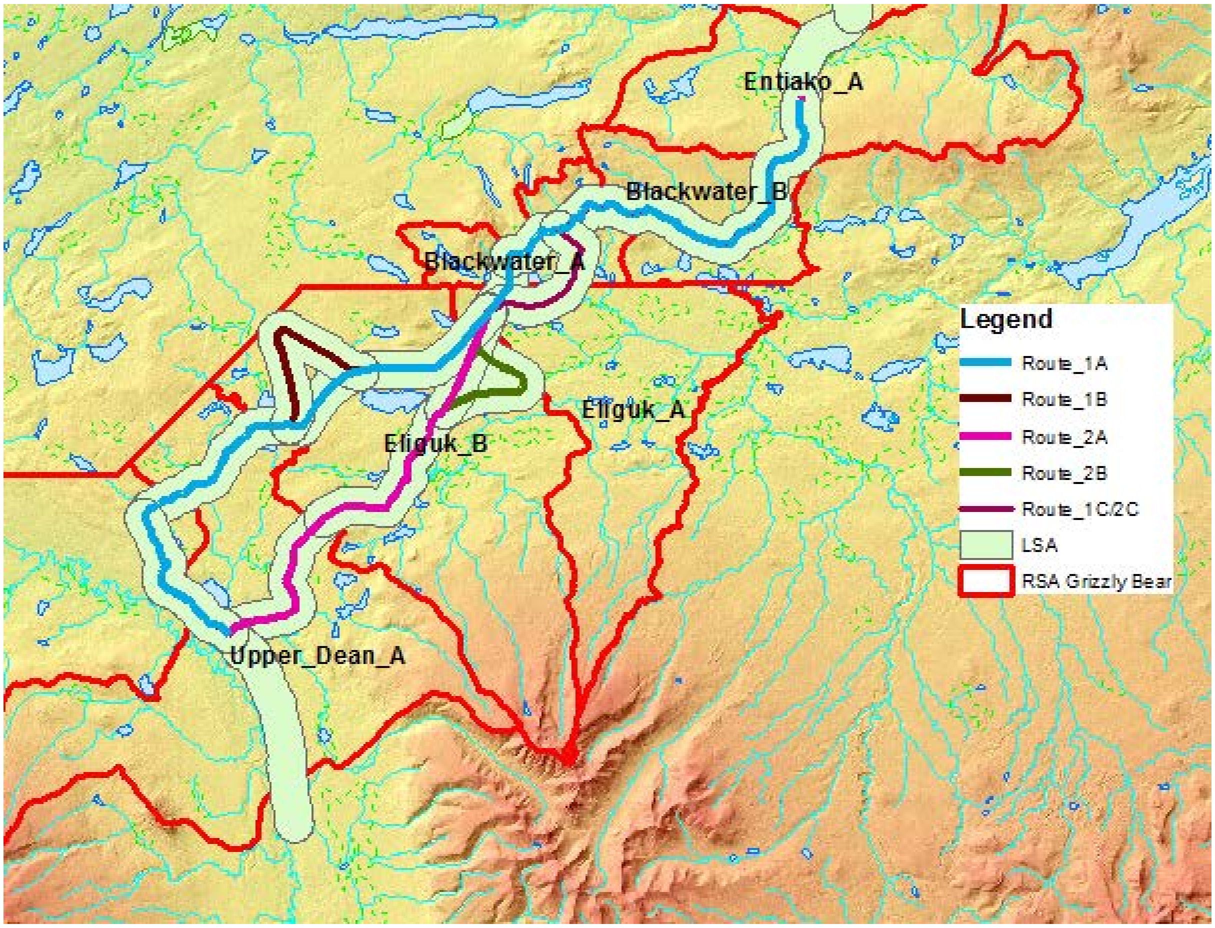

Figure 3.3-1: Local Study Area and Regional Study Area for Grizzly Bear assessment.

3.3.2. Population

The current grizzly bear population estimate within the Blackwater-West Chilcotin Grizzly Bear Population Unit (GBPU) is 53 bears. The Blackwater-West Chilcotin GBPU is considered threatened, with a population estimate that is less than 50% of the estimated carrying capacity (Ministry of Forests, Lands and Natural Resource Operations 2012).

There has never been a density estimating grizzly bear inventory (DNA mark-recapture) within the Blackwater-West Chilcotin GBPU. The current population estimate is based on a predictive population density model developed for the Province in 2012. The population modelling was supplemented with expert opinion of local biologists.

The predictive model was developed using grizzly bear inventories completed within BC, as well as other inventories from across North America, to determine which variables best predict bear abundance across different landscapes. The interior grizzly bear model incorporates seven variables, including indexes of productivity, climate, and human use, to predict bear density within each GBPU in which mark-recapture inventories are not available (Mowat et al. 2013).

Habitat and habitat conditions for grizzly bear within the Project area is characterized in the following sections as part of the assessment and cumulative effects assessment.

3.3.3. Potential Effects

The following section speaks to the potential effects of the Project on grizzly bear during construction and operation phases.

The assessment considers the following:

- Impacts to core security habitat,
- Mortality risk through increased access and indirect mortality of grizzly bear through increased collision, non-regulated hunting and human wildlife conflict.

3.3.3.1 Assessment Approach

A quantitative assessment was completed to determine the effects of the Project and associated risks.

Core security habitat is identified as areas of capable habitat, greater than $10km^2$. The assessment looks at impacts to existing core security habitat that may be lost or altered as a result of the project.

Studies have found that most grizzly bear death occur within 500m of an active road. Roads provide access for unregulated hunting, risk of collision and increased risk with human wildlife conflict. As road density increases, mortality risk increases. Road density is used as a surrogate of mortality risk and was calculated based on km of road per km^2 of area.

3.3.3.2 Assessment Results

3.3.3.2.1 Core Security Habitat

The potential overlap of the Project with core security habitat is provided in **Table 3.3-1** and **Figure 3.3-2.**

The amount of core security habitat within the Project area varies depending on the route selected, ranging from 2277 ha to 3349 ha. The potential overlap equates to 0.8 % to 1.6% loss of the available core security habitat within the RSA (269,861 ha). Indirect effects are expected from the proposed Project as the new access would bisect areas of core security habitat which would render portions of intact habitat ineffective due to the remaining size.

Table 3.3-1: Overlap of project components with core security habitat.

	Project Component	Core Security Habitat Direct Loss (ha)	Indirect Loss of Core Security Habitat (ha)	% Change within Affect Landscape Units
LSA	1A	2801.15	532.03	1.24
	1A + 1B	3230.08	703.65	1.46
	1A + 1C	3348.82	1167.86	1.67
	2A	2277.63	0	0.84
	2A + 2B	2996.36	0	1.11
	2A + 2C	2821.47	596.86	1.27

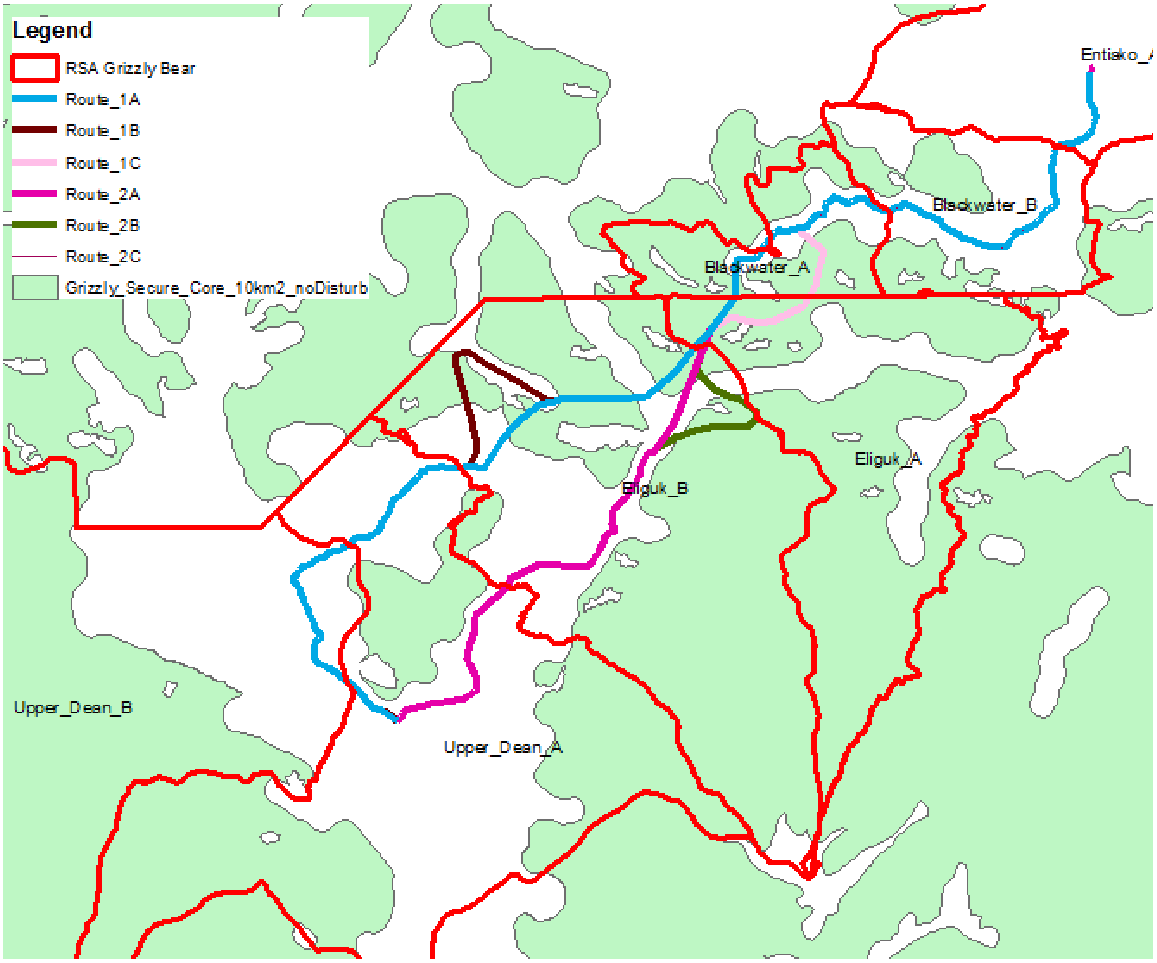

Figure 3.3-2: Core security habitat in proximity to the proposed routes.

3.3.3.2.2 Mortality Risk

Mortality risk was assessed based on road density. Road density was used a proxy for direct and indirect mortality. The risk assessment is limited by the information available. The effects of creating access into previously un-accessed may not be well represented by this assessment; therefore there remains a degree of uncertainty regarding mortality risk. Changes in road density are provided in **Table 3.3-2**.

The project will result in the construction of new road. The new road segments will contribute to increases in road density. Because of the length of the new potential segment, the increases in road density range from 0.01km/km^2 to 0.05km/km^2.

Table 3.3.2: Road Density within the Project assessment area and potential change as a result of the Project.

Landscape Unit	Road density without the Project Km/km²	Road density with Route **1A** Km/km²	Road density with Route **1B** Km/km²	Road density with Route **1C** Km/km²	Road density with Route **2A** Km/km²	Road density with Route **2B** Km/km²	Road density with Route **2C** Km/km²
Blackwater	0.37	0.38	0.38	0.40	0.38	0.38	0.40
Eliguk A	0.33	0.35	0.35	0.37	0.35	0.35	0.37
Eliguk B	0.29	0.34	0.36	0.34	0.31	0.33	0.31
Entiako	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Upper Dean A	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Upper Dean B	0.29	0.29	0.29	0.29	0.29	0.29	0.29

3.3.4. Mitigation Measures

Potential measures that could be applied to avoid, minimize, or restore onsite that would attribute to a reduction in the residual effects are available within the *Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (MFLNRO, 2014) and are summarized in **Table 3.3-3**.

The Project will impact grizzly bear habitat and mortality risk. At a landscape level the impacts are unavoidable; however, route selection may mitigate some potential effects of the road at a site specific level by avoiding sensitive areas. Additionally avoidance of sensitive periods during construction may mitigate effects.

The second level in the mitigation hierarchy is to minimize. Measures to minimize the effects should consider the scope, scale and duration of the impacts. Mitigation measures include considerations for location and road design. All route options will result in minor impacts to core security habitat; however, route 2A results in the least impact. All route options result in an insignificant increase in road density, with option 1A and 2A resulting in the least potential increase across affected Landscape Units. Other measures for minimizing impact may exist depending on road design. If the road is designed as fire egress only, slow speeds and minimized line of sights could be included in the design. Slower speeds and minimized line of sight would help reduce the potential direct and indirect mortality risks associated with the road. If the road is designed to higher standard and for year-round use, opportunities to minimize the effects through design are minimal and risks to all wildlife values are significantly higher. Additionally, prior to construction, preclearing survey of the route should be completed in order to identify areas of high value forage sites, potential denning, mark trails, mark trees and wallows. Final design should avoid potential impacts to these critical features by maintaining wind firm vegetative screening between the road and the key feature. Timing of construction can be adapted to accommodate grizzly bears using key features (**Table 3.3-4**)

The final levels of the mitigation hierarchy are measures for restoration on-site and offsets to address direct or indirect impacts remaining after avoid and minimize mitigation measures are applied. Examples that may be considered include, planting of non-palatable species. As the road would be permanent, restoration opportunities are limited to areas disturbed to facilitate construction but will not fully mitigate the effects; therefore, offset would be the concluding measure for mitigating the effects of the road if deemed necessary.

Table 3.3-5: Recommended mitigation measures to reduce effects of the Project on habitat and mortality risk.

Phase	Mitigation		
	Avoid	**Minimize**	**Restore On-site**
Pre-Construction (pre-clearing, design. Surveying)	• During final route design avoid key features such as forage sites, denning sites, mark trails, mark trees and wallows.	• Select the route that results in the least impact to mortality risk and core security habitat. • • Minimize potential speeds and footprint to limit sensory disturbance	• Develop a Construction Environmental Management Plan with considerations for revegetation
Construction (Clearing, grading, post-construction reclamation)	• Time construction to minimize disturbance to grizzly bears using key features identified	• Maintain wind firm visual screening (forested cover) around key features. • remote camps shall follow best practices for design to minimize human bear conflict • Minimize clearing of vegetation in areas adjacent to the footprint. • Plant native, non-palatable species within disturbed area.	• Prevent the establishment of invasive species by re-vegetating disturbed areas.
Operation		• Reduce speeds • Manage access to limit traffic and reduce sensory disturbance • Promptly remove attractant such as carrion • Establish a motor vehicle hunting closure area	

Table 3.3-4: Risk timing window for grizzly bears based on key features.

Key Feature	Timing of Use
Early spring foraging	April through mid-June
Summer foraging (high elevation)	June through August
Fall foraging (Salmonid)	Mid-August through October
Berry foraging	July through October
Winter denning	October through end of winter (March to May)

3.3.5. Characterization of the Residual Effects

With consideration of potential mitigation measures to avoid, minimize and restore on-site there will be a residual effect on grizzly bear. Residual effects on grizzly bear are characterized in terms of context, duration, frequency, reversibility, consequence and probability (**Table 2.2**). Characterization in terms of magnitude specific to grizzly bear is provided in **Table 3.3-5**.

Table 3.3-5: Characterization of magnitude for moose

Characterization	Description	Quantitative Measure
Magnitude	Assessed size or severity of the impact. Measured as the amount of change in a variable relative to baseline	Negligible – effects are not measurable Low – A measurable change but within the range of expected natural variation Medium – A measurable change but less than high High – a >20% change from baseline

The risks of the proposed Project on grizzly bear habitat are rated as **Low** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to grizzly bear being a blue-listed species and considered sensitive to human disturbance. The magnitude of the loss is rated as low because additional core security habitat exists within the affected LUs. The potential changes to core security habitat from baseline ranges in a loss of 0.8% to 1.6% loss of the available core security habitat within the affected LUs. The loss of core security habitat will occur once during the Construction phase and the loss would be permanent. The probability of an effect is high.

The risks of the proposed Project on grizzly bear mortality risk are rated as L**ow** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to grizzly bear being a blue-listed species and considered sensitive to human disturbance. The magnitude of the change is rated as low because of the amount of the potential changes to road density. The potential change ranges from 1 to 3% change from baseline within the affected LUs. The increase in road density will occur during the Construction phase but the effects will be persistent through Operation. The probability of an effect is high.

3.3.6. Cumulative Effect Assessment

The proposed Project would result in a residual effect to grizzly bear habitat and mortality risk. The effects of the project will interact with impacts from past and present projects.

At a landscape level, the effects assessment on grizzly bear is focused on landscape effects to habitat effectiveness, security habitat and mortality risk. The assessment of effective habitat looks at the amount of capable habitat netted down based on overlap with roads. The assessment of security habitat looks at the amount of capable habitat in roadless areas >10km^2. Mortality risk is reported as a road density of km/km^2.

3.3.6.1 Assessment Results

Effective habitat looks primarily at the displacement risk resulting in bears not being able to make full use of valuable habitat. For the Eliguk sub-units habitat effectiveness risks are low, with the amount of effective habitat overlapping with all capability classes (class 1-5) being 85% and 84% respectively. For the Upper Dean sub-unit A, the amount of effective habitat that overlaps with all capability classes (1-5) is 70%. For the Blackwater LU, the amount of effective habitat that overlaps with all capability classes is 51%. For the Entiako LU, the amount of effective habitat that overlaps with all capability classes is 64%.

The second indicator assesses the proportion of capable habitat in road-less areas greater than 10km^2 which reflect changes in mortality risk as a result of road access. The Eliguk A and B sub-units are rated as low risk with 75% and 71% respectively of the capable habitat falling within secure core areas. The Upper Dean A sub-unit has 52% of all capable (class 1-5) habitats overlapping with secure core areas. The Blackwater LU and Entiako LUs are rated as high risk with 35% and 49% of all capable habitat overlapping core security areas. The proposed road options (1 and 2) overlaps with areas that are not considered secure core because of existing road disturbance. Some areas of the proposed roads would however further reduce secure core areas for grizzly bears through this corridor.

Mortality risk is reflected in **Table 3.3-2**.

3.3.7. Characterization of Residual Cumulative Effects

Residual cumulative effects on grizzly bear are characterized in terms of context, duration, frequency, reversibility, consequence and probability (**Table 2.2**). Characterization in terms of magnitude is provided in **Table 3.3-6** (Interim Assessment Protocol for Grizzly Bear in British Columbia, 2017).

Table 3.3-6: Characterization of magnitude for grizzly bear

Characterization	Description	Quantitative Measure
Magnitude (habitat effectiveness)	Assessed size or severity of the impact. Measured as the amount of change in a variable relative a undisturbed landscape	Negligible – effects are not measurable Low – A measurable change but within the range of expected natural variation Medium – A measurable change but less than high High – a >20% change from capable habitat
Magnitude (security habitat)	Assessed size of severity of the impact. Measure as the amount of change in a variable relative to undisturbed landscape.	Negligible – effects are not measurable Low – >60% core security habitat available within affected LUs High – <60% core security habitat available within affected LUs
Magnitude (mortality risk)	Assessed size of severity of the impact. Measure as the amount of change in a variable relative to undisturbed landscape.	Negligible – effects are not measurable Low – road density <0.3 km/km2 Medium – road density >0.3km/km2 and <0.6km/km^2 High – road density >0.6km/km^2

The risks of the cumulative effects on grizzly bear habitat are rated as **High** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to grizzly bear experiencing decline within the assessment area and the species being affected by other landscape changes. The magnitude of the loss is rated as medium to high because habitats within the affected LUs have experienced adverse impacts through previous road development. The cumulative effect to capable habitat ranges in a 15 to 49% loss of effective habitat within the affected LUs. The highest levels of cumulative effect occur in LUs with current road access and harvesting.

The risks of the cumulative effects on grizzly bear core security habitat are rated as **High** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to grizzly bear experiencing decline within the assessment area and the species being affected by other landscape changes. The magnitude of the loss within affected LUs ranges from Low to High because core security habitat has experienced adverse impacts through previous road development, fire and forest harvesting. Within the affected LUs, the cumulative effect to core security habitat has resulted in the available security habitat ranging from 35 to 75%. The highest levels of cumulative effect occur in LUs with current road access and harvesting.

The risks of the proposed Project on grizzly bear mortality risk is rated as **Moderate** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a moderate context due to the status of grizzly bear within the assessment area and the species being affected by other road development and landscape changes. The magnitude of the effect within the affected LUs varies from low to high because of the changes to road density. Road density within the affected LUs ranges from 0.29 to 0.65km/km^2, with the majority of the effected LUs considered to have a magnitude characterized as medium (road density >0.3km/km^2 but <0.6km/km^2). The increase in road density will occur during the Construction phase but the effects will be persistent through Operation. The addition to road density will be permanent; however, roads within the affected LUs may not be permanent. The probability of an effect is high.

3.3.8. Conclusions

The potential site level risks of the project on grizzly bear is considered **Low** with the Project's contribution to cumulative effects considered low; however, the existing cumulative effects exceed biological thresholds for grizzly bears, in some LUs, even in the absence of the Project which results in a **High** risk to grizzly bear under current conditions. Additionally, the construction of new access will likely pose an increased risk of further development that would contribute to additional impacts. Future forest harvesting, facilitated by the new access, would increase the impacts to core security habitat and mortality risk, and contribute further to cumulative effects. The development of new access may result in increased hunting and recreation which will increase the risk of human-bear conflict or non-licenced hunting. Because of the existing cumulative effects, additional mitigation should be considered, if there is a decision to construct the road, to mitigate existing impact to grizzly bear. Opportunities to deactivate and/or rehabilitate roads or reduce road densities within the affected LUs will contribute to reducing the cumulative effects on grizzly bears.

3.4.Watershed Health

Road development has the potential of impacting hydrological processes which influence peak flows, erosion, and degraded riparian zones. Impacts on hydrological processes may have impacts to fish and other species that may be utilizing the watershed. Surveys conducted throughout the assessment area have identified spawning and rearing rainbow trout in streams within the affected watersheds. If a road is constructed, habitat associated with proposed stream crossings should be assumed to provide critical spawning and rearing functions unless proven otherwise. Historical surveys have verified the presence of rainbow trout, bull trout, northern pikeminnow and suckers within the assessment area.

3.4.1. Assessment Boundary

Two geographic boundaries, as shown in **Figure 3.4-1**, were used to evaluate the effects of the Project on watershed health. The assessment boundary encompasses a LSA and RSA.

The LSA includes a 1 kilometer buffer on either side of the road centerline, which accounts for both the direct and indirect effects of the project. The LSA is limited to the portions of the Project resulting in new or upgraded road, and does not include existing infrastructure.

The boundary of the RSA is identified as the affected sub-basin and 3rd order watershed specified within the BC Data Catalogue (Government of BC, 2018).

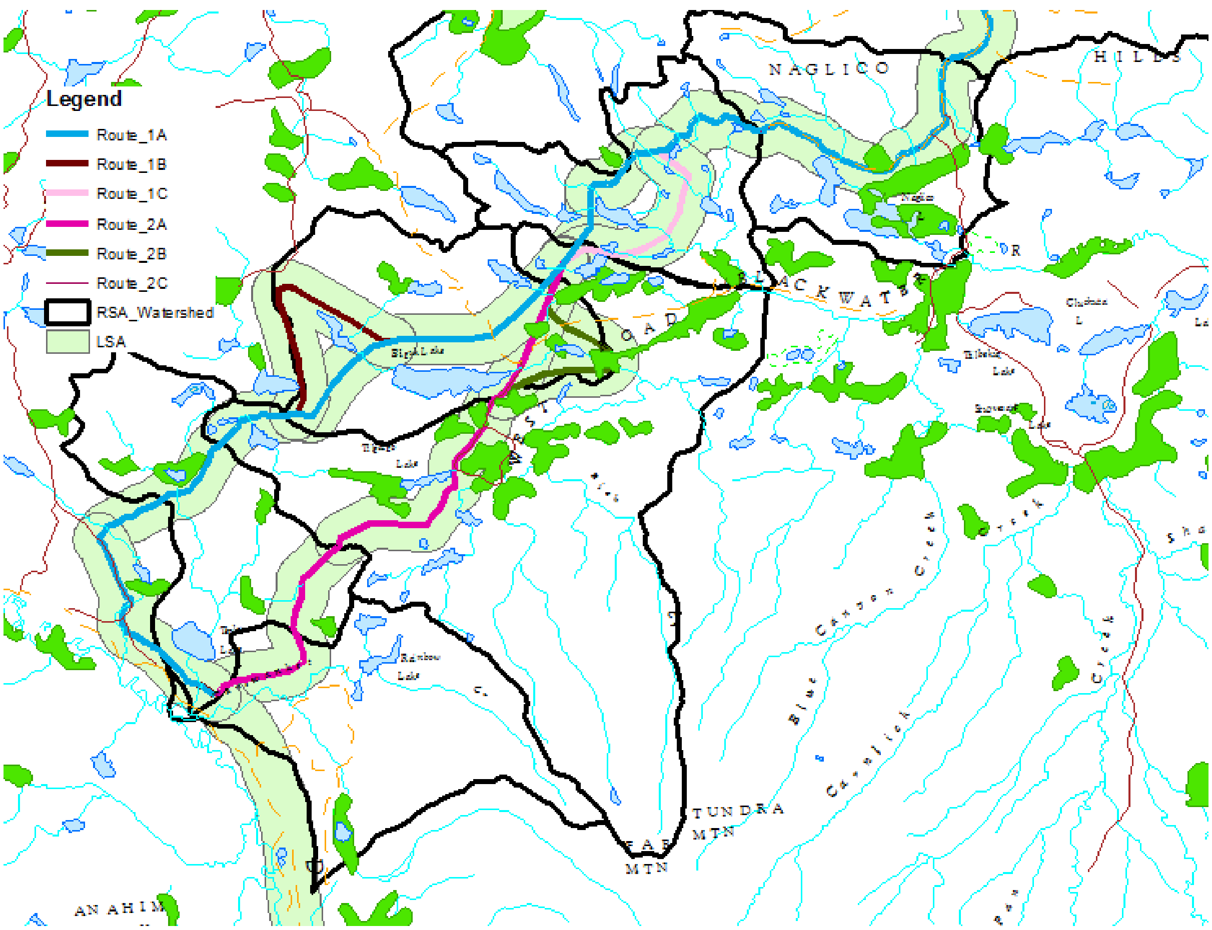

Figure 3.4-1: Assessment boundary for watershed health assessment.

3.4.2. Potential Effects

Several indicators are used to evaluate the current state of a watershed. For the purpose of this assessment at the LSA, road density and stream crossing density are reported, as they are directly influenced by the construction of a new road.

3.4.2.1 Assessment Approach

An increase in road density increases the amount of exposed materials vulnerable to erosion, while potentially increasing peak flows because of presence of hardened surfaces. Road density is calculated as km/km^2. Road densities below $0.6 km/km^2$ are considered low risk, while densities between 0.6-$1.2 km/km^2$ are considered moderate risk (Interim Assessment Protocol for Aquatic Ecosystems in British Columbia, 2016).

Stream crossings are potential points of sedimentation. Crossing density is reported as the number of $crossings/km^2$ based on crossing identified in TRIM. A crossing density of less than $0.16/km^2$ is considered low risk (Interim Assessment Protocol for Aquatic Ecosystems in British Columbia, 2016).

3.4.2.2 Assessment Results

Road densities have been calculated for both moose and grizzly bear in the previous sections. As previously indicated the road density within the Dean, Eliguk and Blackwater LUs are $0.65 km/km^2$, $0.34 km/km^2$ and $0.37 km/km^2$, respectively. As indicated within the assessment approach, as road density increases, risk increases. Based on road density, there is a low to moderate risk to watershed health, depending on LU.

Based on stream information in TRIM and the proposed routes provided for the assessment, the proposed route is in an area of low risk to watershed health from stream crossing density. Any addition stream crossings within the affected watershed would result in the crossing density to remain a low risk.

3.4.3. Mitigation Measures

Potential measures that could be applied to avoid, minimize, or restore onsite that would attribute to a reduction in the residual effects are provided in **Table 3.4-1**.

The Project will have impacts to watershed health. At a landscape level the impacts are unavoidable.

The second level in the mitigation hierarchy is to minimize. Measures to minimize the effects are identified within the Forest and Range Evaluation Program (FREP) extension Note #29 and report #35 and are summarized in Table 3.4-1.

The final levels of the mitigation hierarchy are measures for restoration on-site and offsets to address direct or indirect impacts remaining after avoid and minimize mitigation measures are applied. Examples that may be considered include, re-seeding of disturbed areas as soon as possible. As the road would be permanent, restoration opportunities are limited to areas disturbed to facilitate construction but will not fully mitigate the effects; therefore, offset would be the concluding measure for mitigating the effects of the road if deemed necessary.

Table 3.4-1: Recommended mitigation measures to reduce effects of the Project on habitat and mortality risk.

Phase	Mitigation Measures		
	Avoid	**Minimize**	**Restore On-site**
Pre-Construction (pre-clearing, design. Surveying)	• Avoid constructing roads parallel to riparian features. • Avoid unstable slopes	• install sufficient culverts to minimize flow within ditchlines • Maximize forest-floor buffering to absorb and filter water from the road. • Minimize ditch depth provide more options for safely removing road surface drainage. • Develop an Erosion and Sediment Control Plan	• Develop a Construction Environmental Management Plan with considerations for revegetation
Construction	• Avoid connectivity of runoff with aquatic features	• Minimize the construction footprint	• Re-vegetate disturbed areas as soon as possible.
Operation		• Ensure the use of good-quality road fill and surfacing material • Where the road sub-grade permits, maintain a crowned profile • Ensure grader berms are broken to allow water to leave the road surface	

3.4.4. Characterization of the Residual Effects

With consideration of potential mitigation measures to avoid, minimize and restore on-site there will be a residual effect on watershed health. Residual effects on watershed health are characterized in terms of context, duration, frequency, reversibility, consequence and probability (**Table 2.2**). Characterization in terms of magnitude is provided in **Table 3.4-2** and is based on thresholds from the *Interim Assessment Protocol for Aquatic Ecosystems in British Columbia*.

Table 3.3-5: Characterization of magnitude for moose

Characterization	Description	Quantitative Measure
Magnitude (road density)	Assessed size or severity of the impact. Measured as the amount of change in a variable relative to baseline	Negligible – effects are not measurable Low – <0.6km/km^2 Medium – >0.6km/km^2 but >1.2km/km^2 High – >1.2km/km^2
Magnitude (crossing density)	Assessed size or severity of the impact. Measured as the amount of change in a variable relative to baseline	Negligible – effects are not measurable Low – crossing density <0.16/km^2 High – crossing density >0.16/km^2

The risks of the proposed Project on watershed health are rated as **Low** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a Low context due to the effected watersheds being primarily undisturbed or the new road being located in areas of existing disturbance. The magnitude is rated as Low because the Project's contribution to increased road density ranges from 1-3% from baseline and remains below a medium magnitude, with the exception of a portion of the Dean River LU. Stream crossing density remains below 0.16/km^2. The addition to road density will be permanent; however, roads within the affected Landscape Units may not be permanent. The probability of an effect is high.

3.4.5. Cumulative Effect Assessment

The residual effects of the proposed road will interact cumulatively with past and present projects. The cumulative effects assessment focuses on the Streamflow Hazard and Sedimentation Sensitivity.

Streamflow hazard considers runoff potential, development effect, and runoff attenuation. Runoff potential refers to the likelihood an assessment area is sensitive to forest development so it considers forest cover and precipitation. Assessment areas with high forest cover that is available for harvesting and high snow load are more likely to experience a change in spring peak flows due to development influence on snow accumulation and melt compared to watersheds with limited forest cover and low snow pack levels. Once runoff potential is identified, the amount of development or equivalent clearcut area (ECA) must also be considered. As ECA increases the probability of development influenced changes on runoff also increases. The new roads planned for the area are added to the existing ECA because road construction requires forest clearing. Finally, watersheds will vary in terms of ability to buffer increased streamflow. The drainage density and slope of the watershed determines how effective a watershed is at delivering snowmelt to stream channels. Steeper well-drained systems will deliver snowmelt to a stream channel more efficiently than those with lower drainage density and slopes. In addition, the presence and location of wetlands and lakes lower in the watershed can buffer the peak flow response at the outlet of the watershed assessment area.

Sedimentation hazard is estimated starting with assessment of the inherent sensitivity of the watershed to change in sediment regime as determined by the presence of erodible soils and the coupling of hillslopes to streams. The closer the connection between hillslopes with eroding sediments the higher the likelihood they reach and are transported through the watershed. Roads and stream crossing variables are used to estimate the potential development effect on increasing sediment generation for delivery to streams. As the density of roads, and stream crossing increase the likelihood of sediment reaching streams can also increase. Further, as the proportion of cleared low elevation areas coupled to high slope areas increases there is also increased probability of landslides.

3.4.5.1 Assessment Results

The streamflow hazard for the assessment area is varies across watersheds from Very Low to Moderate. Streamflow hazard is high in the more northern watersheds due to high ECA; however, despite areas of high ECA, lower streamflow hazard scores are related to attenuation from lakes and wetlands within the assessment area, lower stream densities and flatter slopes and terrains.

The sedimentation hazard for the assessment area is considered Very Low based on inherent sensitivity of the watersheds and an assessment of current land use associated with roads close to streams, roads on steep slopes and existing disturbance (harvesting) on gentle slopes immediately above steep slopes.

3.4.6. Characterization of Residual Cumulative Effects

The risks of the cumulative effects on watershed health are rated as **Low** due to the context, magnitude, duration, frequency, reversibility and probability. The effects are considered to have a Low context due to the effected watersheds being primarily undisturbed or the new road being located in areas of existing disturbance. The magnitude is rated as Very Low to Low because of existing disturbance and attenuation, lower stream density and flatter slope and terrains within the watersheds. The addition of the new road will be permanent; however, roads and other disturbances within the affected LUs may not be permanent. The probability of an effect is high.

3.4.7. Conclusions

The potential risks of the Project on watershed health are considered **Low** with the Project's contribution to cumulative effects considered low. Attenuation and watershed sensitivity maintain the hazards within the affected watersheds at a Low rating. However, the construction of new access may have indirect effect on fisheries values within the area. Increased access may result in increased recreational fisheries and potential exploitation of fisheries values in the area. Fisheries information for the project area is incomplete, and should be assessed prior to constructing access.

4. Limitations

The information and conclusions provided within this report are limited by the information available at the time of preparing. No field assessments were conducted in support of the assessment; rather the assessment was conducted based on existing information and spatial analysis. The assessment was conducted based on the alignment provided, which may not be representative of the actual alignment. Therefore there is uncertainty on the direct effects of the project at a site level. Assessments are recommended at road layout or pre-clearing in order to identify sensitive features and allow incorporation of mitigation measures.

5. Monitoring and Adaptive Management

Should a route be approved for construction, a comprehensive Monitoring Plan should be developed. A Monitoring Plan should identify methods for monitoring implementation of mitigation measures and effectiveness of measures used. Within the plan there should be a commitment to adaptive management; which would result in changes to mitigation based on the results of the implementation and effectiveness monitoring.

The focus of the monitoring should address the assumptions and predictions of the assessment such as:

- Changes to moose and grizzly bear habitat
- Mortality Risk to moose and grizzly bear
- Factors affecting Watershed Health

It is recommended that the results of the monitoring plan be reported out subsequent to construction and at an agreed upon duration during operations.

6. Conclusions

The Anahim Connector Road will impact the values discussed within this report. The risk of the impact on the values varies depending on value; however, in general the effects are low risk at the LSA due to the magnitude of the effect from the road and potential mitigation measures available.

The residual effects of the project will interact cumulatively with past and present impacts. The cumulative effects on the values vary significantly, from Low to High. Although the contribution of the Project to cumulative effects is considered small, existing conditions within some LUs pose a high risk to moose and grizzly bear. The cumulative effects assessment only considers past and present effects and does not incorporate potential future development which may be facilitated by the development of the Project. New development, within areas not previously accessed, would increase the risk to the values assessed.

Opportunities exist to mitigate some of the effects of the Project; however, the effectiveness of the mitigation available does not eliminate the effects of the Project on the value. The mitigation available may minimize some of the effects of the project; however, when the project is considered in the context of cumulative effects the overall risks to some values remain high. Mitigation measures available to further mitigate the effects of the road, given existing conditions, are minimal. Offsetting impacts to address factors influencing cumulative effects may be a viable mitigation to reduce risks to moose and grizzly bear. Opportunities for removing existing access may exist within the affected Landscape Units, which would reduce underlying cumulative effects. Additionally, careful planning of future development facilitated by the new road, would help minimize indirect effects of the project.

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Appendix A: Summary of Impacts and Mitigation

Value	**Potential Impacts**	**Risk (high, medium, low)**	**Recommended Mitigation** (Design/Operational Phases)	**Residual Risk (high, med, low)**	**Implemented in Final Route Design?** Why or why not?
Moose	Loss of winter forage habitat and shelter habitat	Low to Moderate	During final route design avoid key features such as mineral licks, wallows and trails.		
			Select the route that results in the least impact to forage and shelter habitat.		
			Design crossings to avoid disrupting natural drainage patterns and ground water.		
			Develop an Erosion and Sediment Control plan to minimize impact to riparian feature.		
			Develop a Construction Environmental Management Plan with considerations for revegetation		
			Minimize clearing of vegetation in areas adjacent to the footprint.		
			Prevent the establishment of invasive species by re-vegetating disturbed areas.		

Value	Potential Impacts	Risk (high, medium, low)	**Recommended Mitigation** (Design/Operational Phases)	Residual Risk (high, med, low)	**Implemented in Final Route Design?** Why or why not?
Moose	Increased mortality risk from improved access	Low	Select the route that results in the least impact to mortality risk.		
			Minimize potential speeds and footprint to limit sensory disturbance		
			Avoid construction during calving season (May 15th to July 15th)		
			Maintain visual screening (forested cover) around key features and static forage habitat.		
			Plant native, non-palatable species within disturbed area.		
			Restrict winter use		
			Reduce speeds		
			Manage access to limit traffic and reduce sensory disturbance		
			Establish a motor vehicle hunting closed area		
			Implement dust control, including water roads and avoiding use of road salts for dust control during the summer and winter		
			Provide breaks in snow banks to allow wildlife escape		

Value	**Potential Impacts**	**Risk (high, medium, low)**	**Recommended Mitigation** (Design/Operational Phases)	**Residual Risk (high, med, low)**	**Implemented in Final Route Design?** Why or why not?
Grizzly Bear	Loss of Core Security Habitat	Low	During final route design avoid key features such as forage sites, denning sites, mark trails, mark trees and wallows.		
			Time construction to minimize disturbance to grizzly bears using key features identified		
			Select the route that results in the least impact to mortality risk and core security habitat.		
			Manage access to limit traffic and reduce sensory disturbance		
			Minimize clearing of vegetation in areas adjacent to the footprint.		
			Prevent the establishment of invasive species by re-vegetating disturbed areas.		
Grizzly Bear	Increased mortality risk	Low	Minimize potential speeds and footprint to limit sensory disturbance		
			Develop a Construction Environmental Management Plan with considerations for revegetation		
			Plant native, non-palatable species within disturbed area.		
			remote camps to follow best practices for design to minimize human bear conflict		
			Reduce speeds		
			promptly remove attractant such as carrion		
			Establish a motor vehicle hunting closure area		

Value	**Potential Impacts**	**Risk (high, medium, low)**	**Recommended Mitigation** (Design/Operational Phases)	**Residual Risk (high, med, low)**	**Implemented in Final Route Design?** Why or why not?
Watershed Health	Increased sedimentation	Low	Avoid constructing roads parallel to riparian features.		
			Avoid unstable slopes		
			install sufficient culverts to minimize flow within ditchlines		
			Maximize forest-floor buffering to absorb and filter water from the road.		
			Minimize ditch depth provide more options for safely removing road surface drainage.		
			Develop a Construction Environmental Management Plan with considerations for revegetation		
			Develop an Erosion and Sediment Control Plan		
			Avoid connectivity of runoff with aquatic features		
			Minimize the construction footprint		
			Re-vegetate disturbed areas as soon as possible.		
			Ensure the use of good-quality road fill and surfacing material		
			Where the road sub-grade permits, maintain a crowned profile		
			Ensure grader berms are broken to allow water to leave the road surface		

Appendix B: Cariboo Region Cumulative Effects Assessment

Cariboo Region
Cumulative Effects Assessment:

Anahim Connector Project
Options 1 and 2

September 2018

Prepared by:
Ministry of Forests, Lands, Natural Resource Operations
and Rural Development
Williams Lake, BC

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CE Information Background:

This Cumulative Effects (CE) interpretation is based on the Cariboo Region's CE tool designed to assess relative environmental risk to large areas of land and water. The CE assessment looks at the current condition of the landscape in relation to the values of interest and gives the reader an understanding of current risks at a broad-strategic level. It does not provide an assessment at a finer, more detailed stand-level nor does it provide a future-looking assessment. Further on the ground assessment or review of up-to-date site-specific information is required to assess risk at the site-level, and in some cases may be recommended below to support this CE assessment. This information is provided to support First Nations consultation and stakeholder engagement, resource planning activities and decision making. This CE assessment interpretation is based on the Cariboo CE tool. Other CE assessment tools and applications may result in different results or interpretations based on its inputs, indicators and scale of assessment. For more information about each of the values and indicators used for assessment, a full description is available in the Cariboo Region CE Report available here: ftp://ftp.geobc.gov.bc.ca/publish/Regional/WilliamsLake/cumulative_effects/reports_and_presentations/Cariboo%20Cumulative%20Effects%20Report%202015%20FINAL(EDIT%20for%20PRINT).pdf

The following wildlife CE interpretations are based on two landscape units (LU) within the Cariboo Region which are broken further into sub-unit A and B – Upper Dean A and B, and Eliguk A and B. The hydrologic stability CE interpretation is based instead on hydrologic units rather than LU – Tanswanket Creek and Upper Blackwater basins.

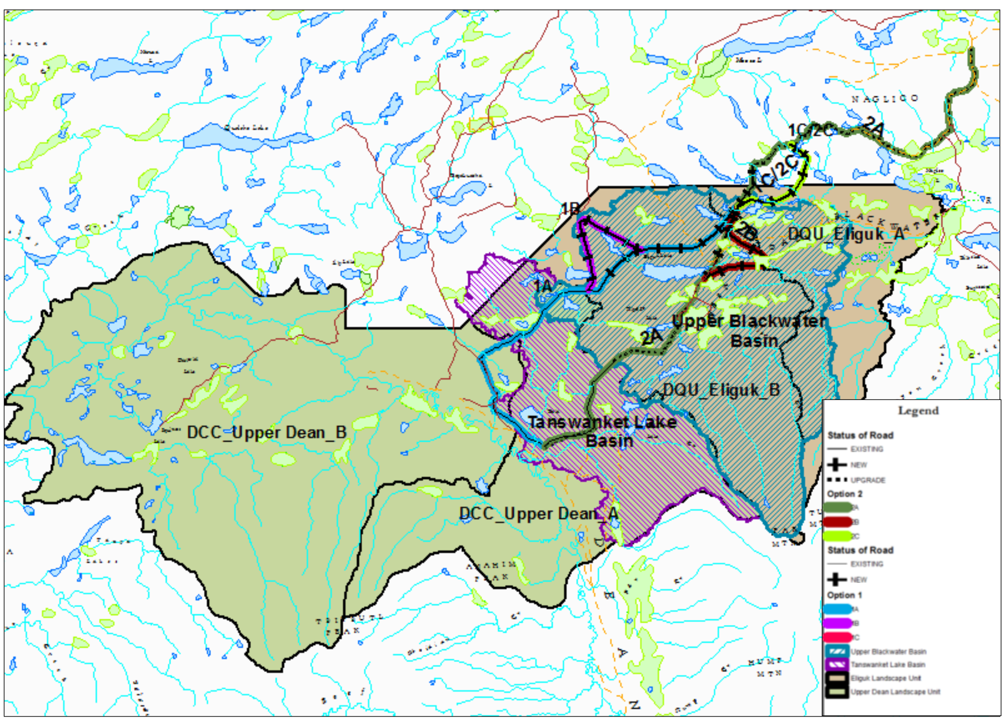

Figure 1. Assessment Area – 2 Landscape Units & 2 Basins within the Cariboo Region

General Description of the Area

Biogeoclimatic (BGC) Zone:

The majority of the area overlapping the assessment area is Sub-Boreal Pine Spruce (SBPS) with a small area of Sub-Boreal Spruce (SBS). The higher elevation areas within these LUs consist of Engelmann Spruce-Subalpine Fir (ESSF) and Montane Spruce (MS) zones.

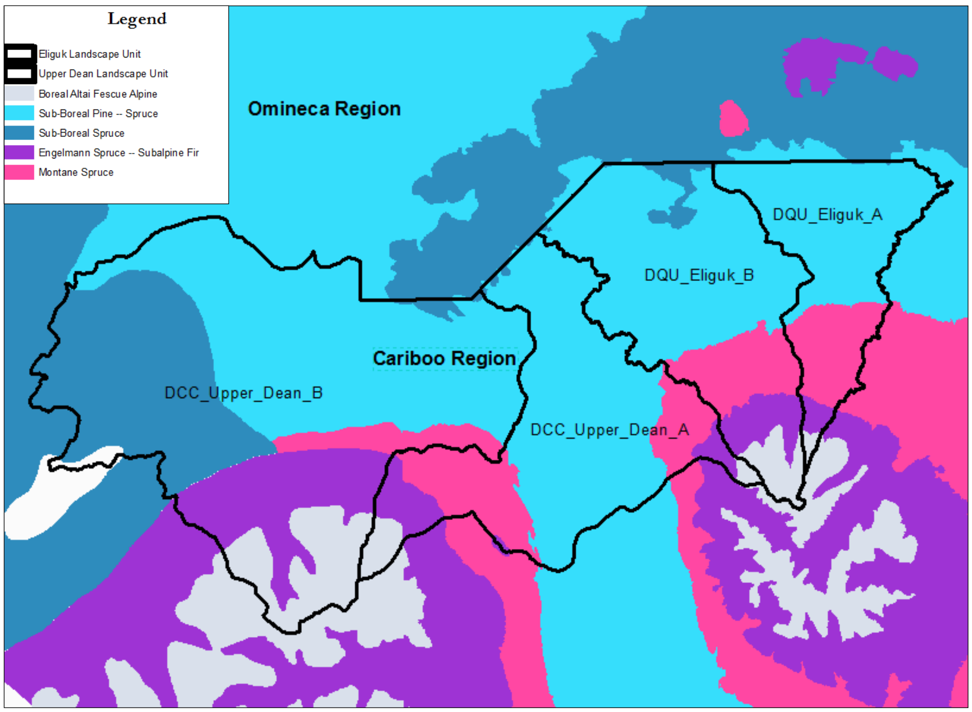

Figure 2. Biogeoclimatic Ecosystem Classification (BEC) Zones

Road Density:

Road density throughout the assessment area is low with moderate densities in the Upper Dean A sub-unit.

- Upper Dean A = 0.654 km/km^2
- Upper Dean B = 0.295 km/km^2
- Eliguk A = 0.337 km/km^2
- Eliguk B = 0.285 km/km^2

Wildfire:

The 2018 wildfire season is currently underway with some large fires burning in the general vicinity of these LU. Exact fire perimeters and impacts won't be confirmed until the fire season is over. None of the 2017 wildfires overlap with the assessment area; however there is a history of wildfires throughout the area with recent 2006 and more historic fire perimeters overlapping the LUs.

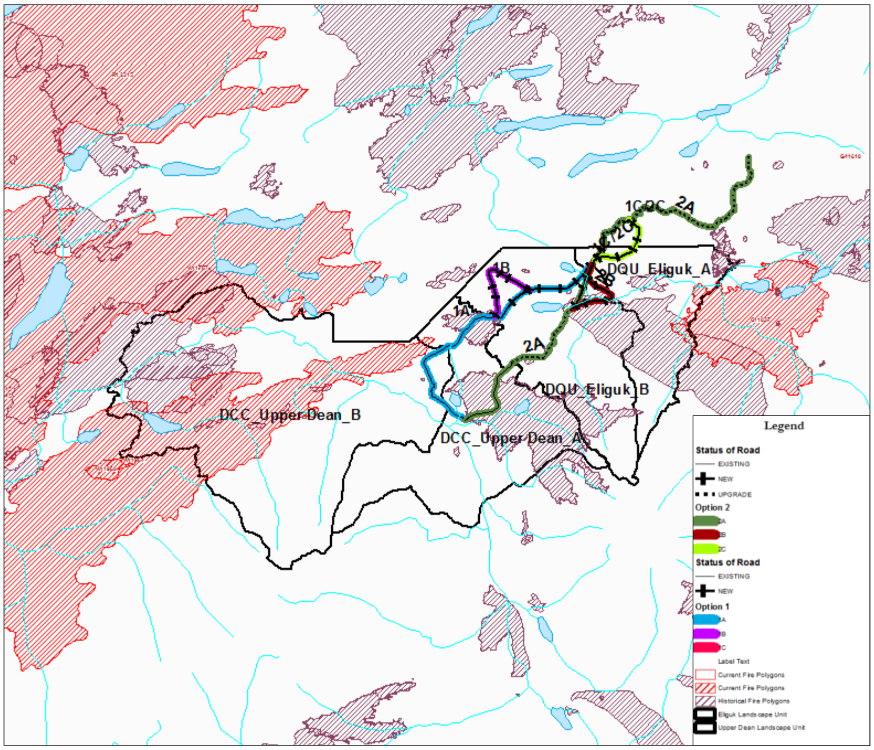

Figure 3. History of Wildfires (historic, 2017 and 2018 (to August 8, 2018)) across Assessment area

Forest Harvest Authorizations:

Overall active, pending and retired forest harvest authorizations are minimal across this area in comparison to the higher harvesting rates to the east in closer proximity to major centers in Quesnel, Williams Lake, and 100 Mile House and to the north in the Omineca region. This is partly due to the longer haul routes to mills in these locations and partly because of the Itcha-Ilgachuz and Tweedsmuir provincial parks and the harvest constraints from the CCLUP in this area.

Cariboo Chilcotin Land Use Plan (CCLUP):

Sections of the proposed roads fall within the *Cariboo Chilcotin Land Use Plan* (CCLUP) boundary and falls across both the *Anahim Round Table Sustainable Resource Management Plan* (SRMP) and the *Quesnel SRMP*. The SRMP were intended to address CCLUP strategies and targets on an area-specific basis through detailed objectives and strategies for the management of natural resources and the maintenance of environmental values.

The objectives set by government for moose, grizzly bear and fish habitat in the Cariboo region are set out in CCLUP as per the following table:

Value	CCLUP or Land Use Order Section
Moose	Appendix #3 zonal and sub-unit resource targets
	Appendix #4 wildlife strategies
	Land Use Order Objective #32
Grizzly bear	Appendix #3 zonal and sub-unit resource targets
	Land Use Order Objective #33-34
Critical Fish Habitat	Land Use Order Objective #12-13

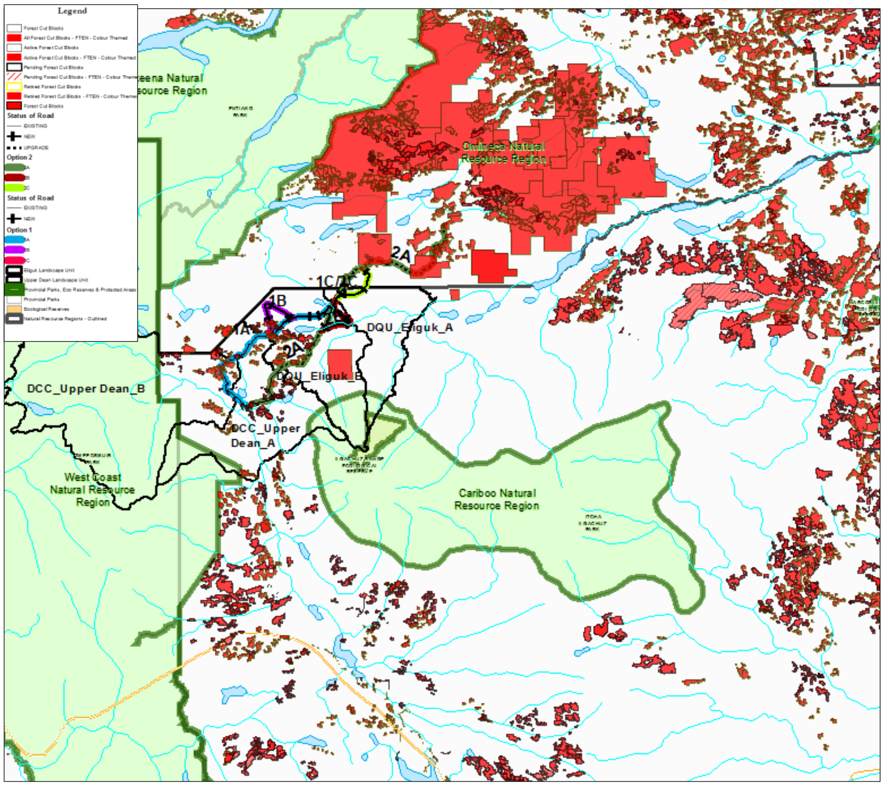

Figure 4. Current and Historical Forest Authorizations in the Assessment Area

In the CCLUP Appendix #3 targets, the objectives set by government is the following provision:

> *"To manage for **grizzly bear**, **moose,** furbearer, species at risk and other sensitive habitats within the areas identified as riparian buffers, recreation areas, caribou habitat and lakeshore management zones and throughout the polygon under the biodiversity conservation strategy."*

The CCLUP Appendix #4 wildlife strategies include provisions for meeting moose habitat requirements, largely through "application of the FPC [Forest Practices Code]". See Cariboo Designated Decision Makers (DDM) Updates #2 [Sec. 3.3]
ftp://ftp.geobc.gov.bc.ca/publish/Regional/WilliamsLake/Cariboo_FSP_Replacements/Direction_Expectations/Expectations%20for%20Cariboo%20Region%20Landscape%20Level%20Biodiversity.pdf

and #3 [Sec. 2.0 and 4.2] regarding the status of the FPC Riparian and Biodiversity Guidebook guidelines as supporting information.
ftp://ftp.geobc.gov.bc.ca/publish/Regional/WilliamsLake/Cariboo_FSP_Replacements/Direction_Expectations/DDM%20expectations_riparian%20and%20WTR%20(2).pdf

These provisions include:

- Forested buffers around wetland and riparian areas (13 priority CCLUP sub-units identified)
- Cover and early seral (shrubby) upland winter habitats, which "*can largely be provided if the biodiversity guidelines for the distribution of seral stages on a Landscape Unit basis are followed"*

- Other aspects of moose habitat needs on a site specific basis, including calving areas and summer habitat protection *"which can be addressed under the biodiversity conservation requirements and the access management targets specified for each CCLUP sub-unit"*
- Careful access management, including limitations on permanent access, deactivation of temporary roads, and limiting road crossings of wetlands and riparian areas as much as possible
- *"Additional buffering of wetlands (up to 200 meters) may be required adjacent to key wetlands or riparian habitats, particularly on the Chilcotin Plateau"*

The Land Use Order Objective #32 is:

> **32** Retain sufficient vegetation to provide security and thermal over for overwintering moose adjacent to high value wetlands shown on map 11 and defined by the spatial dataset, *Cariboo-Chilcotin High Value Wetlands for Moose*, and adjacent W1, W3, or W5 wetlands, including shrub-carrs.

The Land Use Order Objective #33-34 is:

> **33** Apart from existing Wildlife Habitat Areas, retain security cover adjacent to critical grizzly bear foraging habitats which include salmon and trout spawning reaches or shoals, and herb-dominated avalanche track and run-out zones on southerly and westerly aspects, in very high, high and moderate capability grizzly bear units shown on map 12 and defined by the spatial dataset, *Cariboo-Chilcotin Grizzly Bear Capability*.
>
> **34** In very high, high and moderate capability grizzly bear units shown on map 12 and defined by the spatial dataset, *Cariboo-Chilcotin Grizzly Bear Capability*, conduct silvicultural treatments on cutblocks to retain as much existing natural berry production as practicable.

In addition, grizzly bear are provincially blue-listed and are included in the Identified Wildlife Management Strategy (2004). They are federally listed as *Special Concern* by the Committee on the Status of Wildlife in Canada (COSEWIC) and are listed under the *Species at Risk Act* as *Special Concern.* In December 2017, a provincial ban on hunting grizzly bear in BC was established, with the exception of hunting by First Nations for food, social or ceremonial purposes.

The Land Use Order Objective #12-13 is:

> **12** Maintain critical habitat for fish shown on map 4 and defined by the spatial data set, *Cariboo-Chilcotin Critical Habitat for Fish* as no-harvest areas.
>
> **13** Despite objective 12, primary forest activities are permitted in areas classified as critical habitat for fish for the following reasons:
>
> (a) Where harvesting is essential for insect control to curtail severe damage to forest values at the landscape level in a beetle management unit (BMU) classified as suppression for that insect pest,
>
> (b) Road and fence construction where there is no other practicable location available.

High Value Moose Wetlands

"High Value" wetlands were identified through a preliminary list of high value wetlands for moose within the Cariboo Forest region and were determined by measuring the number of known moose-locations surrounding each wetland as they appear on maps that contained moose-locations and wetland polygons. Wetlands that were surrounded by a disproportionately large number of moose were described as "high value". Further field reconnaissance was completed to confirm the value of these wetlands for moose. These areas were mapped and are contained within map 11 of the CCLUP.

The high value wetlands that exist within the assessment area are identified in Figure 5 as well as a look at the larger Chilcotin Plateau area and the location of high value wetlands shows a few important areas of high value wetland complexes but also shows a vast area lacking these wetland forage opportunities for moose. This highlights the importance of the wetland complex within the assessment area as these types of habitat are limited across the Chilcotin and are important areas for moose.

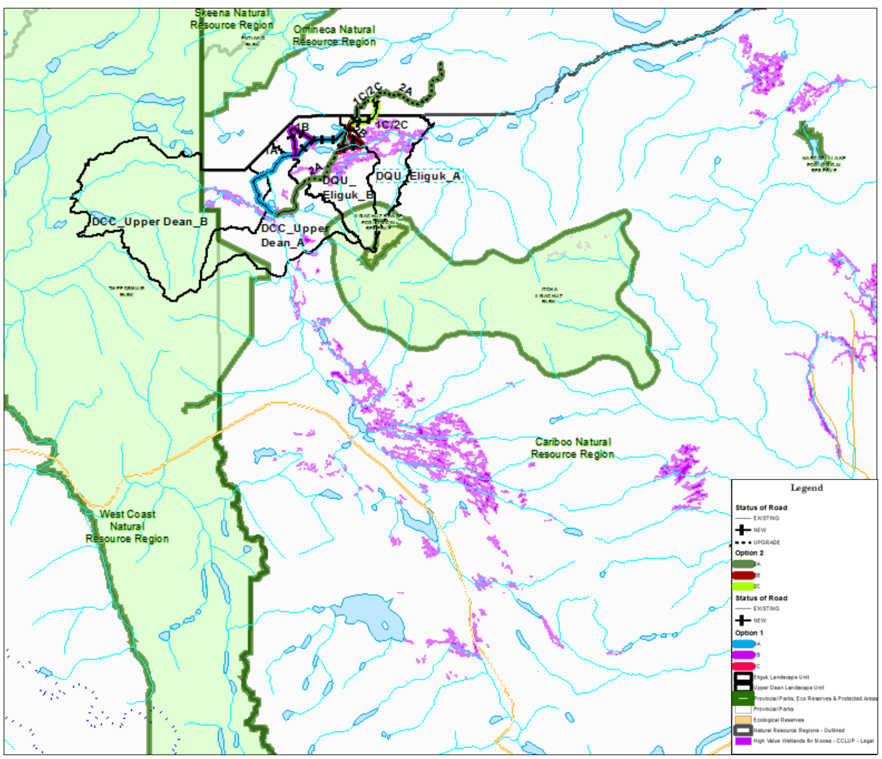

Figure 5. High Value Moose Wetlands across Chilcotin

Moose

CE Background:

The moose CE assessment is based on winter forage and winter shelter habitat as they are key life requisites and important limiting habitats for moose populations. The Moose CE assessment is based on three categories to determine potential impacts to moose and moose habitat: Ecological Importance, Hazard, and Current Mitigation. ***Ecological Importance*** looks at the abundance of all capable moose winter habitat within the assessment unit, while ***Hazards*** are derived from the amount and distribution of moose forage habitat defined as Dynamic and Static and the adjacent available shelter (modelled high suitability habitat), and looks at the level of impact by roads and forest cover reduction. **Dynamic** forage habitats are those created by disturbance such as fire or harvesting which put forested sites back to an earlier, shrubby successional stage that lasts a relatively short period of time at a specific location and then may be created at a different location by further disturbance. **Static** forage habitat is not created by disturbance and does not move around the landscape. It includes habitats such as wetlands, riparian areas and self-sustaining deciduous forest and can be essential foraging habitats for moose, especially in winter. ***Current Mitigation*** indicators are focused on the amount of high suitability habitat in all capability classes that overlap with legal harvesting constraints such as no-harvest designations from the CCLUP. For moose the assessment breaks both the Upper Dean and the Eliguk landscape units into 2 sub-units: A and B (see Figure 1). The assessment is based on Vegetation Resources Inventory (VRI) data from 2016.

CE Summary:

The majority of the assessment area has some level of moose winter habitat capability, although the areas of moderate and higher capability are limited to a few small areas (Figure 6). Most of the capable moose winter habitat falls within the SBPS and SBS BEC zones, with higher elevation areas of the assessment unit associated with MS and ESSF which do not provide capable moose winter habitat. These higher elevation areas will likely be associated more with caribou habitat. The likelihood of effects or Hazards are low across the assessment area, as a result of lower harvesting and road building rates. However, road disturbance of modelled moose habitat is **44%** in the Upper Dean A sub-unit and with moderate amounts of reduced habitat across both landscape units, future harvesting and road disturbance should be carefully planned to minimize additional impact to moose habitat and to reduce current impacts where possible. While natural disturbance from fire or beetle are not incorporated into the assessment modelling, natural disturbance spatial information is available and shows that the area is experiencing high stand mortality (Figure 9). These impacts will increase hazard risks on moose habitat as thermal and security cover will be further reduced. Although Tweedsmuir Provincial Park provides protection to moose habitat in the Upper Dean B sub-unit, the remaining moose habitat throughout the assessment area is lacking much for legal protections (Figure 10).

Assessment Unit	Ecological Importance	Hazard	Current Mitigation
DCC_Upper_Dean_A	M	L	VL
DCC_Upper_Dean_B	H	L	VH

Assessment Unit	Ecological Importance	Hazard	Current Mitigation
DQU_Eliguk_A	M	L	L
DQU_Eliguk_B	M	L	L

Ecological Importance

Assessment Unit	Ecological Importance	% winter moose habitat	Weighted Habitat Quality
DCC_Upper_Dean_A	M	76	19
DCC_Upper_Dean_B	H	85	21

Sub-unit B of the **Upper Dean** LU is assessed as high for moose ecological importance as **85%** of the unit is capable moose winter habitat while **76%** of the sub-unit A is capable moose winter habitat. Both units contain capable moose winter habitat; however, the majority of the habitat is low capability with a few small areas of moderate and high capability (Figure 6). This is demonstrated through the 'weighted habitat quality' indicator that provides a heavier weighting to the higher capability areas. Both sub-units are rated as low for the weighted habitat quality indicator. The higher capability habitats that are identified in Figure 6 should be priority areas for maintenance and/or enhancement planning as they will have high local importance for the moose population.

Assessment Unit	Ecological Importance	% winter moose habitat	Weighted Habitat Quality
DQU_Eliguk_A	M	82	19
DQU_Eliguk_B	M	72	17

Both sub-units of the **Eliguk** LU are moderate for moose ecological importance as **82%** and **72%** respectively of each unit has capable habitat; however there is no highly capable moose winter habitat identified across these two units with one area of moderate capability identified in sub-unit A (Figure 6).

As observed in Figure 2, there are significant amounts of both LU's that are within the ESSF zone where moose are likely excluded from in winter months due to snow depths that restrict movement and require high energy consumption to migrate within. This will concentrate any moose within these LU into the lower elevation SBPS zone where snow levels are generally lower but forage production is also less.

Since capable moose winter habitat across both LU's is moderate but not providing large areas of high moose winter capability, it is important to identify, maintain and where possible recover the higher capable and suitable habitats. In drier ecosystems (such as the SBPS of these two units) where forested sites support limited amounts of shrub forage species, wetlands and riparian areas provide a substantial portion of the feeding habitat available to moose (Keystone, 2006). Since foraging habitat is limited, moose likely use the same areas and resources year round. Because these types of habitat appear to be limited within the assessment area, it is important to maintain what limited moose winter forage and cover habitat is available.

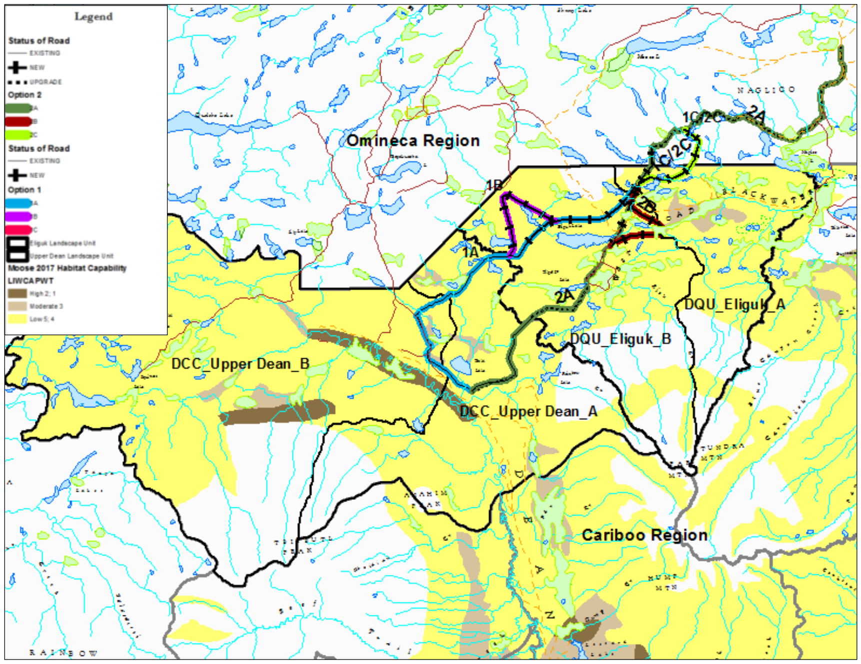

Figure 6. Moose Winter Habitat Capability

Hazard

Overall hazards for both the Upper Dean and Eliguk LU are assessed to be low for moose, based upon 4 indicators defined by the Cariboo CE Tool and described below.

Assessment Unit	Hazard	% without adequate cover	Reduced Habitat (adjacent forage and cover)		% road disturbance
			Total	Static	
DCC_Upper_Dean_A	L	0	6	7	44
DCC_Upper_Dean_B	L	16	1	17	17

Assessment Unit	Hazard	% without adequate cover	Reduced Habitat (adjacent forage and cover)		% road disturbance
			Total	Static	
DQU_Eliguk_A	L	5	21	21	2
DQU_Eliguk_B	L	4	8	9	21

Habitat Reduced

Two indicators look at the amount of modelled suitable habitat (available forage with adjacent cover) reduced as a result of disturbance. This indicator breaks the habitat into two types: '***Total***' which looks at a combination of Dynamic (i.e. from cutblocks, fires, disturbance) and Static forage habitats and '***Static***' which solely assesses how much of the cover adjacent to static habitat (i.e. wetland, riparian areas) has been reduced. **Upper Dean sub-unit A** has had minimal habitat reductions (6% of cover adjacent to Total habitat and 7% of cover adjacent to Static habitats). **Sub-unit B** has 17% of the cover adjacent to Static habitats reduced which is a more significant disturbance. The **Eliguk sub-unit A** has seen a moderate amount of cover adjacent to total and static habitat reduced (21% reduction for both habitat types), while **sub-unit B** has not seen the same level of disturbance (8% reduction in cover adjacent to Total and 9% reduction of cover adjacent to Static habitat). As described previously, the critical forage habitats for moose in these dry ecosystems are the static wetland and riparian areas and any potential disturbance in or adjacent to these areas are important to identify and consider in future planning and decisions.

Road Disturbance

A third indicator assesses the amount of road disturbance of the modelled suitable habitat (i.e. forage habitat with adjacent cover). Road disturbance is defined by a 1000m buffer applied to all paved and major gravel roads that cross through modelled suitable habitat (note that the modelling does not include small undefined roads and in-block roads that provide access and may cause some level of additional risk to moose). Road disturbance is moderate for the **Upper Dean sub-unit A** with 44% of the suitable habitat disturbed by roads, while in **sub-unit B** 17% of the habitat is disturbed by roads. Road disturbance within the **Eliguk LU** is less, with 21% of the modelled suitable habitat in **sub-unit B** disturbed by roads and only 2% in **sub-unit A**. Figure 7 illustrates where the modelled suitable habitat has been disturbed by roads (red hatching) and not disturbed (green hatching) across both landscape units.

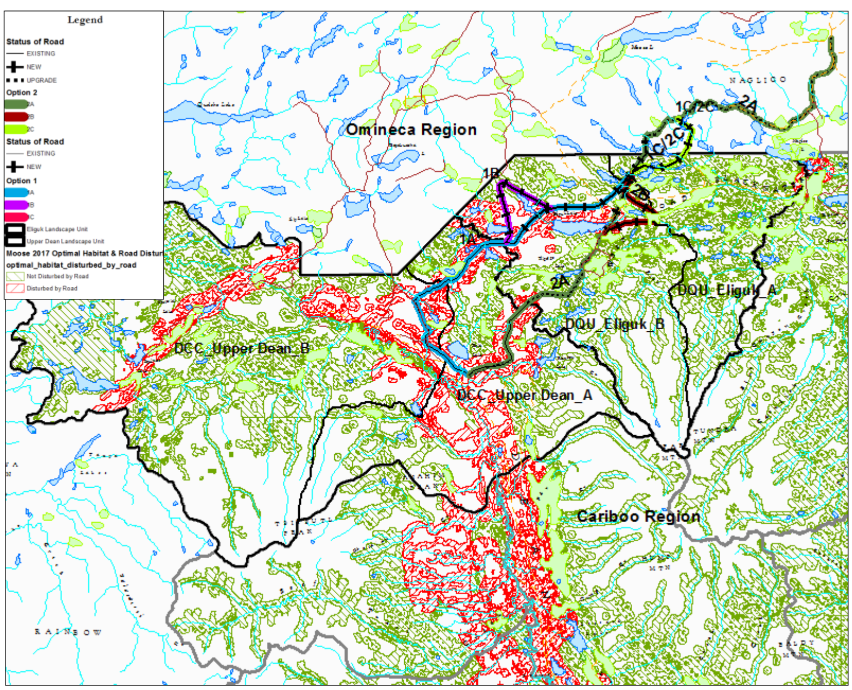

Figure 7. Modelled Moose Suitable Habitat Disturbed by Road

While not included in the CE assessment methodology, additional road density information is available for the assessment area. This calculation includes all roads available within the BC Data Warehouse layers used (i.e. includes large paved roads through to small in-block and undefined roads) and therefore incorporates more roads than the moose CE road disturbance modelling.

- Upper Dean_A road density = 0.654 km/km^2
- Upper Dean_B road density = 0.295 km/km^2
- Eliguk_A road density = 0.337 km/km^2
- Eliguk_B road density = 0.285 km/km^2

Adequate Cover

Each moose winter home range requires both forage and adequate cover to provide effective habitat. A landscape with very high levels of disturbance can sometimes have much moose forage but not enough cover. A fourth indicator to assess hazard to moose habitat identifies how much of the capable habitat over potential female moose home ranges within the unit is without adequate cover (Figure 8). Cover is defined as forest >60 years of age and ≥40% conifer. "Adequate cover" is defined as 30%+ for the dry and moist ecotypes of these units. The **Upper Dean sub-unit A** is assessed to have adequate cover while **sub-unit B** has 16% of the capable habitat lacking adequate cover which is rated as moderate for this indicator. The **Eliguk sub-units** both have adequate cover with only 5% and 4% of the capable habitat lacking adequate cover across the A and B sub-units.

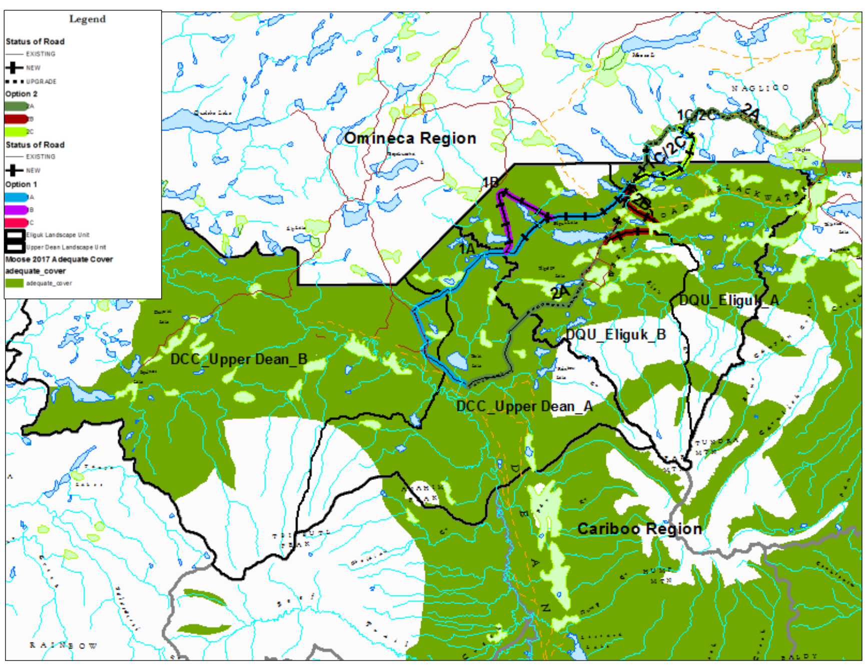

Figure 8. Moose Adequate Cover

Natural Disturbance

Pine mortality data was not used quantitatively within the moose CE modelling but it is provided for qualitative interpretation as shown in Figure 9 with estimated stand mortality as well as 2017 wildfire and historic wildfire perimeters. Currently (summer 2018) there are fires burning in the vicinity of these units with the level of impact unknown until the fire season is over. The 2017 wildfire perimeters did not overlap with the assessment area; however there are impacts from large 2006 fires as well as older fires seen across the area. The relationship between various levels of stand mortality and its effectiveness for moose security and thermal cover is not known with any precision. Thermal and security cover values in high mortality pine stands would be reduced in relation to green stands, but would be significantly higher than in clearcut areas. (Dawson, et al. 2015)

- Upper Dean A & B = SBPSmc = 68% of this area is >50% mortality
- Eliguk A & B = SBPSmc/SBSmc2/SBSmc3 = 40% of this area is >50% mortality

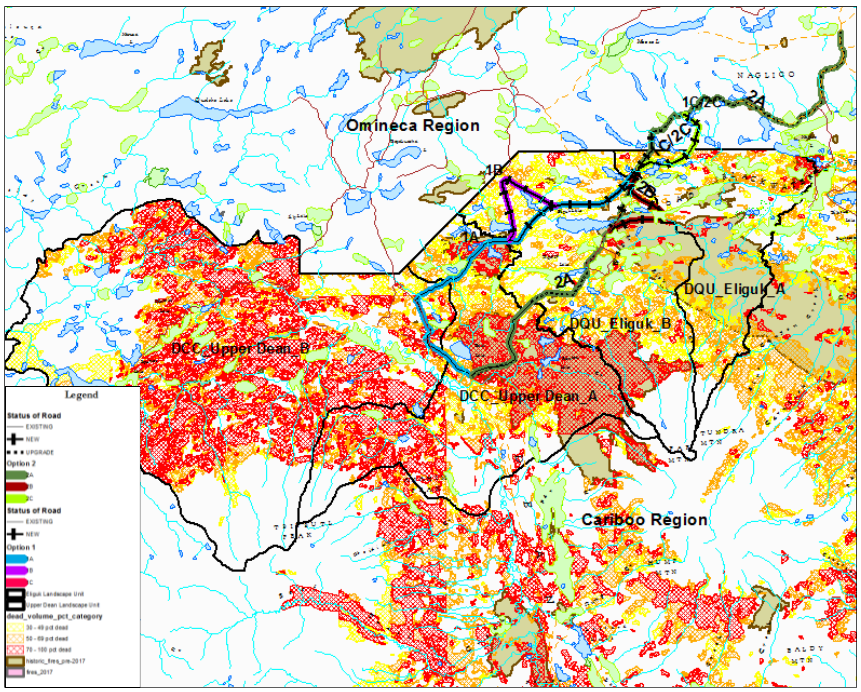

Figure 9. Stand Mortality and Wildfire History (to 2017)

Current Mitigation

Current mitigation assesses how much of the moose capable winter habitat is overlapped with some form of legal protection (i.e. parks and protected areas, CCLUP harvest restrictions (i.e. OGMA, MDWR, caribou harvest restrictions, critical fish habitat, etc.)).

Assessment Unit	Current Mitigation	Percent Protected	
		All Capable Winter Habitat	Adjacent Static – Forage & Cover
DCC_Upper_Dean_A	VL	14	11
DCC_Upper_Dean_B	VH	88	89

Assessment Unit	Current Mitigation	Percent Protected	
		All Capable Winter Habitat	Adjacent Static – Forage & Cover
DQU_Eliguk_A	L	16	9
DQU_Eliguk_B	L	24	8

The **Upper Dean sub-unit A** has very low current mitigations (14% overlapped with legal protections) while the **sub-unit B** has very high mitigations associated with 88% of the moose capable habitat being protected by the Tweedsmuir Provincial Park. In addition there are some areas of caribou “no-harvest” and “modified harvest” protections overlapping with Upper Dean sub-unit A although the majority of the caribou harvest protections overlap with the Eliguk LU (Figure 10). Both the **Eliguk sub-units** are rated as low current mitigation measures with 16% and 24% respectively under some level of protections. Much of the mitigation provided by the caribou harvest constraints do not overlap with capable moose habitat as caribou utilize different ecosystems (i.e. ESSF and MS).

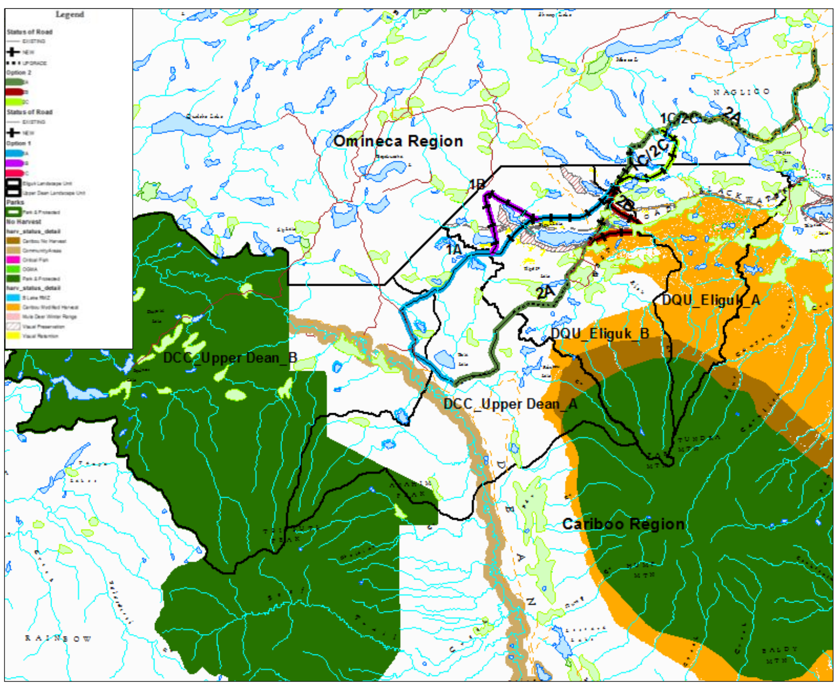

Figure 10. Current Mitigation for Moose

Comparison of Option 1 and Option 2 CE Assessment for Moose:

Ecological Importance/Moose Winter Habitat Capability

Option 1 runs adjacent to some of the moderate capability habitats and the high capability/high value moose wetland habitats identified, while Option 2’s proposed route runs directly through some of the high value moose wetland complex. In the drier ecosystems of the west Chilcotin, moose forage opportunity throughout the year and especially in winter is limited to wetter zones including wetlands and riparian areas along lakes, streams and rivers where adjacent cover is available. Therefore these identified high value wetlands will be of significant local importance for moose in winter and year round.

The proposed ***new*** section of **Option 1** runs adjacent to this large complex of high value moose wetlands. The proposed ***new*** section of **Option 2** crosses through some of this wetland complex, and in particular Option 2B diverts further into the wetland complex in order to avoid potential archaeological sites adjacent to Eliguk Lake. Either of these new road options will allow access into an area of critical high value moose habitat that may not have been previously accessible by vehicle. Option 2B is higher risk as it crosses further into the wetland complex. Vehicle access leads to increased use by humans by 4X4 vehicle, ATV, and/or by foot as well as increased potential for harvesting disturbance - all of which increase the disturbance and mortality risk to moose.

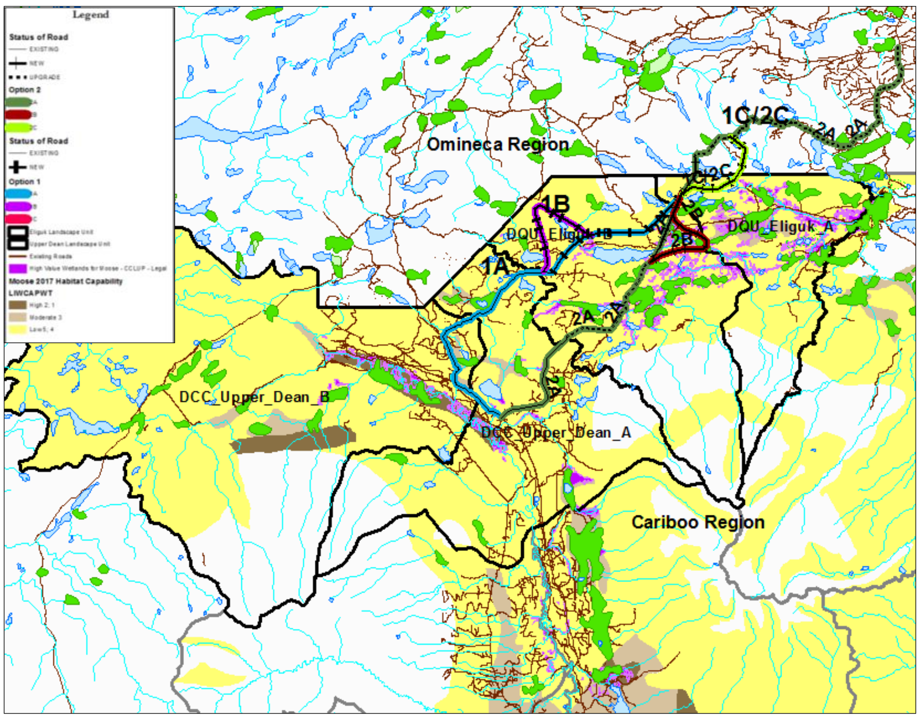

Figure 11. Options 1 & 2 and Moose Capable Winter Habitat and High Value Moose Wetlands

Hazards

Existing hazards for moose in these two LU are low as a result of low disturbance (i.e. forest harvesting) activities. There has been a moderate level of road disturbance to existing habitat through the core of this area (Upper Dean sub-unit A = 44% of modelled suitable habitat disturbed by roads and 21% in Eliguk sub-unit B). Similar to what's been discussed above specific to the high value moose wetlands, Option 2 will result in a road being introduced into an area where modelled suitable moose habitat is currently undisturbed by roads. Option 1A/1B is proposed to extend existing roads in an area where other roads currently exist. Section 1C/2C, however, is proposed through previously undisturbed moose habitat (and then into the Omineca region which is not included in this assessment).

While not included in the CE assessment methodology, additional road density information is available: the greatest road density is associated with Upper Dean_A with a 0.65 km/km^2 density. Research has suggested that there is a maximum or threshold road density of 0.6 km/km^2 for a "naturally functioning landscape containing sustained populations" of large mammals. Above this threshold, Forman et al. (1997) (cited in Beazley et al. 2004) found some large mammal populations decline due to disturbance effects and increased mortality. Specific to moose, Beazley et al. (2004) found they were negatively impacted when road density exceeds 0.6km/km^2. Recommendations surrounding access management often include reducing road (including trails, seismic and other linear structures) densities to below 0.6km/km^2 (lower densities as low as 0.16km/km^2 may be required to meet objectives) in moose winter habitat and calving habitat (GOABC, 2016).

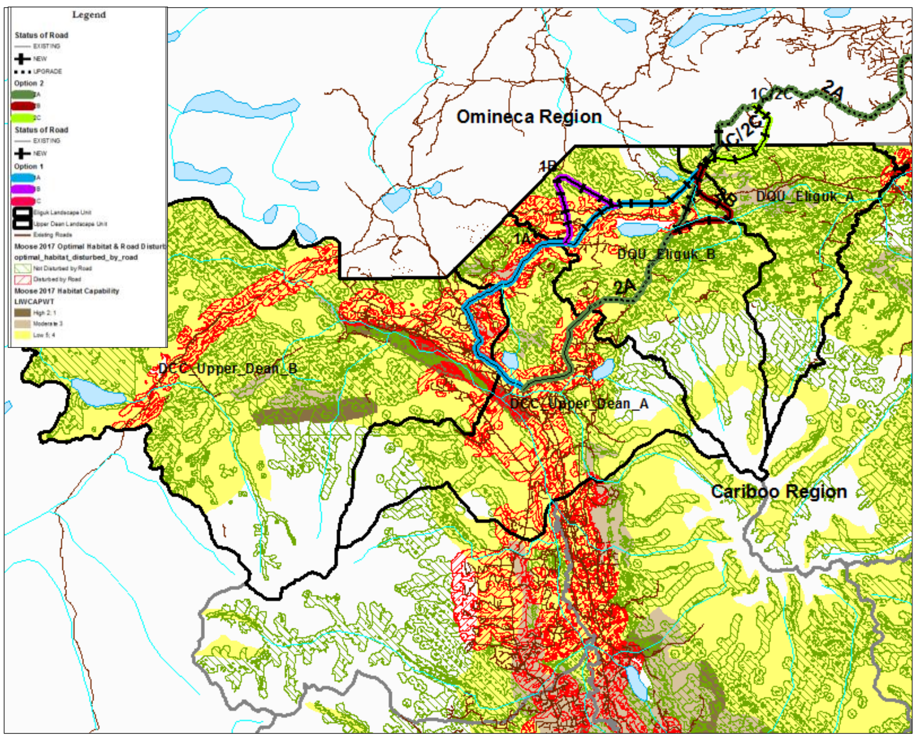

Figure 12. Option 1 & 2 and Moose Habitat Disturbed by Roads

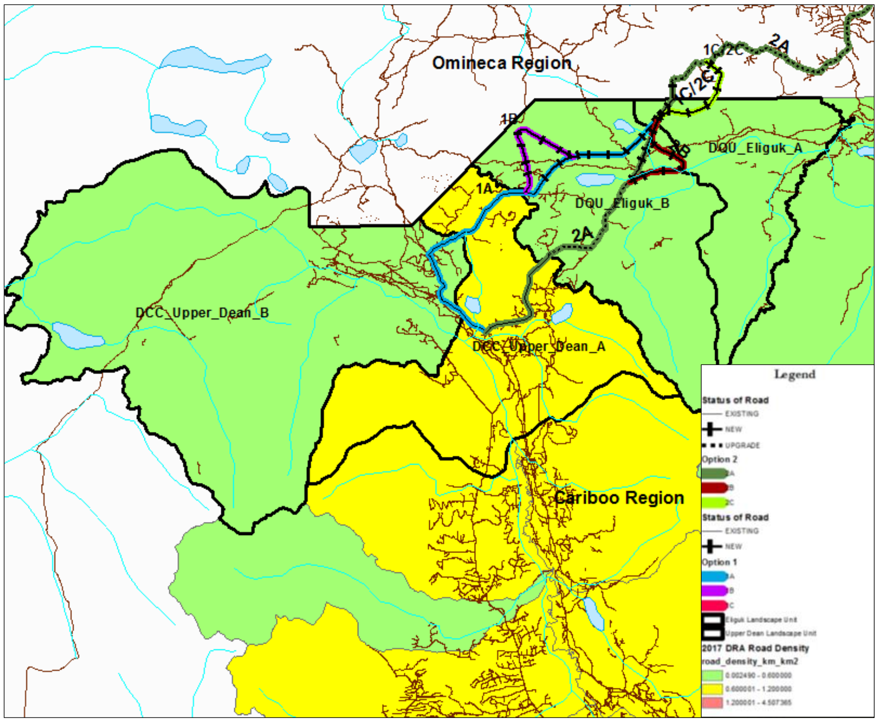

Figure 13. Road Density

In addition to road density, the type of roads that are present throughout an area may also be important for assessing risk to moose. Loop roads increase the efficiency of hunters, especially those in vehicles, by allowing more rapid and complete viewing of an area. Increased hunting efficiency leads to increased moose vulnerability. Loop roads should not be used in areas with high value moose habitat, or should be made impassable immediately after harvest (Davis, et al. 2013).

Current Mitigation

Current mitigation throughout this area is limited to the parks and protected areas provided by Tweedsmuir Provincial Park and Itcha Ilgachuz Provincial Park as well as some caribou modified and no harvest restrictions – very little of which overlap with identified moose habitat (Figure 14).

Potential Mitigation Measures:

If a decision to complete the Anahim Connector road is made, mitigation measures should be developed to include deactivation and road rehabilitation to ensure moose habitat areas are maintained around the key wetland locations. Access mitigation planning should include looking for areas where larger core habitat areas can be created with moose travel corridors connecting the existing habitat as well as identifying other potential forage habitat locations such as deciduous forests. As increased harvesting rates may result from the development of the Anahim connector road, further protections should be implemented to ensure the local wildlife populations are not impacted and habitat requirements are maintained. As summarized in Keystone (2006) with regards to forest harvesting management actions, isolated high value moose wetlands should be protected with 200m forested buffers plus targeted placement of wildlife tree patches to increase the amount of forest cover adjacent to the wetland. Retention of sufficient forest to provide connectivity between wetlands for use as moose travel corridors is also recommended. Access management measures include closing all forestry roads within 1km of high value wetlands once forest harvesting is complete, and avoiding road construction in proximity to or crossing high value wetlands. Management practices for high value wetlands that are part of wetland complexes includes implementing extended harvest rotations, using seral stage management, and limiting the area of harvest to one third of the wetland complex (Keystone, 2006).

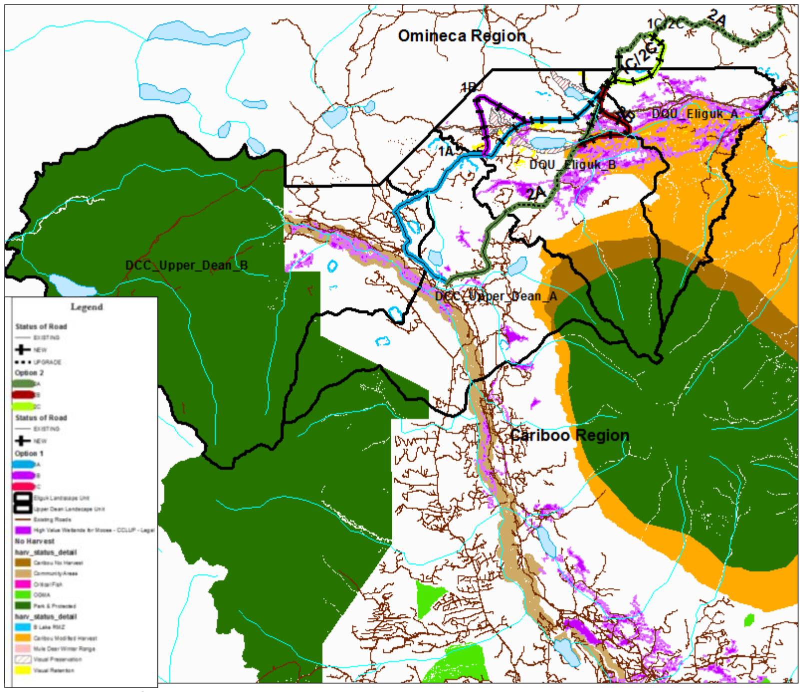

Figure 14. Option 1 & 2 and Moose Current Mitigation Measures

Grizzly Bear

CE Background:

The Cariboo Region's CE assessment tool includes a value looking at grizzly bear. The assessment is focused on 4 aspects of grizzly bear ecology:

- current population viability status,
- habitat quality including habitat capability and presence of significant salmon resources,
- reductions in habitat effectiveness related to density of human access, and
- proportion of capable habitat within road-less secure core areas. Secure core habitat is defined as roadless areas greater than 10km^2.

Like the other wildlife values, the grizzly bear CE assessment is based on three categories to determine potential impacts to grizzly bear habitat: Ecological importance, Hazard and Current Mitigation. ***Ecological Importance*** looks at the classification of the population units as viable, threatened or extirpated, as well as the abundance of capable grizzly bear habitat across the assessment unit. Capable grizzly bear habitat is based upon Broad Ecosystem Inventory mapping from 2012 and is broken into 5 classes ranging from very high (1) to very low (5). Where salmon resources and data are available, an additional indicator looks at salmon abundance, consistency of salmon returns and their availability to bears. ***Hazard*** ratings assess the amount of **effective habitat** (i.e. capable habitat netted down based on overlap with road density classes as well as the amount of **secure core habitat** (i.e. capable habitat in roadless areas >10km^2). These two indicators look at both impacts to all capable habitat (class 1-5) and at the higher capability habitat (class 1-3). ***Current Mitigation*** indicators are focused on the amount of capable habitat overlapped with no-harvest designations. No-harvest designations include parks, protected areas, goal 2 protected areas, permanent Old Growth Management Areas (OGMA), caribou no-harvest areas and riparian reserves around streams, wetlands and lakes. For grizzly bear the assessment breaks both the Upper Dean and Eliguk landscape units into 2 sub-units A and B (see Figure 1). The assessment is based on Vegetation Resources Inventory (VRI) data from 2014.

In 2016, the provincial Cumulative Effects Framework (CEF) released a grizzly bear protocol and results for CE assessment. These results are available for the Cariboo Region and will be summarized below in addition to the Cariboo Region's CE tool results.

Assessment Unit	Ecological Importance	Hazard	Current Mitigation
Upper Dean A	H	L	L
Upper Dean B	M	M	L

Assessment Unit	Ecological Importance	Hazard	Current Mitigation
Eliguk A	H	L	VL
Eliguk B	H	L	M

CE Summary:

Ecological Importance

The Blackwater-West Chilcotin GBPU overlaps the assessment area and is classified as **threatened.**

Assessment unit	Ecological Importance	Population Status	Capability 1-5 %	Capability 1-3 %	Salmon Rating
Upper Dean A	**H**	threatened	**94**	**31**	**nr**
Upper Dean B	**M**	threatened	**20**	**24**	**nr**

Assessment unit	Ecological Importance	Population Status	Capability 1-5 %	Capability 1-3 %	Salmon Rating
Eliguk A	**H**	threatened	**100**	**23**	**nr**
Eliguk B	**H**	threatened	**99**	**8**	**nr**

Overall Ecological importance is rated as **high** across the assessment area. Capable grizzly bear habitat is available across the assessment area, with **Eliguk A and B and Upper Dean A** containing greater than 90% of the unit having some level of capable bear habitat (class 1-5). However, much of the area contains lower capability habitat with the **Eliguk A and B sub-units** having only 23% and 8% respectively of the unit in the moderate and high capability (class 1-3) classes and **Upper Dean A** with 31% of the unit in moderate and high capability. There is one area of very high habitat capability across the Upper Dean LU (Figure 15), aligning with the Dean River and may be associated with protein resources such as salmon or trout available for bears to feed on. As seen in Figure 15 habitat capability mapping was not completed for a large portion of the **Upper Dean B sub-unit**; as this will affect the overall risk rating for this unit and as it does not overlap with the proposed route options, the Upper Dean B sub-unit is not summarized further within this interpretation.

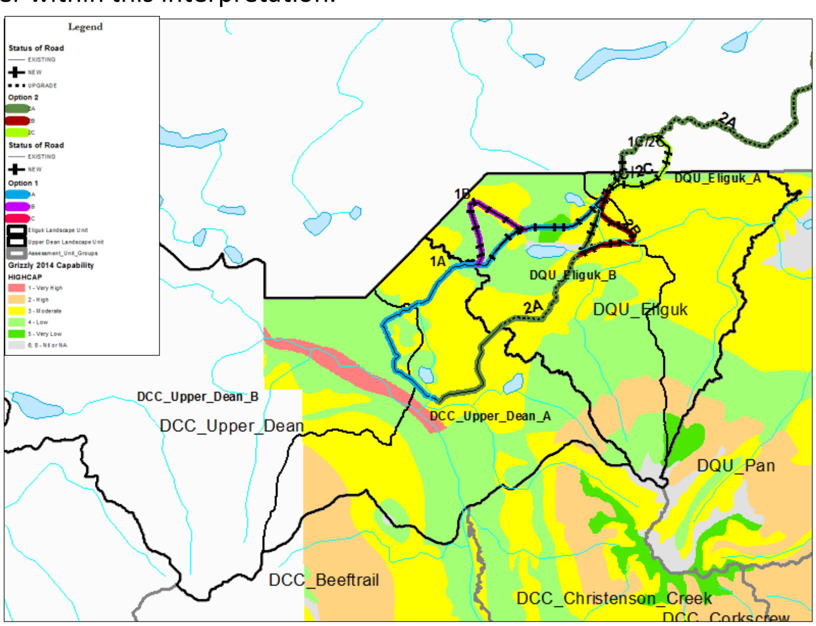

Figure 15. Grizzly Bear Habitat Capability

Hazard

Overall hazards for the assessment area are assessed to be ***low*** for grizzly bear. This assessment is based upon 2 related indicators of human access effects on grizzly bears defined by the Cariboo CE Tool: habitat effectiveness and secure core area. These indicators are widely used for grizzly bear assessments in western North America. Note that these two analyses are usually calculated based on suitable habitat. Capable habitat was used in this analysis to reflect the long term nature of the required planning horizon during which the habitat suitability would be in flux (Dawson, et al. 2015).

Assessment unit	Hazard	Habitat Effectiveness		Secure Core Habitat	
		Capability 1-5 %	Capability 1-3 %	Capability 1-5 %	Capability 1-3 %
Upper Dean A	**L**	**70**	**90**	**52**	**81**
Upper Dean B	**M**	**59**	**74**	**34**	**55**

Assessment unit	Hazard	Habitat Effectiveness		Secure Core Habitat	
		Capability 1-5 %	Capability 1-3 %	Capability 1-5 %	Capability 1-3 %
Eliguk A	**L**	**85**	**88**	**75**	**80**
Eliguk B	**L**	**84**	**100**	**71**	**100**

Habitat Effectiveness

This indicator looks primarily at the displacement risk resulting in bears not being able to make full use of valuable habitat. For the **Eliguk sub-units** habitat effectiveness risks are **low**, with the amount of effective habitat overlapping with all capability classes (class 1-5) being 85% and 84% respectively. The amount of effective habitat that overlaps with moderate and high capability habitat (class 1-3) is 88% and 100% respectively. For the **Upper Dean sub-unit A**, the amount of effective habitat that overlaps with all capability classes (1-5) is 70% and the amount overlapping with moderate and high capability (class 1-3) is 90%. In general, existing disturbance, which as discussed above is low, has not resulted in a loss of effective habitat for grizzly bear across the assessment area.

Secure Core Areas

The second indicator assesses the proportion of capable habitat in road-less areas greater than $10km^2$ which reflect changes in mortality risk as a result of road access. The **Eliguk A and B** sub-units are rated as **low** risk with 75% and 71% respectively of the capable habitat falling within secure core areas, and 80% and 100% respectively of the moderate and highly capable habitat (class 1-3) within secure core areas. The **Upper Dean A** sub-unit has 52% of all capable (class 1-5) habitats overlapping with secure core areas and 81% of the moderate and high capability habitats (class 1-3) within secure core areas. Figure 16 illustrates that some of the proposed road options (1 and 2) overlaps with areas that are not considered secure core because of existing road disturbance. Some areas of the proposed roads would however further reduce secure core areas for grizzly bears through this corridor.

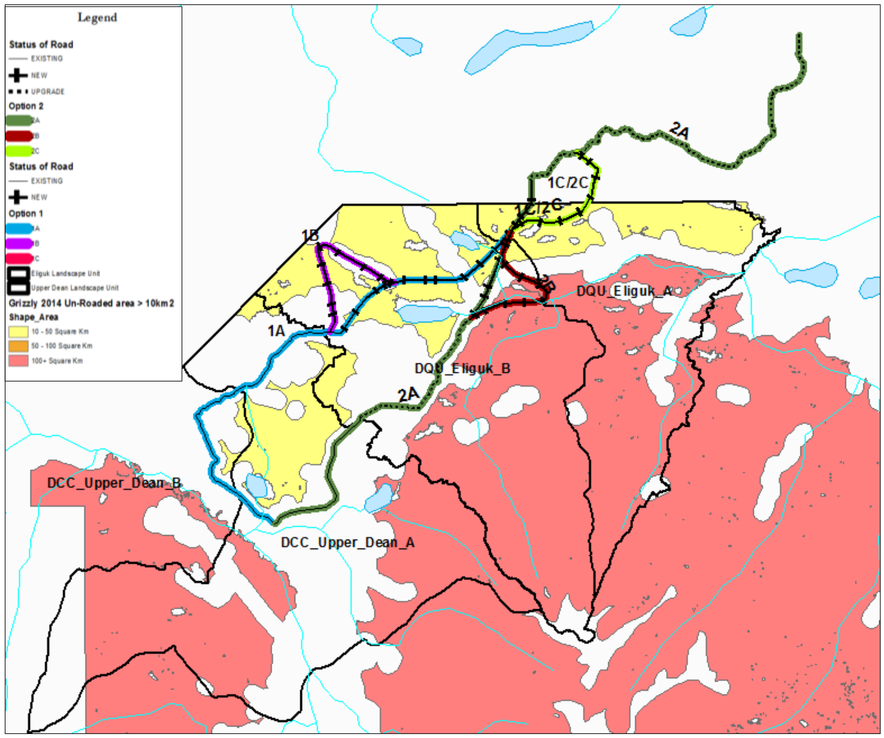

Figure 16. Un-roaded Areas as Secure Core Assessment for Grizzly bear

Current Mitigation

Current mitigation assesses how much of the grizzly bear capable habitat is overlapped with some form of legal protection (i.e. parks and protected areas, CCLUP harvest restrictions (i.e. OGMA, MDWR, caribou harvest restrictions, critical fish habitat, etc.)).

Assessment unit	Current Mitigation	% Protected	
		Capability 1-5 %	Capability 1-3 %
Upper Dean A	L	19	31
Upper Dean B	L	13	35

Assessment unit	Current Mitigation	% Protected	
		Capability 1-5 %	Capability 1-3 %
Eliguk A	VL	10	18
Eliguk B	M	21	95

The **Upper Dean sub-unit A** has low current mitigations: 19% of all capable habitat and 31% of moderate to high capable habitat overlapped with legal protections. The **Eliguk sub-unit A** is rated as very low current mitigation measures with 10% of all capable habitat and 18% of moderate and high capability habitat under some level of protections. **Eliguk sub-unit B** has a moderate level of current mitigation; due to overlap from both the Itcha Ilgachuz Provincial Park as well as areas of CCLUP harvest designations (Figure 17).

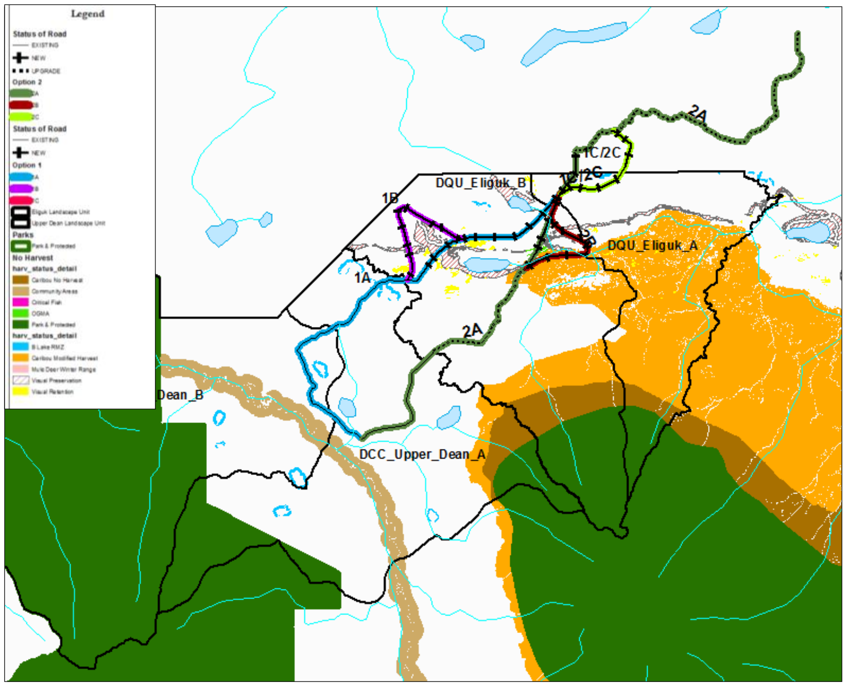

Figure 17. Current Mitigation for Grizzly Bear

Provincial CE Framework Grizzly bear results

The provincial CE Framework has also developed an assessment tool for grizzly bear (MOE/FLNRO, 2017) which includes further indicators than those discussed above from the Cariboo Region. The results of the provincial CE assessment support the Cariboo Region's interpretation of risk to grizzly bear across the assessment area. A summary of further indicators and interpretation for the assessment area are provided below.

Bear Density:

Current knowledge about bear density is limited. Some populations have been measured; others are estimated based on a regression model that relates landscape-scale factors to the known densities (MOE/FLNRO, 2017). This indicator assesses density as number of bears per 1000km^2 and a density of <10 bears/1000km^2 is considered high risk.

Landscape Unit	Bear Density/1000km^2	Risk Result
Upper Dean	11.85	Pass
Eliguk	2.73	**Flagged**

Core Security:

Core security areas are defined as areas that have adequate habitat with a minimum of human use. They are large enough to accommodate a female grizzly bear's daily foraging requirements. The integrity of the security area is sensitive to the extent and spatial arrangement of developments including roads, settlements, recreation areas and industrial areas (MOE/FLNRO, 2017). This indicator assesses the proportion of capable secure core in patches ≥10 km^2 within the capable portion of the LU, with ≥60% within capable secure core identified as low risk and <60% within capable secure core as higher risk and is flagged.

Landscape Unit	% Capable Secure Core	Risk Result
Upper Dean	72%	Pass
Eliguk	74%	Pass

Front Country:

The front country is defined by urban and rural landscapes to include both relatively high human density and grizzly bear attractants in the form of livestock, livestock carcasses, livestock feed, fruit trees, human food/garbage and grain. Bears tend to be absent from urban areas, due to historic human-bear conflict, so these areas do not increase mortality risk to the same extent unless there are anthropogenic attractants along the urban interface. Rural agricultural landscapes essentially provide good quality habitat with human access, and hence can act as sink habitat. In these areas, human-grizzly bear conflicts can lead to defence-of-life-and-property and management kills (MOE/FLNRO, 2017). This indicator is a function of human population size, travel time on roads, and land cover. A LU is flagged as higher risk if >20% of the unit is considered front country.

Landscape Unit	% Front Country	Risk Result
Upper Dean	3.97%	Pass
Eliguk	0%	Pass

The building of the Anahim Connector road will reduce travel time to this area from larger communities which will increase the amount of area considered front country and therefore may increase risk to grizzly bear populations.

Hunter Day Density:

Bears die at a disproportionate rate when they are close to active roads travelled by people carrying firearms. Mortality may occur from legal hunting, mistaken identity kill, poaching, vehicle collisions or may be conflict-related (self-defence, management control, landowner defense-of-life-and-property) (FLNRO, 2016).

This indicators looks at the average annual hunter day density calculated on number of days over 10 year period (2003-2012)/per year for the occupied portion of the management unit (MU). A unit with >1.509 hunter days/km^2 is flagged as higher risk.

Landscape Unit	hunter days/km2	Risk Result
Upper Dean	0.30	Pass
Eliguk	0.58	Pass

Note: this indicator does not differentiate between different species that hunters are hunting or the different time of year of the hunts which both may affect the relative risk to grizzly bears. Further review of compulsory inspections may help address this uncertainty.

Quality Food:

Grizzly bears are omnivores with a diet that varies with location and season. In BC, coastal and interior grizzly bears have very different foraging behaviour and ecology driven by the availability of salmon. For the purposes of this assessment, provincially available data for forage was limited to salmon biomass and high capability areas. Information on ungulate density is intended to be used in the future as information becomes available (FLNRO, 2016). The Quality Food indicator is identified as salmon biomass by LU (sum of 5 species of salmon by kg in LU over all available time periods >10,000kg), and/or total weighted area of BEI capability in classes 1 (very high) and 2 (high) > 50% of the LU. If a LU has large salmon bio mass or high capability it is flagged.

Neither of the assessment LU’s are defined as Quality food, as neither have large numbers of salmon nor does the area contain large amounts of high or very high capable habitat.

Lethal Encounter indicators:
This indicator combines the front country indicator with areas of higher hunter density days to highlight areas of human presence and higher proportion of hunters. This indicator is flagged if >20% of the LU is front country and there is a high average annual hunter day density.

Neither of the assessment LU's are flagged for either the front country or the hunter day density indicators and therefore are not flagged for the lethal encounter indicator.

Comparison of Option 1 and Option 2 CE Assessment for Grizzly bear:

Ecological Importance/Grizzly Bear Habitat Capability

Ecological importance is **high** across the assessment area because the entire area is some level of capable grizzly bear habitat; however much of the area falls into lower capability classes with both Option 1 and 2 crossing areas of moderate and low capability (see Figure 15). At a landscape level, the area is important habitat as grizzly bears have considerable variation in the food sources they access across their home ranges and throughout the seasons. This results in significant seasonal movement across the landscape as bears move between areas of abundant food sources (FLNRO, 2014). Because of their large home range sizes and the importance of highly productive, site-specific habitats within that range, linear developments such as roads or extensive habitat alteration at the landscape level can disrupt connectivity. This disruption can affect population viability as bears must be able to disperse to form a widespread, low density but connected sub-regional and regional population (Dawson, et al. 2015).

Local site investigation should be completed to ensure important areas for grizzly bears such as winter denning sites, berry or foraging sites, mark trees, mark trails, bedding areas, wallows etc. are identified. Should a decision be made to proceed with either road option, site investigation should identify any critical areas and all measure to ensure avoidance of important habitats be committed to.

Hazards

Existing hazards for grizzly bears across the assessment area are **low** as a result of low disturbance activities and low human populations in the surrounding areas. Areas of secure core (areas classified as >10km^2 without roads) and effective habitat exist across the assessment area, however there is risk that Option 1 or 2 will create new roads through this area. While the building of Option 1 or 2 will increase road densities through this area, it is the associated roads that will come to support forest harvesting, recreation and other activities that will further increase risk to grizzly bear habitat effectiveness and mortality risk across this area.

While the focus of the Cariboo CE tool is on indicators for grizzly bear habitat, the assessment also provides insight into grizzly bear mortality risks associated with human development and access. As discussed by Proctor, et al. 2018, in areas where humans and bears overlap, a large majority of grizzly bears over age 2 are eventually killed by people and almost all are killed near roads (not from vehicle collision but by hunting/poaching/human-bear conflict). Although not included in the CE assessment methodology, additional road density information is available: the greatest road density is associated with Upper Dean sub-unit A with a 0.65 km/km^2 density. Research has suggested that there is a maximum or threshold road density of 0.6 km/km^2 for a “naturally functioning landscape containing sustained populations” of large mammals. Above this threshold, Forman et al. (1997) (cited in Beazley et al. 2004) found some large mammal populations decline due to disturbance effects and increased mortality. Proctor et al. 2018 summary of work surrounding grizzly bear populations in BC and Alberta found that the optimal threshold road density was ~0.5km/km^2 (range 0.4-0.6) and that grizzly bear densities were 3-4 times higher in habitats with road densities <0.6 km/km^2 than in habitats with >0.6 km/km^2.

Current Mitigation

Current mitigation throughout this area is limited to the parks and protected areas provided by Tweedsmuir Provincial Park and Itcha Ilgachuz Provincial Park as well as some modified and no harvest restrictions provided by the CCLUP (see Figure 17). There are no established or proposed Wildlife Habitat Areas (WHA) for grizzly bear through the assessment area.

Proposed Mitigation Measures:

If a decision to complete the Anahim Connector road is made, mitigation measures should be developed to include deactivation and road rehabilitation to ensure grizzly bear habitat areas are maintained and increased to ensure secure core areas exist. Access mitigation planning should include looking for areas where larger core habitat areas can be created with travel corridors connecting the existing habitats. As increased forest harvesting rates may result from the development of this connector road, further protection should be implemented to ensure the local wildlife populations are not impacted and habitat requirements are maintained. Habitat mitigation strategies for work in bear habitat must focus at each of the landscape level, stand level and smaller-scale feature or habitat-element level, taking into consideration local grizzly bear movements, which may vary somewhat in timing, depending on conditions in any given year (FLNRO, 2014).

In addition, planning efforts should consider the potential impacts of bears shifting into surrounding areas in order to avoid the activity of the Anahim Connector road area. This may lead to increased bear-human or bear-livestock conflicts in surrounding areas that leads to increased mortality risk for bears. Discussion with and educational tools for local communities and the agriculture sector may help prevent an increased risk of bear mortality.

Hydrologic Stability

CE Background:

The Cariboo Region's CE assessment tool includes an assessment of hydrologic stability which is a critical feature of watersheds affecting the quality, amount and timing of water flows which in turn affect fish and other aquatic organisms, human water use, built structures and the stability of watercourses (Dawson, et al. 2015). The assessment evaluates the factors that affect stream flow and sedimentation risk.

Like the other values, the Hydrologic stability assessment is based on three categories to determine overall risk: Ecological Importance, Hazard and Current mitigation. **Ecological Importance** is assessed in relation to the value of the hydrologic units for fish. The indicators related to **Hazard** look at the inherent sensitivity of the area and the current hazard potential related to streamflow and sedimentation. The sensitivity score evaluates the physical characteristics of the unit that makes it more or less prone to negative effects from development. The hazard rating combines the sensitivity rating with land use factors to assess the likelihood of hydrological problems. The **Current Mitigation** assessment looks at the level of protection of forested lands from existing protections, including CCLUP no-harvest and modified harvest designations.

The hydrologic stability tool provides assessment units across a hierarchical scale of watershed units: Super Watersheds, Large Watersheds, Watersheds, Basins, Sub-basins and Residual Units. For this assessment, two basins were selected for interpretation as they provide the best assessment of the inherent sensitivities and risks associated with the area of the proposed Anahim Connector road options: Tanswanket Creek and Upper Blackwater basins (Figure 18).

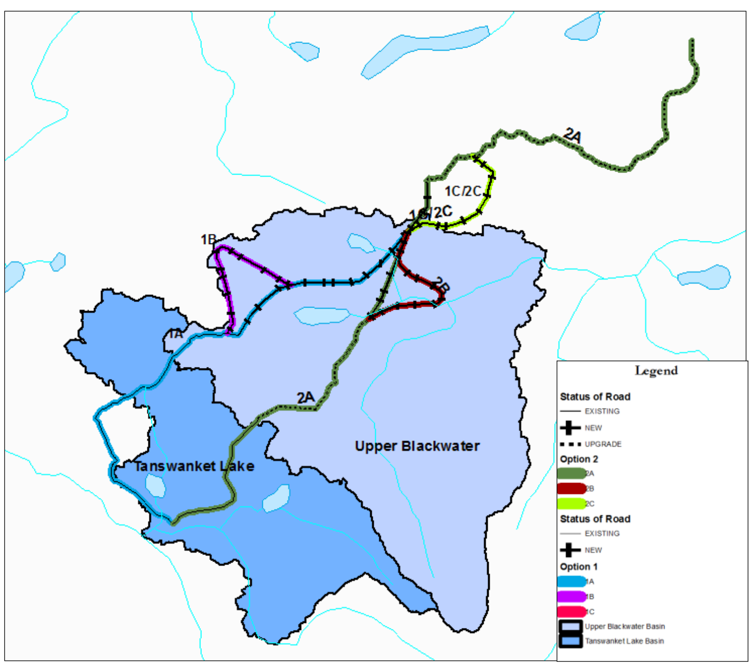

Figure 18. Basins Overlapping the Assessment Area

Reporting Name	Fish Value Rating	Streamflow Sensitivity	Streamflow Hazard	Sediment Sensitivity	Sediment Hazard	Current Mitigation	ECA
Tanswanket Creek	no data	L	VL	M	VL	L	17.47

Reporting Name	Fish Value Rating	Streamflow Sensitivity	Streamflow Hazard	Sediment Sensitivity	Sediment Hazard	Current Mitigation	ECA
Upper Blackwater	no data	L	VL	M	VL	M	7.78

CE Summary

Ecological Importance

For the Hydrologic Stability assessment, importance of the unit for fish habitat is used as the indicator for Ecological Importance. However, the CE fish value assessment has not yet been completed for the west Chilcotin area of the Cariboo Region and a fish value rating is not available. Regional fisheries biologists (L. Williston, personal communication, September 5, 2018) provided the following:

- Lack of recent information with regards to status of current fish habitat,
- Surveys conducted in the late 1970's identified spawning and rearing rainbow trout in streams throughout these watersheds. If the road is approved, habitat associated with proposed stream crossings should be assumed to be providing critical fish spawning and rearing functions until proven otherwise,
- Historical surveys (late 1970's) verified the presence of rainbow trout, bull trout, northern pikeminnow and suckers within these watersheds (Figure 19).

Hazard

Streamflow Sensitivity

Streamflow refers to water flowing in, or discharging from, a natural surface stream, and ***streamflow sensitivity*** refers to how responsive or readily affected streamflow in a particular catchment is to land use activities and natural disturbance (Lewis, et al. 2012 as referenced in Dawson, et al. 2015). Streamflow sensitivity is **low** across both assessment units – **Tanswanket Creek** and **Upper Blackwater** basins. This assessment is based upon 1) the climate of the area and in particular the precipitation regime as it affects annual runoff and spring freshet or peak flows, and 2) vegetation cover, which affects the amount of precipitation that reaches the ground and is available for runoff (Dawson et al. 2015). A finding of low streamflow sensitivity identifies that regardless of any land use disturbance this area is less likely than other areas to experience streamflow issues.

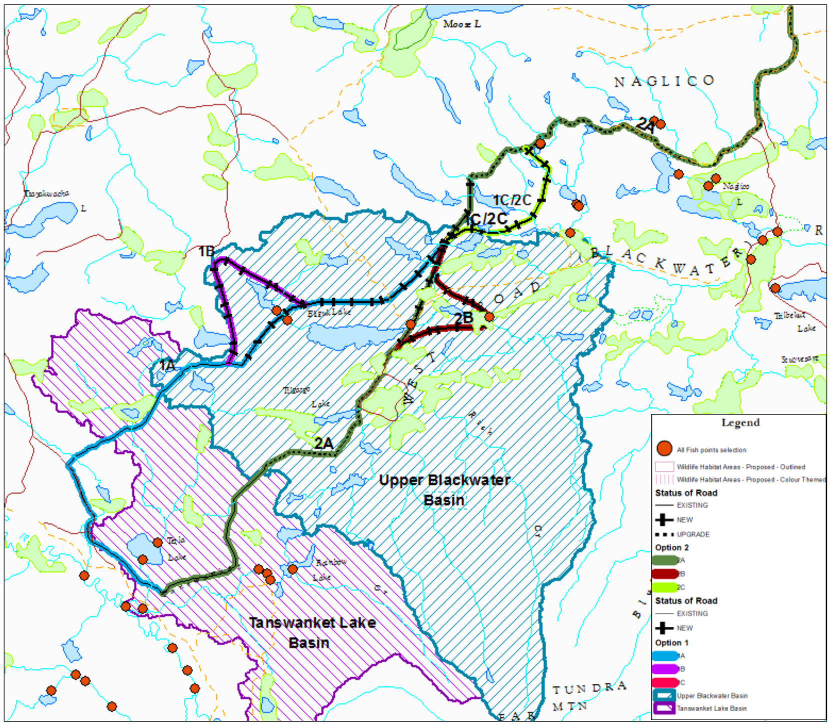

Figure 19. Fish Observations within the vicinity of Option 1 and 2.

Streamflow Hazard

Overall streamflow hazard across **both basins** is assessed to be **very low**. Streamflow hazard refers to the likelihood that harmful changes in streamflow will result from current land use activities. This takes into consideration the natural sensitivity of the area to streamflow impacts as well as runoff attenuation which refers to how efficiently runoff is slowed, captured and stored as it is routed through the basin. Runoff attenuation is determined by 2 indicators: Drainage Density Ruggedness (DDR) and Absence of Lakes and Wetlands. DDR indicates the potential for rapid runoff delivery to and through streams, which may contribute to harmful flood events and is based on stream density (km/km^2) and elevation relief. The presence of lakes, ponds and wetlands in a watershed can have an attenuating influence on peak flow discharges. The second indicator reflects the attenuating capacity of the lakes and wetlands to buffer peak flow response. To account for land use activities, in this case forest canopy loss, the Equivalent Clearcut Area (ECA) indicator is used to determine the area over the assessment unit in which a reduction in forest cover has occurred that is hydrologically equivalent to a recent clearcut. The ECA for the **Tanswanket Creek** basin is 17.47% and for **Upper Blackwater** is 7.78%. It is recognized, depending on the area, peak flows typically increase once ECA values exceed 20% (Dobson, 2007).

Sedimentation Sensitivity

Sediment sensitivity refers to the potential for sediment to be generated when affected by land use activities. Sensitivity is determined by looking at 3 indicators: 1) erodible soils, 2) steep coupled slopes, and 3) absence of lakes and wetlands (described above). The erodible soils indicator estimates the potential for soil erosion to occur based on the soil data information available for the assessment unit (Figure 20). The steep coupled slopes indicator estimates the potential for sediment to be generated from land use on potentially unstable terrain and to enter a stream. It is based upon steep (>50%) slopes that are hydrologically connected to streams. The sensitivity to sedimentation of both the **Tanswanket Lake** and **Upper Blackwater** basins is **moderate**.

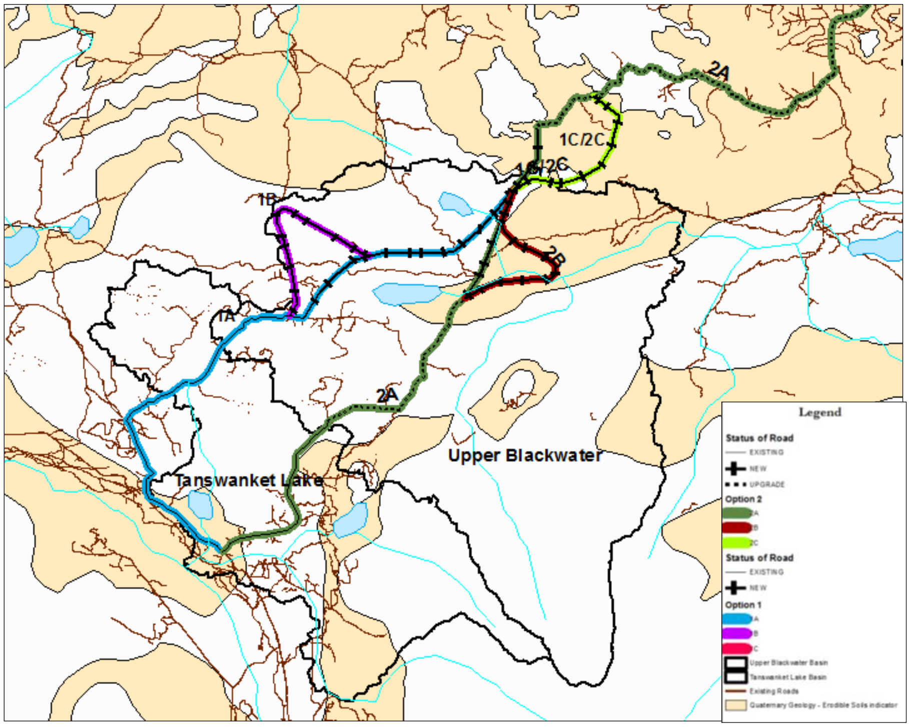

Figure 20. Erodible Soils Indicator

Sedimentation Hazard

The sediment hazard assesses the likelihood that harmful levels of sediment will be generated from existing land use activities, enter into a stream and be delivered downstream. It is based upon the inherent sensitivity of the basin to sediment (described above) and an assessment of current land use disturbance, based upon 3 indicators, 1) roads close to water [road length within 50m of a stream per unit area 9km/km^2)], 2) roads on steep coupled slopes [% total road length (km) on steep coupled slopes (km/km^2)], and 3) disturbance on gentle over steep [estimated area of logging on gentle slopes (<50%) immediately above steep slopes (>50%) coupled to streams]. Sediment hazard for both the **Tanswanket Lake** and **Upper Blackwater** basins is **very low**.

Current Mitigation

Current mitigation assesses how much of the forested land across the assessment unit is overlapped with some form of legal protection (i.e. parks and protected areas, CCLUP harvest restrictions (i.e. OGMA, MDWR, caribou harvest restrictions, critical fish habitat, etc.)). This identifies the likelihood that further impacts may occur depending on the amount of legal protection already in place. Current mitigation assessment for the **Tanswanket Lake** basin is **low** and **for Upper Blackwater** basin is **moderate**. The Upper Blackwater has more protections in place associated with a greater portion of the unit overlapping with CCLUP caribou no harvest and modified harvest protections as well as the overlap with the Itcha Ilgachuz Provincial Park (Figure 21).

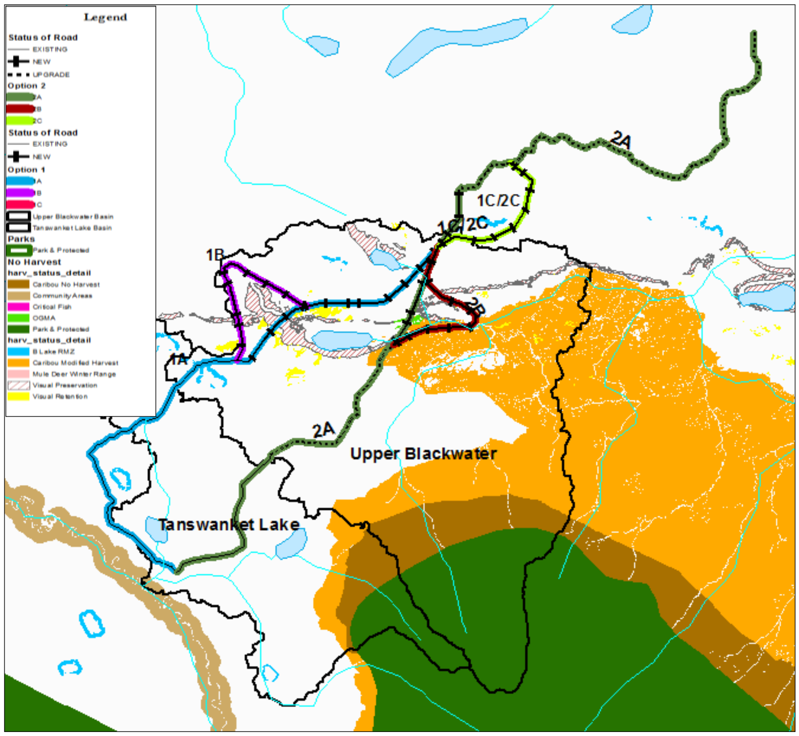

Figure 21. Current Mitigation for Hydrologic Assessment Area

Comparison of Option 1 and Option 2 CE Assessment for Hydrologic Stability

Ecological Importance/Fisheries Values

While the CE tool's fish value assessment has not been completed for the western areas of the Chilcotin, regional fisheries staff and historic fisheries assessment have documented fish spawning and rearing habitat as well as the presence of rainbow and bull trout and other fish species throughout the assessment area.

Options 1 and 2 both require crossing of Ulgako Creek which is known to support fisheries values. Further potential concern identified by regional fisheries biologists related to an increase in angling activity in the Upper Dean River area if either route options are built. Currently access to this area is via Highway 20 from Williams Lake with 3+ hours of travel time. The Anahim Connector road would provide quicker access to this area from northern communities which may result in an increase in anglers utilizing the area.

Hazard

Sedimentation hazard across the assessment basins are rated as **low** based on the existing amount of disturbance from road building, forest harvesting and development across the area. The sensitivity of the area for sedimentation risks however is assessed to be **moderate** and therefore should road densities and development increase, this area will be more susceptible to increasing sediment impacts. Should road building or other development proceed, local site investigation and GIS available information (as provided in Figure 20) should be used to guide and design development activities to ensure sedimentation hazard does not increase.

Steep slopes (>50%) don't appear to be an issue in the area of either Option 1 or 2; however both sections of 2B and 1C/2C are proposed through the quaternary deposit layer (Figure 20, 22). Quaternary deposits are often glacio-fluvial or glacio-lacustrine sedimentary deposits that lack cohesion and are highly prone to erosion. Field experience has shown that quaternary deposits are a continuous and problematic source of sediment generation and delivery where they occur in the southern interior (Lewis, et al. 2016).

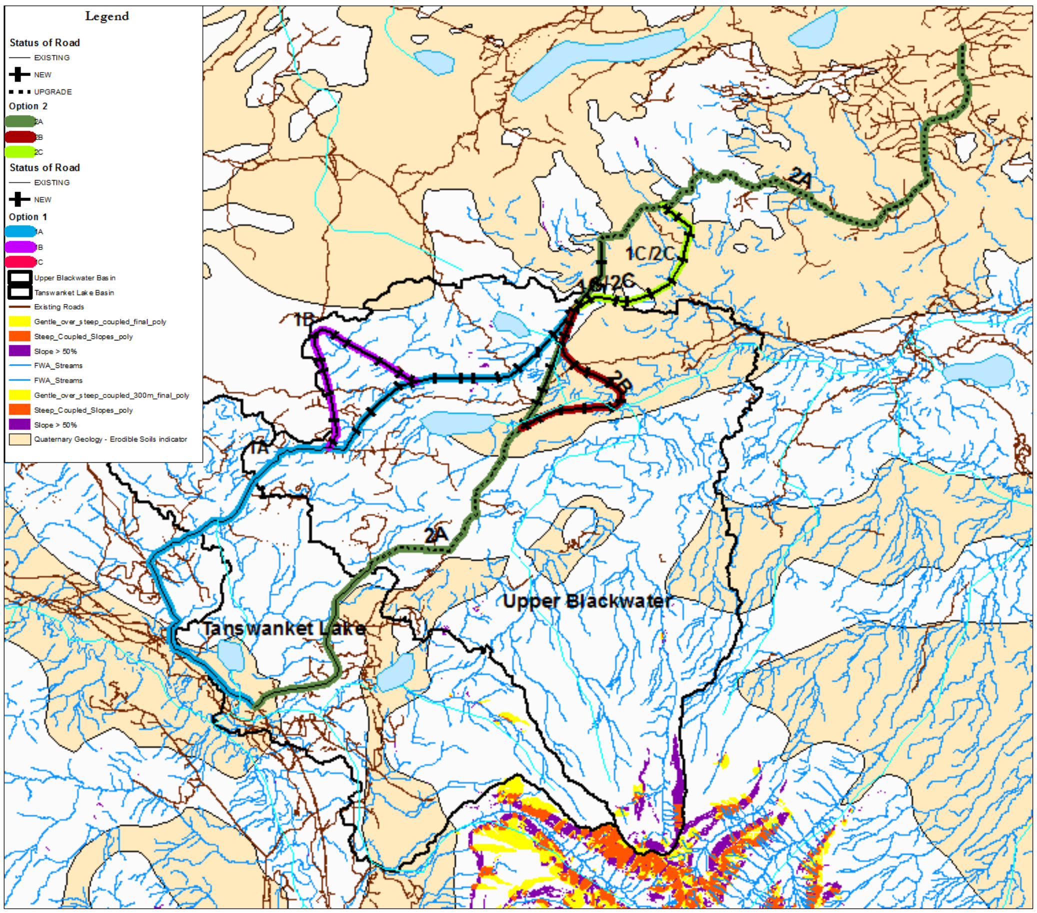

Figure 22. Sedimentation and Streamflow Indicators

Current Mitigation

Current mitigation throughout this area is limited to the parks and protected areas provided by Tweedsmuir Provincial Park to the west and Itcha Ilgachuz Provincial Park to the east as well as some caribou modified and no harvest restrictions – none of which overlap with the proposed route options 1 or 2.

Proposed mitigation:

If a decision is made to build either option 1 or 2, site investigation should be completed to identify and avoid any important or sensitive areas with respect to aquatic resources. Considering appropriate permitting and best practices are followed for any stream crossings, culvert or bridge placements, impacts should be minimal.

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2. Proposed Anahim Connector Road Risk Assessment and Mitigation Report

Woodland Caribou (*Rangifer tarandus*)

Prepared by:
Cariboo Region Caribou Technical Committee
Ministry of Forests, Lands, Natural Resource Operations
and Rural Development
10/23/2018

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Contents

1 Executive Summary

The Anahim Connector Road will have significant negative impacts to the Itcha-Ilgachuz, Rainbow and Tweedsmuir caribou herds. A significant negative impact is defined by a high or moderate likelihood of impacts from the road contributing to further caribou population declines. These negative impacts are not possible to fully mitigate and are likely to lead to further decline in these threatened populations. The route will create a barrier to caribou movement across the migration corridor that connects the three caribou herds due to caribou avoidance of roads. Population connectivity is critical to the survival of metapopulations, and isolated populations are more likely to become extinct. Additional negative impacts include functional habitat loss from habitat avoidance, direct habitat loss, increased mortality from increased predation, increased mortality from increased hunting, and increased mortality from vehicle collisions. An overall increase in cumulative disturbance in critical caribou habitat is associated with the loss of caribou populations. The increase in cumulative disturbance within critical habitat from the Anahim Connector expands beyond the area of proposed construction because of the expected increase in traffic, human presence and timber harvesting along the length of the roads within critical habitat that connect to the Anahim Connector, notably the Dean River Forest Service Road.

Seasonal road closure is the primary option to partially mitigate the impacts to caribou. However, significant negative impacts to caribou populations still exist even with seasonal road closures. This is for two main reasons. First, caribou cross the road corridor during multiple seasons to move between calving grounds and winter range. Second, the proposed road is 3.5 km away from low-elevation summer habitat which is used by the caribou for calving. Predator densities in and access to this sensitive habitat will increase once the road is built, which will lead to increased calf mortality. Increased predation rates will not be mitigated by seasonal road closures. Road closures will be effective at reducing mortality from vehicle collisions and functional habitat loss, as caribou avoid inactive roads

to a lesser degree than active roads. However, vehicle collisions causing significant population decline is of lower concern in comparison to other impacts.

In summary, the impacts of the Anahim Connector road to this threatened caribou metapopulation are highly negative and cannot be effectively mitigated. The proposed construction and upgrades for the Anahim Connector route are entirely within some of the little remaining undisturbed critical low-elevation winter range for these caribou herds. The habitat surrounding the proposed road construction and upgrades is likely to become more important to caribou, especially the Tweedsmuir herd, as a migration corridor to intact habitat and low-elevation winter range following the recent fires in North Tweedsmuir and Entiako Provincial Parks. Tweedsmuir caribou have increasingly used the habitat near the proposed Anahim Connector route since fires in 2014 and 2018 burned most of their low-elevation winter habitat. Although the Itcha-Ilgachuz herd is in steep decline, it is an important herd for the recovery of caribou in British Columbia as the largest remaining herd in the Southern Mountain National Ecological Area (SMNEA). In addition, all impacted caribou herds are vital to conserving the spatial extent of caribou in Canada as the only remaining caribou herds in west-central BC. In recognition of their high conservation value, costly and controversial lethal predator removal is being considered to recover the Itcha-Ilgachuz and Tweedsmuir herds. The success of this work will be hampered by the negative impacts of the Anahim Connector road.

2 Assessment Boundary

The spatial boundaries of the assessment to woodland caribou include the following:

- Local Study Area (LSA): a 2 km buffer on either side of the proposed route, based on a 1.8 km average avoidance distance by woodland caribou of active roads.
- Regional Study Area (RSA): the Environment and Climate Change Canada (ECCC) critical habitat boundaries for the Itcha-Ilgachuz, Rainbow and Tweedsmuir caribou herds. All habitat for the impacted caribou herds is included in the RSA to consider the landscape context and cumulative effects of the Anahim Connector Route on caribou.

3 Caribou population trends

3.1 Itcha-Ilgachuz Population Trends

The Itcha-Ilgachuz herd is one of the most southerly distributed populations within the distribution of the northern mountain caribou ecotype (Figure 1). Their 9,457 km^2 range lies in the northwestern

Cariboo Region and encompasses the Chilcotin Plateau, and the Itcha and Ilgachuz Mountains in the Fraser Plateau ecoregion (Goward 2000). Animals are separated from the Rainbow herd to the west by the Dean River, and from the Charlotte Alplands herd to the southwest by the Highway 20 corridor. Animals from the Itcha-Ilgachuz, Rainbow and Charlotte Alplands herds occasionally share common winter range. They are separated from the Tweedsmuir herd to the north by the valley south of Moose Lake. The Itcha-Ilgachuz caribou spend winters both in montane forested habitat south and east of the Itcha Mountains, and in subalpine habitat in the Ilgachuz Mountains (Cichowski 1993 and 2007)

The Itcha-Ilgachuz herd has been monitored through a combination of spring post-calving, fall rut, and late-winter recruitment surveys. Population estimates are derived from sightability corrected total count aerial surveys completed in the spring after calving (June). Caribou telemetry indicates that the highest proportion of the herd is utilizing high elevation habitat in June, making the caribou easier to locate, count, and classify. The Itcha-Ilgachuz caribou population estimate increased from a low of 350 in 1977 to a peak of 2800 in 2003 (Dodd 2017). A portion of the increase is likely a result of improved survey methodology over that time. Since 2003 the population has steadily declined (Figure 1).

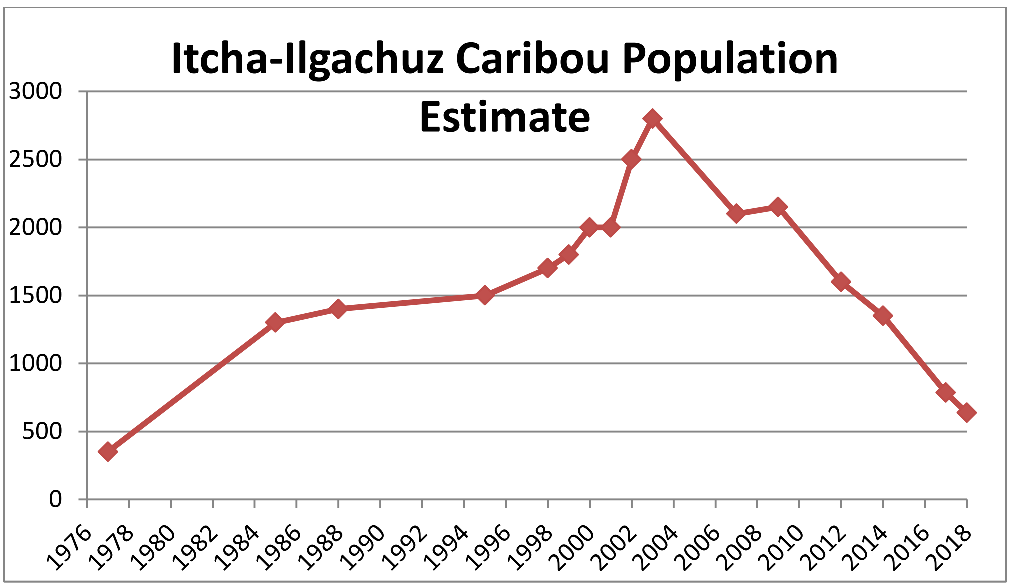

Figure 1. 1977 to 2018 Itcha-Ilgachuz caribou herd estimate from spring aerial surveys.

The 2018 population estimate is 637, down 53% from the 2014 estimate of 1350. The 2018 population estimate is a decrease of 77% when compared to the peak count in 2003. The recent (2014-2018) average annual rate of change is -17%. The Itcha-Ilgachuz post-calving percent calves has been relatively stable from 1982 to 2017, averaging 26% (Figure 2). The 2018 post-calving percent calves was 10%, significantly lower than the historic average. The cause of this abnormally low calf abundance is unknown, although possible links to *Neospora caninum,* a parasite previously shown to cause abortions in livestock, are being investigated.

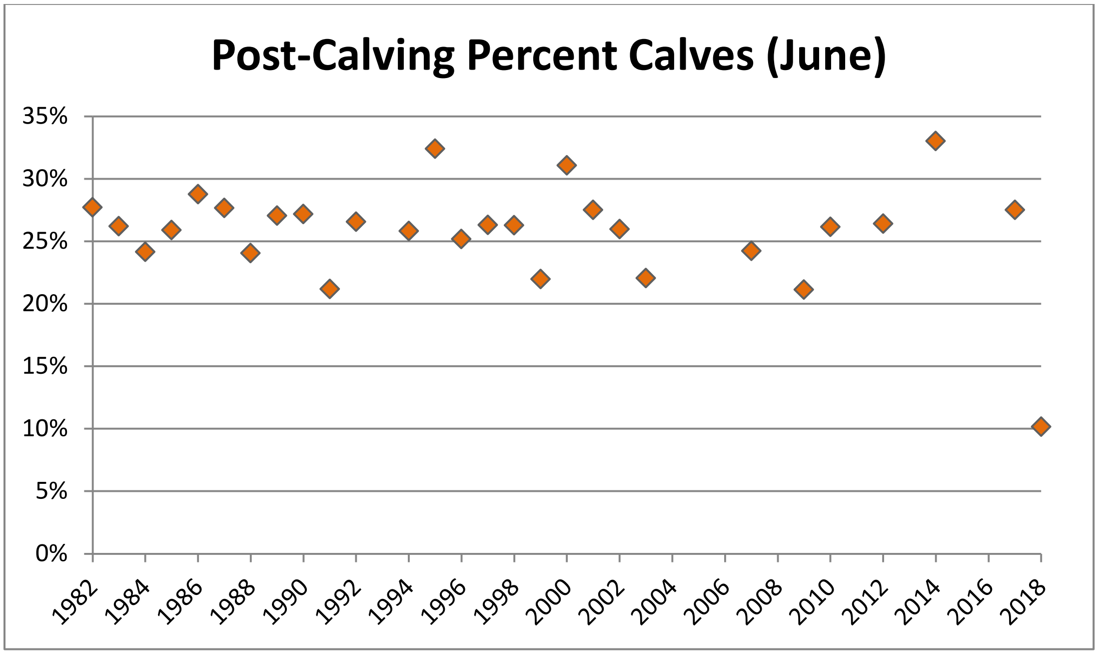

Figure 2. Post-calving percent calves for the Itcha-Ilgachuz caribou herd from 1982 to 2018.

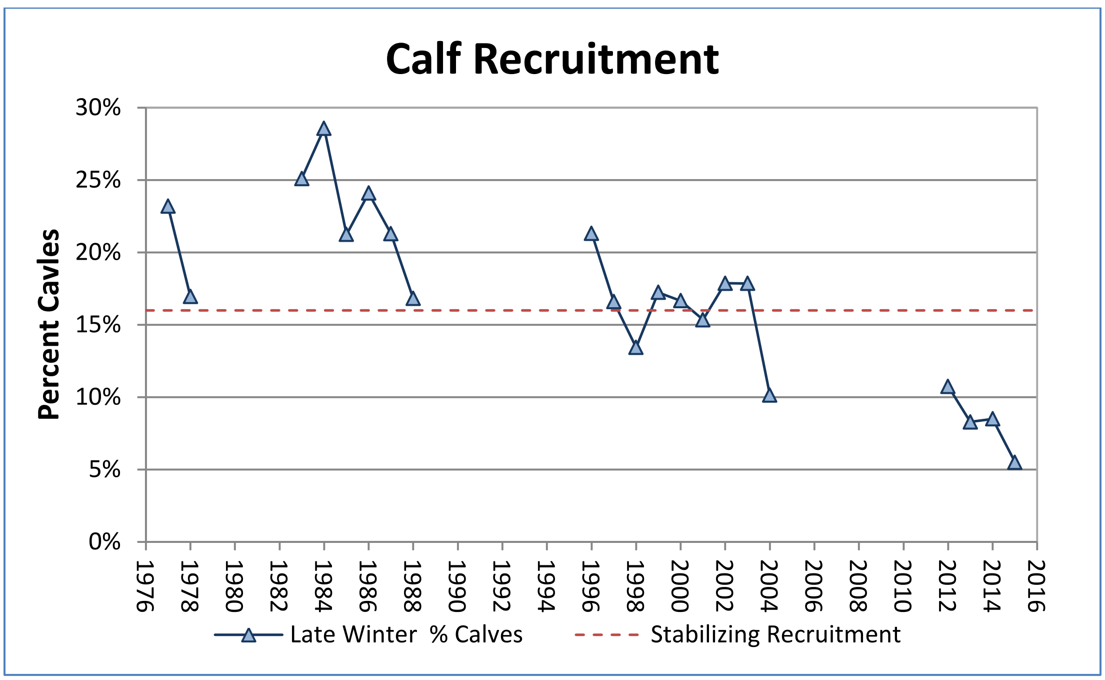

Figure 3. Late winter calf recruitment for the Itcha-Ilgachuz caribou herd from 1977 to 2015, estimated as the percent of calves in the number of caribou counted in aerial surveys in late winter (March).

Caribou populations generally increase when annual recruitment rates exceed the 15-16% required to balance natural adult mortality and maintain population stability (Bergerud, 1992). The annual calf recruitment for the Itcha-Ilgachuz caribou, as measured during late winter surveys, has decreased sharply since 2003 (Figure 3). Between 1996 and 2003, a period of population increase for the Itcha Ilgachuz herd, annual calf recruitment averaged 17%. Between 2012 and 2015, a period of population decline, annual calf recruitment averaged 8.2%. This sharp decrease in annual recruitment suggests a reduction in calf survival is contributing to overall population declines. Given the abnormally low post-calving percent calves observed in spring 2018, and recent decreases in calf survival from June to March, the calf recruitment in March 2019 is likely to be extremely low, resulting in possible reproductive failure for the 2018/19 biological season.

The Itcha-Ilgachuz herd is currently managed under a Limited Entry Hunting (LEH) season for 5-point or larger bulls for residents, and a quota system for guide outfitters. Under the LEH system, an interested hunter must apply to the LEH lottery and be successfully draw to be able to legally hunt. The LEH season was implemented for the 2017 hunting season following population decreases observed during the 2014 survey. Prior to 2017, the Itcha-Ilgachuz licensed harvest was managed under an open season for 5-point or larger bulls and quota for guide outfitters. The licensed harvest has averaged 19.4 bulls per year from 2009 to 2016. The 2017 harvest, under LEH, was 3 bulls (Table 1). The 2017 harvest was likely influenced by the 2017 wildfires; reducing hunter participation and access to Itcha-Ilgachuz Park. Serious consideration is being given to stopping the caribou hunt due to the steep decline and low calf recruitment in the population. A government decision regarding suspension of the Itcha-Ilgachuz licensed hunt is expected in late November 2018.

Table 1. Licensed Itcha-Ilgachuz caribou harvest from 2009 to 2017.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Licensed Harvest	23	18	22	19	16	15	26	16	3

For the Itcha-Ilgachuz caribou, the primary known cause of mortality has been wolf predation, which makes up at least 33.3% (n=7) of known mortalities (n=21) (Table 2), and up to 42.8%, if probable wolf predations (n=2) are included. Determining known causes of mortality for this herd has been challenging, however, as "rapid response" mortality investigations were not a priority in earlier radio-collaring studies for this herd.

Cause of mortality	1985-88	1995-2003	2011-14	2018	Total	% of known or probable mortalities (n=22)
Predation - Wolf	3	3		1	7	31.8
Predation - Cougar			1	1	2	9.1
Predation - Bear					0	0.0
Predation - Wolverine					0	0.0
Accident		1			1	4.5
Hunting		1	1		2	9.1
Poaching	1				1	4.5
Hunting or Poaching			1		1	4.5
Probable bear predation	1			1	2	9.1
Probable wolf predation				2	2	9.1
Probable poaching			1		1	4.5
Not predator related	1	1		1	3	13.6
Total known or probable	6	6	4	6	22	NA
Unknown		8	10	1	19	NA
Total	6	14	14	7	41	NA

Table 2. Causes of mortality of radio-collared Itcha-Ilgachuz caribou from 1985 to present. Mortalities compiled from McNay and Cichowski 2015 and from mortality investigation forms completed by Cariboo regional biologists from 2015-2018.

3.2 Rainbows Population Trends

The Rainbows herd's 310,128 hectare range encompasses high elevation habitat in the Rainbow Range and low elevation wintering habitat north of Charlotte Lake and west of the Dean River corridor. Additional wintering habitat is located on the northern slopes of the Ilgachuz Range. Animals are generally separated from the Itcha-Ilgachuz herd to the east by the Dean River although telemetry studies have documented multiple movements between the Rainbow Range and Ilgachuz Range. The Rainbow herd is separated from the Tweedsmuir herd to the north by Eutsuk and Tetachuck Lakes, which are manmade lakes created by the Nechako/Alcan dam. The populations were likely more connected before the creation of these lakes.

The Rainbows herd has been monitored through a combination of spring post-calving, fall rut, and late-winter recruitment surveys. The population estimates are derived from aerial surveys conducting in the fall (October). The Rainbows' population estimate has been decreasing since a peak estimate of 175 in 1995. The most recent population estimate, from 2016, was 40 animals, down 20% from the 2008 estimate of 50 animals (Figure 4). The long term (three generation) trend for the Rainbows herd is *declining*, as defined by Thomas and Gray (2002), with an average annual rate of change of –6.4% (1996-2016). The Rainbows' post-calving percent calves has shown high variability with a low of 14% in 1997 and a high of 45% in 1987 (Figure 5). The current percentage of calves in the population immediately after calving in June is unknown as the last spring survey was completed in 2001. Annual calf recruitment for the Rainbows caribou, as measured during late winter surveys, is available from 1996 through 2003 (Figure 6). Recruitment averaged 10%, with 7 out of 8 surveys indicating recruitment well below levels required to maintain a stable population.

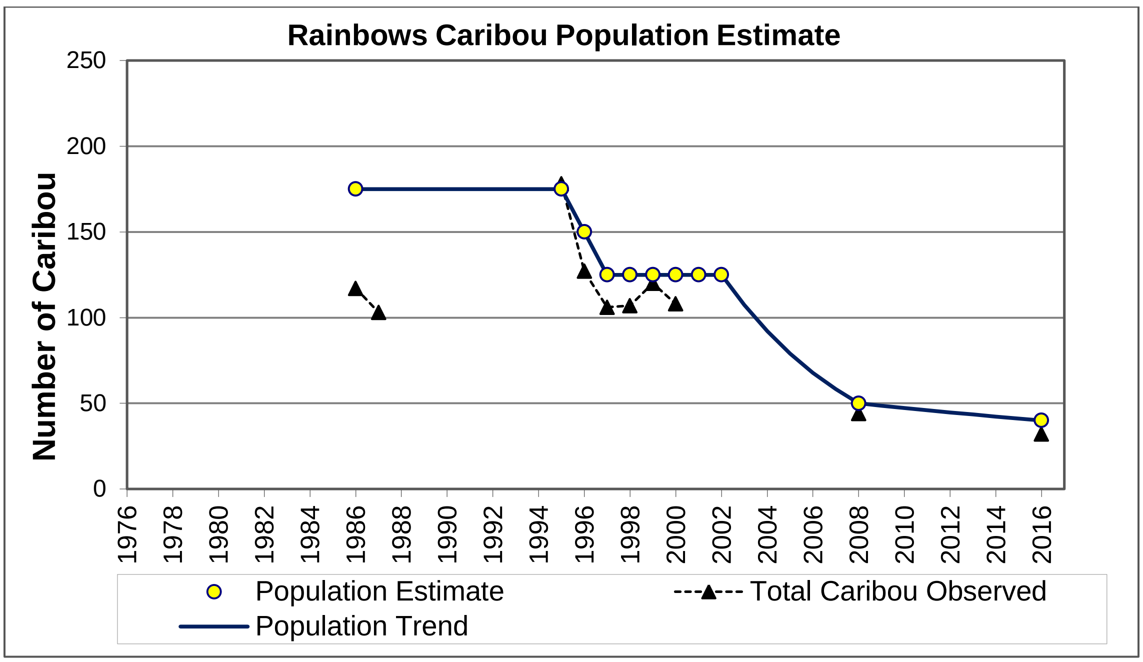

Figure 4. Total observed caribou and population estimates for the Rainbows caribou herd from 1974 to 2016.

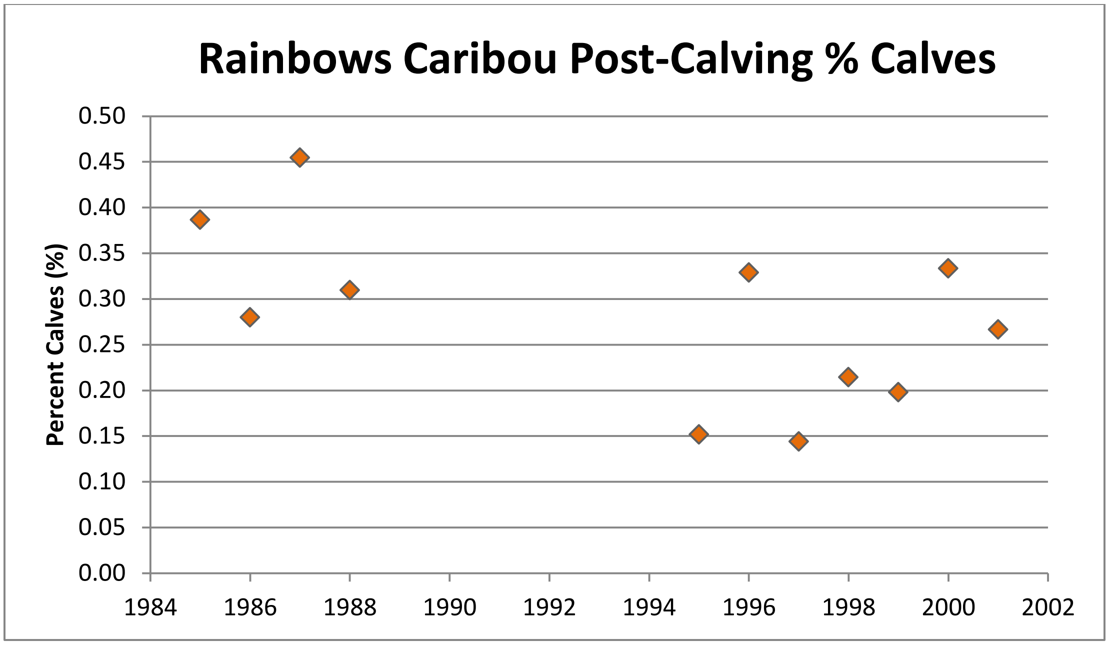

Figure 5. Post-calving percent calves for the Rainbows caribou herd from 1985 to 2001.

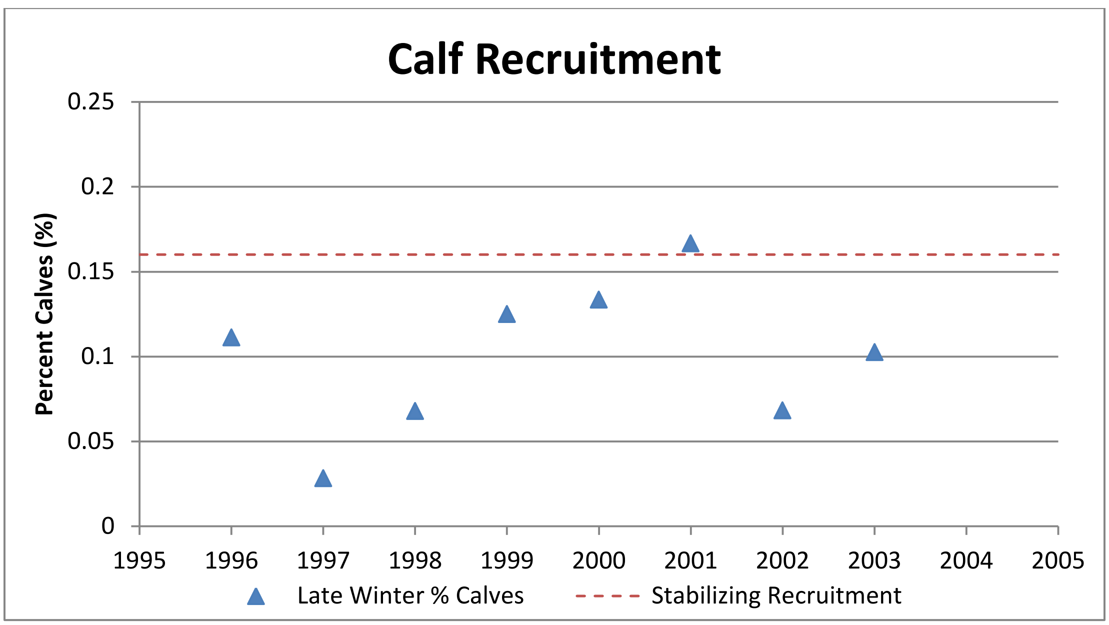

Figure 6. Late winter (March) calf recruitment for the Rainbows caribou herd from 1996 to 2003.

3.3 Tweedsmuir Population Trends

The Tweedsmuir Caribou Herd is a migratory herd, typically occurring in northern Tweedsmuir Park and throughout the western portion of the herd range in the spring, summer and fall and in the East Ootsa and Entiako Park and adjacent forest to the east and south during the winter. In winter, Tweedsmuir caribou use both low elevation mature pine-lichen forests, often in complex with low elevation wetlands, and higher elevation mature coniferous forests. The range of the herd covers approximately 1,760,000 ha, with over 1 million ha protected within Tweedsmuir Park, Entiako Park, and Huchsduwachsdu Nuyem Jees/ Kitlope Heritage Conservancy.

The status of the Tweedsmuir caribou population can be difficult to determine because a significant part of the population may be below treeline at any given time (Cichowski, 2015). Several survey methods have been used, however, population estimates are largely derived from aerial surveys conducted in the fall (October), when a larger proportion of the herd is in high elevation habitat and easier to locate. One of the earliest population estimates was 600 animals in 1963 (Cichowski, 2015). This estimate decreased to 200-300 animals in 2003 and subsequently, to 150-200 in 2015 and ~185 in 2017 (MFLNRO Skeena, 2017). Adult female caribou mortality rates have been consistently moderate to high, while calf recruitment rates have been low to moderate over the course of the most recent monitoring period (MFLNRO Skeena, 2017; Roberts, 2016). Population estimates from 1963 to 2017 are available for this herd (Figure 7).

In contrast, the most recent fall survey (October 2017) resulted in a minimum count of 146 caribou, an increase from the 94 counted in 2013 (Roberts & Grant, 2017). Furthermore, 24% of the total count were calves (Roberts & Grant, 2017), well above the 15% suggested for a stable population (Bergerud, 1996) and a significant increase from the 2016 survey where calves were 14% of the total count. Annual calf recruitment for the Tweedsmuir caribou, as measured during late winter surveys, is available from 1990 through 2018 (Figure 8). Recruitment averaged 11% across all surveys throughout this time period, with 13 out of 17 surveys indicating recruitment well below levels required to maintain a stable population.

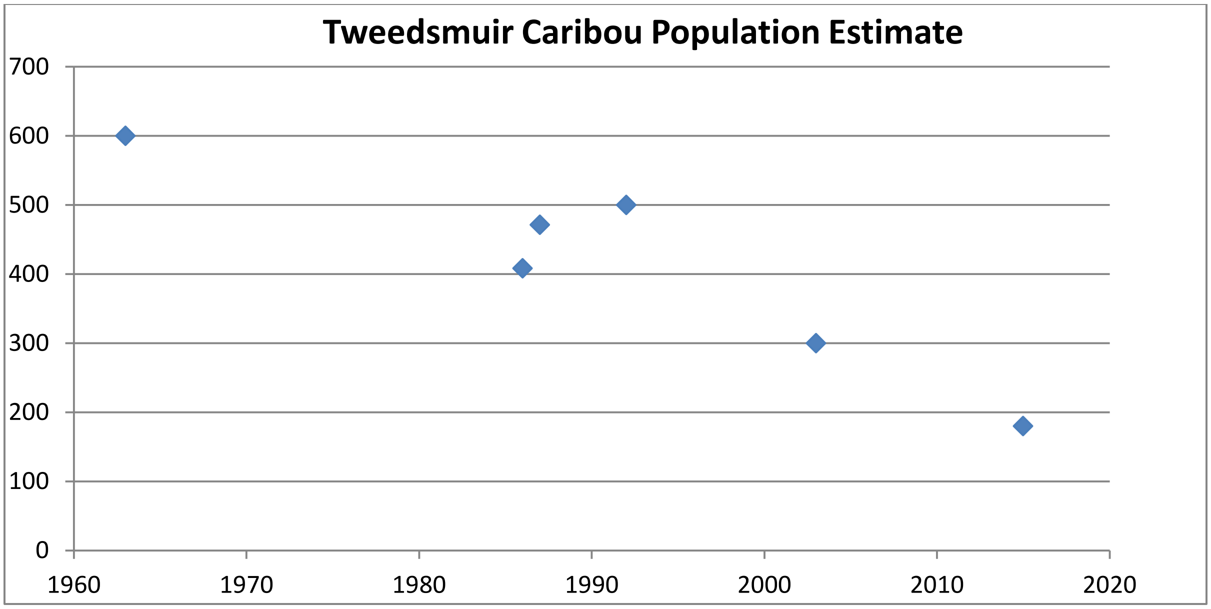

Figure 7: Tweedsmuir caribou population estimate) 1963 – 2015.

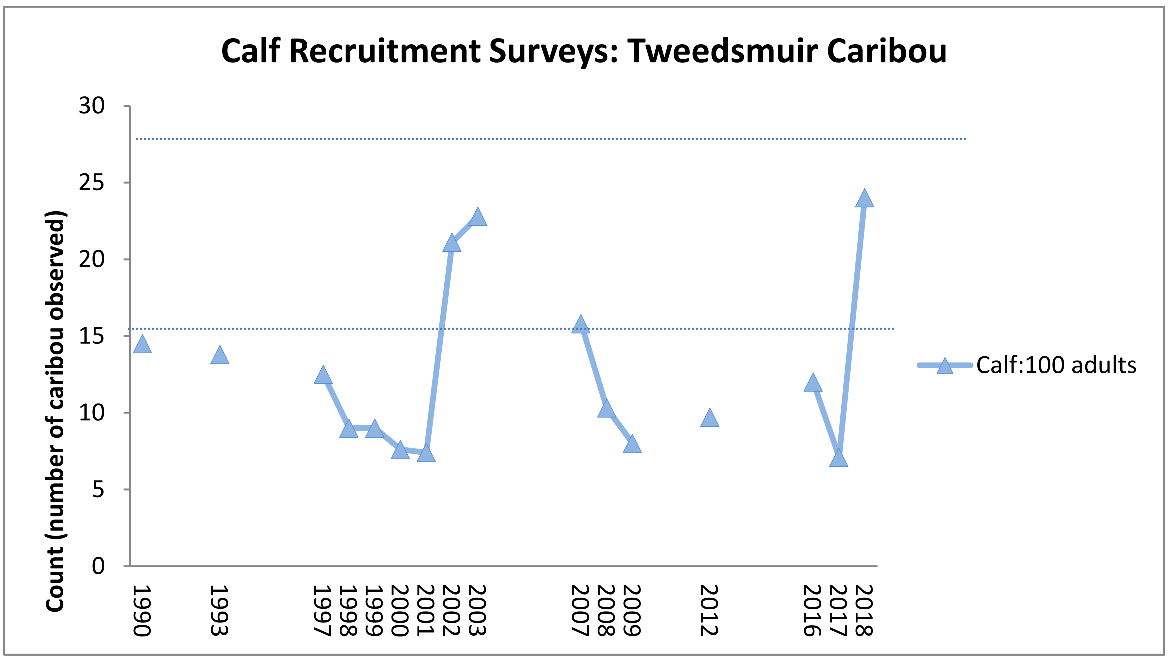

Figure 8. Late winter (March) calf recruitment for the Tweedsmuir caribou herd from 1990 to 2018.

Recent radio-collared data from the Tweedsmuir caribou range was used to estimate an annual survival rate of 0.786 for adult females, with the vast majority of known mortality causes being attributed to wolf (*Canis lupus*) predation. When combined with recent estimates of juvenile recruitment, these survival estimates yielded a population growth rate of 0.885, which suggests a rapidly declining caribou population (DeMars and Serrouya, 2018). A recent estimate of wolf density within known winter range of Tweedsmuir caribou was 26 wolves/ 1000 km2, a value almost four times greater than the upper range of values associated with caribou population persistence (e.g. ≤6.5 wolves / 1000 km2) (Apps, et al., 2018). Predation is thought to be the primary direct mortality factor in the observed decline over the past three decades (suspected 54% decline from 1983-2009; Cichowski 2015). In addition to wolves, a number of predator species are found within the Tweedsmuir caribou range and adjacent areas, including grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), wolverine, coyote and lynx (Cichowski 2015). Another notable finding in the most recent monitoring (2014-18), is the high proportion of predation mortality that occurred in winter (7 of 8 deaths). This timing is very unusual for caribou mortalities in British Columbia (Wittmer et al. 2005), including the previous monitoring of the Tweedsmuir population reported in Cichowski (2015). This new pattern suggests a major ecosystem change (DeMars and Serrouya, 2018).

4 Caribou Habitat

The proposed construction and upgrades for the Anahim Connector route are entirely within some of the little remaining undisturbed critical low-elevation winter range for these caribou herds. Critical habitat for these caribou herds was defined by Environment and Climate Change Canada and the province of British Columbia using GPS and VHF collar caribou locations (ECCC 2017). Caribou habitat in this region is under intensifying pressure due to both human-caused and natural disturbances. Two components of caribou habitat are considered essential for ensuring viable caribou populations: summer calving habitat and winter habitat. Caribou require large areas of suitable habitat that contain adequate available forage and security cover. There has been major habitat disturbance from extensive mountain-pine beetle kill and wildfire in the ranges of all three herds. The majority of the Tweedsmuir herd low-elevation winter range has burned in the last 10 years, including a large portion in 2018. Most of the Rainbows and Itcha-Ilgachuz caribou low-elevation summer and winter habitat is located outside of protected areas and is subject to logging. The area of proposed construction for the Anahim Connector road is within some of the only remaining intact low-elevation winter range for these caribou herds, and will likely become increasingly important. The habitat is especially critical to the Tweedsmuir herd as both a migration corridor to intact habitat in the Itcha-Ilgachuz Mountains and as some of their only remaining undisturbed low-elevation winter range. Undisturbed winter range has become rare for Tweedsmuir caribou because of large wildfires in the past 5 years and forest harvesting. While there are pockets of forested habitats that remain standing, much of this is fragmented from roads and harvesting. The proposed Anahim road route is located in one of the only remaining undisturbed areas of known winter range. Observed use since the 2014 fire confirms that caribou are continuing to use this area and that use in the area of the Anahim Connector route has increased and expanded.

The migration corridor is also critical habitat for both the Itcha Ilgachuz, Rainbow and Tweedsmuir herds as an area of herd range overlap which allows for mixing of individuals across herds. These overlap areas are key to the long-term viability of metapopulations as they facilitate genetic mixing and prevent isolation of small herds. For instance, Itcha-Ilgachuz and Rainbows caribou have been documented calving in the Rainbow Mountains in one year and in the Itcha-Ilgachuz mountain range the next year after periods of shared range use of the two herds in the Dean River area (Young and Freeman 2001). The additional and increasing use of the low-elevation winter habitat near the Anahim Connector by Tweedsmuir- Entiako caribou following the 2014 Chelaslie fire and 2018 fires in North Tweedsmuir and Entiako Provincial Parks further emphasizes the importance of this area to metapopulation viability.

4.1 Itcha-Ilgachuz habitat

Itcha-Ilgachuz habitat use

The Anahim Connector area is significant to the Itcha-Ilgachuz herd as critical low elevation winter habitat and as a migration corridor for Itcha-Ilgachuz caribou between Itcha-Ilgachuz and Entiako or North Tweedsmuir Provincial Parks. During the winter, Itcha-Ilgachuz caribou have two habitat use strategies: low-elevation forest dwelling and high-elevation alpine dwelling. The majority of caribou in the Itcha-Ilgachuz herd use the low-elevation forest dwelling winter strategy and winter in low-elevation pine forests north, east and south of the Itcha-Ilgachuz mountain ranges. The small minority remain on windswept alpine slopes in Itcha-Ilgachuz Provincial Park. Itcha-Ilgachuz caribou calve near treeline within Engelmann spruce – subalpine fir forests or within the alpine tundra summer habitat areas of Itcha-Ilgachuz or Tweedsmuir Provincial Park. Areas of proposed road upgrades for the Anahim Connector road are 3.5 km away from potential calving grounds used by the Itcha-Ilgachuz caribou herd.

Itcha-Ilgachuz habitat conditions

Of the 878,261 hectares (ha) total of Itcha-Ilgachuz critical habitat delineated by the Itcha-Ilgachuz herd boundary, 22% (193,470 ha) is within provincial parks or "no harvest" caribou Wildlife Habitat Areas (WHAs). 25% (219,152 ha) of the herd's critical habitat is within modified timber harvest areas with timber harvesting practices designed to maintain lichen, the main winter forage of caribou. The majority

(97.3%) of the Itcha-Ilgachuz herd's low-elevation winter habitat is outside is subject to timber harvesting. 26.8% of the herd's low-elevation winter habitat is within conditional harvest WHAs which have timber harvesting strategies that protect lichen, the main forage for caribou. Disturbance in the herd's range far exceeds the threshold of 35% recommended by Environment and Climate Change Canada (ECCC) to maintain caribou populations. ECCC specify that within Low Elevation Winter Range, management should strive to keep 65% of the habitat in an undisturbed state, or inversely to keep disturbance below 35%. Disturbance is not restricted to anthropogenic activities and includes natural disturbances such as wildfire. Currently, 69% of the Itcha-Ilgachuz herd's low-elevation critical winter habitat is disturbed. Disturbance is defined as timber cutblocks, roads, private residences, and wildfires. Human disturbances are surrounded by a 500 meter buffer to account for avoidance by caribou.

4.2 Rainbow habitat

Rainbow habitat use

The Anahim Connector area is highly significant to the Rainbow caribou herd, and is critical habitat both for migration and low-elevation winter range. The area proposed for construction and upgrades for the Anahim connector is a major connectivity corridor used by Rainbow herd caribou to travel between summer/fall range and winter range. The area is also a major connectivity corridor for the herd to travel between winter and calving ranges. Finally, the area is also designated as critical winter caribou habitat. Rainbow caribou calve in alpine habitat within Tweedsmuir and Itcha-Ilgachuz Provincial Park, and during the summer they migrate for calving to the north side of the Ilgachuz Mountains, crossing over the migration corridor where traffic will increase and where construction is proposed for the Anahim Connector route. Areas of proposed upgrades for the Anahim Connector road are 3.5 km away from calving grounds used by the Rainbow and Itcha-Ilgachuz caribou herds in Itcha-Ilgachuz Park. During the winter, Rainbow caribou have two habitat use strategies similar to the Itcha-Ilgachuz caribou herd: low-elevation forest dwelling and high-elevation alpine dwelling. The majority of caribou in the Rainbow herd use the low-elevation forest dwelling winter strategy, and will migrate to the north side of the Ilgachuz Mountains or the Upper Dean River Area using the Dean River Valley Corridor, where traffic is expected to increase as a result of the Anahim Connector road. Alpine dwelling rainbow caribou, which are a small minority of the caribou in this herd, remain in the high-elevation alpine environments in Tweedsmuir.

Rainbow habitat conditions

Within the Rainbow herd's 310,128 ha range, 53% is protected from timber harvesting and industrial development, mostly within Tweedsmuir Provincial Park. Most of the herd's high elevation winter and summer habitat (92%) is protected in Tweedsmuir Provincial Park. However, all of the herd's low elevation winter range is subject to timber harvesting, and only 18.5% of the herd's low-elevation summer habitat is protected from timber harvesting. 18.7% of the herd's habitat is designated as a modified timber harvest WHA, with a silvicultural strategy designed to maintain terrestrial and arboreal lichen, the main forage for caribou.

The disturbance levels in the Rainbow herd's critical habitat are above the 35% disturbance threshold in low-elevation winter range recommended by Environment and Climate Change Canada (ECCC) to maintain caribou populations. Disturbance within the Rainbow herd's Low Elevation Winter Range is 74% when considering timber harvest, roads and wildfires. Human disturbances are with a surrounded with a 500m buffer to account for avoidance by caribou.

4.3 Tweedsmuir caribou habitat

Tweedsmuir habitat use

The Anahim Connector area is significant to the Tweedsmuir herd as critical low elevation winter habitat and as a movement corridor between Entiako or North Tweedsmuir Provincial Parks and the Itcha-Ilgachuz range. Areas of proposed road upgrades for the Anahim Connector road are also in areas where radio-collared caribou have been located since 2014, and within core winter range identified using home range analyses based on winter GPS locations. Undisturbed winter range has become increasingly rare for Tweedsmuir caribou because of large wildfires in 2014 and 2018 and forest harvesting. While there are pockets of forested habitats that remain standing, much of this is fragmented from roads and harvesting. The proposed Anahim road route is located in one of the only remaining contiguous and relatively undisturbed areas of known winter range. Observed use since the 2014 fire confirms that caribou are continuing to use this area and home range analyses have shown that use in the area of the Anahim Connector route has increased and expanded towards Itcha-Ilgachuz Park in the south-east. During the winter, Tweedsmuir caribou have two habitat use strategies: low-elevation pine-lichen forest – wetland complex dwelling and high-elevation forest – subalpine/ alpine dwelling. The majority of caribou in the Tweedsmuir herd use the low-elevation forest dwelling winter strategy and winter in low-elevation pine forests in the East Ootsa triangle, Entiako Provincial Park and adjacent low elevation forests within 10 km of Entiako Park, including south to the northern portion of the Dean River watershed. Depending on winter conditions, a small minority may use high elevation ESSF forests in the East Ootsa triangle and high elevation forests near the Fawnie Mountains. During winters of high snow loads, such as during 2017-18, a higher proportion of caribou were found in these higher elevation forests for most of the winter. Caribou have also been noted to spend time in the alpine in the Quanchus Range of north Tweedsmuir and the Fawnie Mountains. Prior to calving, Tweedsmuir caribou typically migrate from this eastern side of their range, towards North Tweedsmuir, the Whitesail Reach, or the Coast Range. They calve either on islands within low-elevation spring/summer habitat near Whitesail Reachor within the high-elevation summer habitat areas of Tweedsmuir Provincial Park or the Troitsa Landscape Unit.

Tweedsmuir habitat conditions

Of the 1,373,251hectares (ha) total of Tweedsmuir critical habitat delineated by the Tweedsmuir herd boundary, ~60% is within the Tweedsmuir Provincial Park, Entiako Provincial Park and Huchsduwaachsdu Nuyem Jees/Kitlope Heritage Conservancy. Additionally, Old Growth Management Areas (OGMAs), caribou management zones in the Caribou Migration Corridor (CMC) that limit seral stages, a draft wildlife habitat area (WHA) in the Whitesail, and Ungulate Winter Range in the Fawnie Mountains contribute to limiting forest harvesting in critical low elevation habitat. The remainder of the Tweedsmuir herd's low-elevation winter habitat is outside of management areas specific to caribou objectives and is subject to timber harvesting. This amounts to approximately 170,000ha of low elevation winter range. Disturbance in the herd's range far exceeds the threshold of 35% recommended by Environment and Climate Change Canada (ECCC) to maintain caribou populations. ECCC specify that within Low Elevation Winter Range, management should strive to keep 65% of the habitat in an undisturbed state, or inversely to keep disturbance below 35%. Disturbance is not restricted to anthropogenic activities and includes natural disturbances such as wildfire. Prior to the fires in 2018, approximately 60% of the Tweedsmuir herd's low-elevation critical winter habitat was disturbed; with the 2018 fires and forest harvesting, this proportion is now closer to 65-70% disturbed. Disturbance includes timber cutblocks (< 40 years old), roads and utility lines, private residences and settlements, flooded reservoir, and wildfires. With the exception of wildfire and reservoir, disturbances are buffered by a 500 meter boundary to represent avoidance of these features.

5 Project Impacts

The Anahim Connector Road will have significant negative impacts to the Itcha-Ilgachuz, Rainbow and Tweedsmuir caribou herds. A significant negative impact is defined by a high or moderate risk of impacts from the road contributing to further caribou population declines. Table 3a outlines factors used to determine risk, which include the duration of the impact, the ability to effectively mitigate the impact, and the population or individual-level extent of the impact. Peer-reviewed scientific publications were used to evaluate the effectiveness of various mitigation options and the population or individual level extent of the impact. The majority of the negative impacts are not possible to fully mitigate. The Anahim Connector route would create a barrier to caribou movement across the migration corridor connecting the three impacted herds, which increases their risk of extirpation. These herds are the only remaining populations of caribou in west-central BC, and include the largest herd left in southern British Columbia. Additional negative impacts, summarized in Table 3, include functional habitat loss from habitat avoidance, direct habitat loss, vehicle collisions, increased predation, increased human hunting and an overall increase in cumulative disturbance in critical caribou habitat, which is associated with the loss of caribou populations. The impacts to caribou from the Anahim Connector extend beyond the areas of new road construction, and include the estimated 26 km of Forest Service Road (FSR) that will be upgraded to 80 km/h roads, and the connecting FSRs, notably the Dean River FSR, that will experience increased traffic as a result of the Anahim Connector. The road will increase human use of the surrounding area for recreation, hunting and timber harvesting, and therefore will increase disturbance to caribou over a large portion of their critical habitat.

5.1 Loss of connectivity between populations

The Anahim Connector road would bisect the only remaining unroaded section of the migration corridor connecting the three caribou herds within the Tweedsmuir and Chilcotin caribou Local Population Units (LPUs). Dispersal is a key process in the persistence of local populations units, and genetic isolation increases the risk of local extirpation due to genetic bottlenecks and lack of gene flow. The migration corridor is also an area of herd range overlap which allows for mixing of individuals across herds. These overlap areas are key to the long-term viability of metapopulations as they facilitate genetic mixing and prevent isolation of small herds. Animals have been documented calving in the Rainbow Mountains in one year, and in the Itcha-Ilgachuz mountain range the next year. Although the Anahim Connector road will not completely restrict caribou migration, it will create a semi-permeable barrier between the herds. Even semi-permeable barriers to animal movement can lead to population level declines. Caribou are well-documented to avoid roads (Table 3), and avoidance increases with traffic volume. This Anahim Connector route will significantly increase the isolation of each of these herds, which are the only remaining herds in west-central British Columbia.

Caribou use the currently unroaded section where the Anahim Connector road construction is proposed throughout the year to move between critical habitat in Itcha-Ilgachuz and Tweedsmuir Provincial Parks (Map 1). The area scheduled for upgrades and construction sees high use by caribou in comparison to adjacent sections of habitat that connects the Itcha-Ilgachuz and Tweedsmuir herd ranges (Maps 1 and 2), likely because it is the only remaining unroaded section connecting the two herd ranges. In addition, the road will increase traffic along the entire length of the Dean River migration corridor which connects the Itcha-Ilgachuz and Rainbow caribou herds, which spans from the Dean River to the area between Eliguk and Moose Lake. The caribou locations in Map 1 span from 1985-2018. The year of construction of the Dean River FSR and the level of use along the road is not well known, and determining the relationship between documented caribou locations, the date of road construction, and seasonal traffic volume along the road would require further analysis. However, a preliminary analysis of the area using Google Earth imagery shows that road upgrades and timber harvesting along the Dean River FSR accelerated in the late 1990's and early 2000's. Until 1999, the Dean River road extended north only to Basalt Falls, and in 2000 it was extended to Agodak Lake. Therefore, caribou telemetry points recorded along the Dean River FSR between 1985-the late 1990's showing movement across the Dean River occurred when there was less activity along the corridor. It would be a valuable exercise to analyze how rates of movement across the Dean River corridor may have changed with development to inform the potential impacts of the Anahim Connector Route on caribou movement, however this was not possible given the time constraints of this report. Many research studies from both North America and Europe have documented caribou avoidance of active and inactive roads (Table 3), which increases with increasing traffic activity. Although some caribou may continue to move across roads, research suggests that movement rates are reduced by these semi-permeable barriers, and that roads increase the amount of time it takes for caribou to move through an area. The increased barrier to movement between these three caribou herds is a significant negative impact from the Anahim Connector road, and will not be possible to fully mitigate.

5.2 Increased cumulative disturbance

The cumulative impacts of anthropogenic activities are one of the most urgent problems facing the conservation and management of caribou populations in Canada. This issue is especially challenging for species like woodland caribou with far-ranging distributions, slow life histories, and sensitivity to human activities. Habitat change resulting from cumulative human developments is well documented as having contributed to the decline of caribou across much of their mountainous and boreal ranges.

The increase in cumulative disturbance in caribou critical habitat which will result from the Anahim Connector road is significant and will occur on a landscape scale across the ranges of all three herds. Roads that penetrate remote areas often lead to deforestation and habitat destruction. Roads greatly facilitate human activities leading to increases in disturbance and habitat loss such as hunting, recreation and timber harvesting. For example, 95% of all deforestation occurs within 50 km of highways or roads (Laurance et al. 2011). Timber harvesting not only causes direct habitat loss, but also leads to increased predation rates on caribou through a series of ecological interactions. Timber harvesting creates a surplus of early seral habitat, which increases the density of moose and deer, the primary prey of wolves. This eventually leads to higher wolf densities and unsustainable rates of wolf predation on caribou, which results in caribou population decline. Negative behavioral and physiological impacts to caribou from disturbance such as human recreation include increased movement rates, increased vigilance, decreased foraging and increased levels of stress hormones.

5.3 Habitat loss and fragmentation

The Anahim Connector road will cause significant direct (caused by road construction) and functional habitat loss (caused by caribou avoidance of the road) in critical low elevation winter range habitat for the Tweedsmuir, Rainbow and Itcha-Ilgachuz herd (Tables 4-6). The habitat that will be lost if the road is built is within a key migration corridor that connects these three herds and contains some of the last remaining undisturbed low-elevation winter range for the Tweedsmuir herd, which has lost the majority of their low-elevation winter range to wildfire in Tweedsmuir and Entiako Provincial Parks in the last 10 years and to forest harvesting in the previous 20 years.

Most caribou habitat loss from the Anahim Connector route is from functional, rather than direct, habitat loss (Table 4-6). Caribou avoid roads, seismic lines and human activity, which causes functional habitat loss over large areas. Avoidance is due to increased mortality risk near roads, from increased predation and hunting near roads. The average avoidance distance by woodland caribou of active roads is 1.8 km, based on a summary of research on the avoidance of roads by woodland caribou in Canada (Table 3). Research reports a minimum avoidance distance of 250 m (Dyer et al. 2002) and a maximum of 11 km (Williamson-Ehlers 2001). Caribou also show avoidance of inactive roads, although to a lesser degree. The degree of avoidance of roads fluctuates by season, but avoidance occurs in all seasons. Habitat fragmentation will contribute to caribou avoidance of the areas surrounding the proposed routes and will contribute fragmentation between the critical habitats of the three caribou herds. This may prevent caribou from using high-quality habitat such as mineral licks, calving sites or wintering areas. For example, the Tweedsmuir caribou travel to the Anahim connector project area either from North Tweedsmuir Provincial Park or from Entiako Park. Additionally, Tweedsmuir caribou have moved across the proposed road corridor to the foothills of Itcha-Ilgachuz Provincial Park and South Tweedsmuir Park. Movement to critical wintering forage areas will be hindered and made more dangerous to caribou by the proposed Anahim connector route. Although large sections of the road that will connect to the Anahim Connector are already built, the increased traffic along the Dean River FSR and the Kluskus FSR will lead to additional functional habitat loss and fragmentation within critical caribou habitat. Many wildlife species, including caribou, avoid active roads with higher traffic volume to a greater degree than inactive roads or roads with less traffic volume. Increased traffic along the Kluskus FSR will be especially detrimental to Tweedsmuir caribou because it goes through high-value Tweedsmuir winter range. Increased human use of the Kluskus FSR would risk permanent abandonment by Tweedsmuir caribou of this area as winter range. Increased traffic along the Dean River FSR will be especially detrimental to both Rainbows and Itcha-Ilgachuz caribou, as they cross the Dean River Valley to move between habitat in the Rainbow and Itcha-Ilgachuz mountains. It is likely that caribou use of the Dean River area has declined since the Dean River FSR was constructed and traffic has increased along the route, although VHF collar data from before the Dean River FSR was constructed is not available to compare movement rates before and after road construction. However, similar studies have shown roads decrease caribou movement rates.

The total amount of functional and direct habitat loss from the various route options are presented in Tables 2, 3 and 4. Direct habitat loss is calculated based on a maximum road running width and right of way of 50 meters (Les Higgs, FLNRORD road specialist, pers. comm 10.18.2018). Functional habitat loss was calculated as a 1.8 km buffer on either side of the route, which is the average avoidance distance of roads by woodland caribou in Canada calculated from published research (Table 3). Direct and functional habitat loss was calculated from three caribou habitat representation sources: 1) Rainbow caribou summer, winter alpine and winter forest dwelling habitat suitability models (Apps 2001; Table 4), which is based on Resource Selection Functions (RSFs) derived from Rainbow caribou GPS collar data; 2) Itcha-Ilgachuz caribou summer/fall and winter forest dwelling habitat suitability models based on RSFs of Itcha-Ilgachuz GPS collar data (Apps 2017; Table 5); and 3) Environment and Climate Change Canada (ECCC) critical habitat types (Table 6) to provide an analysis of what route would cause the least impact to high quality habitat. Although all three herds are part of the Northern caribou ecotype, it is important to note that the 2001 and 2017 habitat suitability models best represent habitat for the Rainbows and Itcha-Ilgachuz herd the best, and there may be slight differences in habitat suitability for each of the three herds. Habitat loss calculations were also done in ECCC critical habitat types (Table 6) to summarize the amount of habitat loss in different critical caribou habitat types, because these habitat designations are shared between all caribou herds and because the route options extend outside the spatial extent of the Apps 2001 and 2017 habitat suitability models. Because the spatial extent for the habitat suitability models does not overlap the entire Anahim Connector routes and existing roads, the total habitat loss calculations are lower for the calculations done with the habitat suitability models (Tables 4 and 5) than the ECCC caribou habitat (Table 6).

Route option 2A results in less total habitat loss from new road construction than other route options (Tables 4-6). However, road upgrades for Route 2A result in more high-quality habitat loss (over 3,000 more ha) in comparison to Routes 1A, 1B and 1C. Routes 2B and 2C have the same amount of high-quality habitat loss from road upgrades as Route 2A (Tables 4 and 5). In addition, Routes 2A/B/C are within 3.5 km of caribou calving grounds, in comparison to Routes 1A/B/C, which are 9 km from the calving grounds. Due to these considerations, there is no route option that will clearly minimize impacts to caribou. All routes will cause habitat loss, increase cumulative disturbance, reduce movement of caribou across the migration corridor and increase mortality risk. New road construction for route 2A results in a total direct and functional habitat loss of 2,083 ha from new roads. When functional habitat loss caused by road upgrades is taken into consideration, the direct and functional habitat loss in ECCC critical caribou habitat caused by Route 2A increases to 16,783 ha.. When considering the scale of caribou range, which is over 800,000 ha for the Itcha-Ilgachuz herd, the difference in habitat loss between the route options is minimal. The greatest impacts from the Anahim Connector, which are ubiquitous between all routes, are the landscape level impacts on decreasing metapopulation connectivity and contributing to cumulative disturbance in caribou critical habitat.

5.4 Increased caribou mortality from increased predation

The Anahim Connector road is likely to indirectly result in increased mortality in the three caribou herds because of an increased risk of predation. The cause of increased predation is complex and is facilitated by multiple factors. Increased predation is ultimately enabled by environmental change. As result of road construction there is likely to be may be an increase in early seral habitat from an expected increase in timber harvesting. Timber harvesting will increase the abundance and distribution of the primary prey species of wolves, moose and deer, which will support higher predator densities. Roads also increase the movement rates and hunting efficiency of wolves, the main predator of caribou. Roads allow wolves to move 2-3 times more efficiently across the landscape, which increases wolf predation on caribou. Compacted snow on backcountry roads and snowmobile trails, which will likely increase in the area after the road is built, will also allow wolves to access caribou habitat throughout winter. An increase in recreational snowmobiling, and thus compacted trails that allow easier access to caribou habitat by wolves, is expected as a result of the road. In addition, early seral habitat along the road right-of-way is likely to concentrate caribou predators by increasing the density of primary prey such as moose and deer in the area. Early seral habitat is also likely to attract bears, which are predators on caribou calves. Route option 1 is only 3.5 km away from calving grounds for the Itcha-Ilgachuz and Rainbow caribou herd inside Itcha-Ilgachuz Provincial Park. The proximity of the road to caribou calving grounds, and the proven use of roads by predators will likely increase predation rates on caribou calves and increase predator use of this sensitive caribou habitat.

5.5 Increased mortality risk from vehicle collisions and hunting

Roadways are a significant source of mortality for wildlife. When migration routes and home ranges are bisected by roads, animals are exposed to traffic as they move along open road corridors, new food resources along the road right of way from increased vegetation forage, and high use of roadways by predators may create an “ecological trap” for caribou near roads. Research has found a temporal pattern to roadkill that varies depending on diel activity cycles and seasonal dispersal. Caribou use the Anahim Connector area, where there is proposed road construction, as winter habitat, but also cross the area during the spring and fall to move between calving grounds and winter habitat, so will be exposed to road mortality risk multiple time during their annual movements. Caribou also cross the Dean River FSR, where increased traffic is expected, at similar times of year, and will be exposed to increased mortality risk from increased traffic volume along this road as well. Caribou cross roads at peak human activity times, with most caribou road crossings occurring between 8-10 am, and 80% occurring between 6 am to 6 pm (Dyer et al. 2002). Vehicle collisions may result in multiple animal mortalities as caribou congregate in herds or small groups.

In less populated areas, wildlife is more at risk of increased hunting mortality risk from roads than increased mortality from vehicle collisions. In these areas, increased human access is correlated with reduced densities of wildlife due to increased hunting and poaching pressure – a “secondary effect” of roads. In addition, research has shown that caribou specifically suffer higher hunting mortality near roads. These vulnerable and declining caribou populations, along with other valuable wildlife species such as moose, will likely suffer increased hunting mortality if the road is built.

6 Mitigation Measures and Residual Risk

The following section considers the effectiveness of mitigation actions including seasonal road closure, wildlife crossings, habitat restoration in other parts of the herds' critical range, lethal predator removal, road curvature, speed restrictions, fencing and hunting closures. The option of not building the route is also considered as the only option that would avoid significant negative impacts to caribou. Residual risk is defined as either a high, moderate or low risk that the environmental impact will remain after the mitigation action. A mitigation measure with a high residual risk signifies that the mitigation action is unlikely to reduce the impact. Moderate residual risk signifies that the mitigation is likely to partially reduce the impact, while low residual risk signifies that the mitigation is likely to mostly or completely remove the impact.

6.1 Do not build Anahim Connector Route

The first principle in BC's Environmental Mitigation Hierarchy is to "avoid impacting environmental values and components." The only option to avoid significant negative impacts to caribou from this project is to not build the road. There is no mitigation action, or combination of mitigation actions, that will effectively mitigate the significant negative impacts of this road on caribou, which is detailed in the following section and Table 3. The road would create a barrier to caribou movement across the migration corridor connecting the three impacted herds, which increases their risk of extirpation. These herds are the only remaining populations of caribou in west-central BC, and include the largest herd left in southern British Columbia - the Itcha-Ilgachuz herd. Negative impacts to these high conservation value caribou herds from the Anahim connector road are expected to further their decline and probability of extirpation, as there is not a route option that will effectively mitigate the negative impacts (Tables 4-6).

6.2 Close road seasonally

Seasonal road closure is likely to be the most effective mitigation option for caribou. Although it will not fully mitigate the negative effects of the road, it will partially mitigate the effects of functional habitat loss, loss of population connectivity, vehicle collisions and hunting. Seasonal road closure will not mitigate increased predation risk and direct habitat loss.

Seasonal road closure will reduce functional habitat loss and increase population connectivity because caribou avoid inactive roads to a lesser degree than active roads. Caribou have an average avoidance distance of 0.5 km of inactive roads, vs. 1.8 km average avoidance of active roads. Seasonal closure will also reduce caribou mortality from human hunting and vehicle collisions. However, enforcement of closures may be difficult, and may not be effective unless considerable staff time and funds are devoted to enforcing the closure. Previous attempts to gate or restrict access on other roads in the Cariboo region has resulted in members of the public attempting to destroy gates or get around them on ATVs or snowmobiles. In addition, since caribou use the Anahim Connector area during spring, summer and fall, closing the road in winter only would not decrease the barrier effect of the road to movement or increased mortality risk from collisions during spring and fall migrations.

Finally, closing the road will not decrease predator use of the road, so predation risk to caribou using the migration corridor will remain high. Since this area is primarily used as a migration corridor, any avoidance of the road will decrease migration as the road bisects the corridor, and even partially restricted migrations can have negative effects on populations. Although this mitigation has moderate residual risk, it is recommended as the most effective mitigation option to reduce the negative impacts of the road on vulnerable caribou populations. Other than not building the road, appropriately timed seasonal road closures of significant duration would be the most effective mitigation option to reduce the negative impacts of the road on vulnerable caribou populations. However, this mitigation option has moderate residual risk and will not fully mitigate the impacts to caribou. Also, as this mitigation would require the road to be closed for significant periods of time during the year, it is unclear whether this mitigation option would meet the needs of those seeking the construction of the road. The majority of caribou crossings and use of the area near the road occurs from December – June, with peak crossing during April, when caribou are moving across the proposed road construction area to access calving grounds. There is also significant use of the corridor during January, February and May. Closure of the road would be recommended from Dec 1 – June 5th.

6.3 Build wildlife crossings

Wildlife crossings can assist in maintaining connectivity between populations and have been highly effective in Banff National Park at reducing Wildlife Vehicle Collisions (WVCs; Parks Canada 2017). However, the placement, type and configuration of the crossing will determine if it is used by animals, and there is not clear evidence that wildlife crossings would be an effective option to increase caribou movement across roads due to avoidance of roads by caribou. Wildlife crossings, in combination with fencing, in Banff National park reduced mortalities by 80% for a wide range of carnivore and ungulate species. Caribou were extirpated from Banff National Park in 2009, and their range did not extend into the area where the overpasses were built. However, the park constructed 38 total crossings along an 82 kilometer stretch of highway for a cost between $2 million to $4 million dollars per crossing. Research on the effectiveness of the crossings found that there was a “learning curve” for animals to use the crossings, and that while elk learned to use them almost immediately, warier species such as wolves and grizzly bears took up to 5 years to begin to use the crossings. Ungulates preferred to use overpasses, rather than underpasses. Overpasses are significantly more expensive than underpasses. Building an effective system of overpasses for caribou would be expensive, and it is uncertain as to how effective it would be given the sensitivity of caribou to disturbance. The residual risk for this mitigation option is high, and is therefore it is not recommended.

6.4 Restore or protect habitat in other parts of the herds' range

Protecting or restoring low-elevation winter range critical caribou habitat in other parts of the Chilcotin or Tweedsmuir LPU is a potential mitigation option to offset the direct and functional habitat loss caused by the road construction. Protecting 100-250 km^2 interconnected blocks of forest in low elevation winter range would be the most effective habitat protection strategy due to the woodland caribou anti-predator strategy of using large areas of intact habitat to space away from predators and humans. However, it may be difficult to implement this strategy because of the limited supply of undisturbed high quality habitat that remains within the Chilcotin and Tweedsmuir LPU critical habitat. Functional habitat restoration involves deactivating and restoring roadways to reduce predator use and hunting efficiency. Although both habitat protection and restoration are highly recommended to recover these caribou herds, they cannot mitigate the key, unique habitat that will be lost due to the Anahim Connector road construction. This mitigation option has high residual risk, meaning that habitat restoration will not mitigate impacts of the road on loss of connectivity between subpopulations, due to the unique nature of this unroaded habitat as a migration corridor connecting caribou herds. Restoring and protecting habitat in other areas will not offset the habitat lost where the Anahim Connector is proposed to be built. This is a unique and vital area for migration that connects the three caribou herds to each other and there is no other area within the herd's range that functions as a corridor to connect the herds. In addition, this area contains some of the only remaining undisturbed low-elevation winter habitat in the range of this metapopulation.

6.5 Lethally remove predators

The lethal removal of wolves to recover threatened caribou populations has been an effective recovery tool in the Yukon (Hayes et al. 2003) and northeastern British Columbia (M. Bridger, Peace Region wildlife biologist, pers. Comm. 2018.06.18). Wolves are the main predator of Itcha-Ilgachuz caribou, and wolf use and density in the area may increase following road construction due to wolf selection of linear features and increase of early seral habitat along the road right of way that will attract the primary prey of wolves (deer and moose) to the area. In addition, predator removal is expensive and intensive. A rough budget estimate is ~ $300,000 per year, and predator removal would need to be done for at least 4 years to be effective. Predator removal is being considered as a conservation option to reduce the decline in the Itcha-Ilgachuz caribou herd. Although removing wolves would likely increase survival of adult caribou and reduce predation rates, lethally removing predators to mitigate habitat destruction caused by road building is not an effective long term strategy as the loss of functional habitat is the ultimate cause of the declines in these populations. Predator removal is a controversial management action that is likely to be met with some public criticism. Also, the lethal removal of predators in support of caribou recovery while concurrently building a road through an unroaded section of critical habitat is likely to result in the objectives of the Provincial Caribou Recovery Program being called in to question. Lethally removing predators will not mitigate the habitat destruction, loss of population connectivity, risk of mortality from increased human harvest or vehicle collisions, although it may increase adult caribou survival for the short-term. This mitigation option has high residual risk and is not recommended due to public criticism and the lack of mitigation to other significant project impacts.

6.6 Construct curves into road

Constructing curves into the road was proposed as a potential mitigation option to reduce the line-of-sight distance to reduce wolf predation and hunting mortality on caribou. However, curves in roads increase wildlife road kill because curves reduce driver visibility and the response times of animals to oncoming vehicles. Although decreasing sight distances may hypothetically help reduce mortality from human hunting on caribou, no research was found that has shown this to be effective, and any reduction in human hunting may be negated by increased road kill from vehicle collisions. In addition, no research was found that shows this to be effective at reducing predation rates of wolves on prey. Roads increase wolf use and building curves into the road will not decrease wolf use of the roads or mitigate habitat and population connectivity loss. In addition, research has found that decreased sight lines cause an increase in perceived predation risk from prey (Iribarren and Kotler 2012; Shrader et al. 2008). This mitigation option has high residual risk and is not recommended.

6.7 Speed Restrictions

Reducing vehicle speed on roadways is a mitigation option that is effective for many species at reducing mortalities from vehicle collisions. However, it will likely be difficult to enforce speed restrictions on this route given the remote location of the road. In addition, mortality from vehicle collisions is the impact of lowest concern in terms of contributing to a significant caribou population decline. Although the residual risk for this mitigation option is moderate and it will be difficult to enforce, it is recommended to reduce caribou vehicle collisions.

6.8 Fencing

Fencing can be highly effective at reducing wildlife-mortality from vehicle collisions. Fencing reduced wildlife mortality by 80% along highways in Banff National Park (Parks Canada, 2017). However, fencing may also further reduce wildlife metapopulation connectivity by making the roadway a less permeable barrier to wildlife. Due to the increased barrier fencing would pose to caribou movement, dispersal and immigration between populations and critical habitat, this mitigation option is not recommended.

6.9 Hunting Closures

Implementation of hunting closures for both licensed and unlicensed (First Nations) hunters would partially mitigate the risk of increased mortality through human harvest. Implementing hunting closures would not mitigate the risk of increased poaching and is not considered as effective a mitigation option as seasonal road closures. The closure of the First Nations caribou hunt would be an infringement of aboriginal rights as protected under Section 35 of the *Constitution Act*. Infringement of aboriginal rights for the purpose of mitigating an environmental impact of road construction is likely not justified and is not recommended.

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8 Table 3. Environmental Impacts and Mitigation

See Table 3a below for criteria used to determine the risk of the impact contributing to caribou population declines

Impacts	Risk of impact contributing to caribou population decline	Risk of impact occurring (high, medium, low)	Possible Mitigation Options	Residual Risk (high, med, low) - risk that the environmental impact will remain after mitigation, or the risk that the mitigation will not be effective	Recommend mitigation action (yes/no)	References
Loss of connectivity between populations, leading to geographic isolation of small populations and increased risk of extinction. Dispersal is a key process in the survival of local caribou populations.	High	High. All routes would bisect a key migration corridor connecting three caribou subpopulations within the west-central metapopulation. Construction of the Anahim Connector road, regardless of route, would fragment the caribou metapopulation and make extinction more likely for these caribou herds, which contain the largest herds in southern BC and are of high conservation value. The effects of population fragmentation from roads has are significant for caribou and arise when populations are subdived into smaller groups and genetic exchanges between the groups decreases or ceases because of the barrier effect of a road. The overall effect is to make local extinctions more likely as the sources of immigration and disperal are disconnected.	Build overpasses or underpasses at key crossing areas	High. Woodland caribou avoid active and inactive roads, so after the road is built they are likely to avoid the area. In addition, roads lead to increased use of areas by predators, so predation risk to caribou in the area will likely increase, which will lead to increased mortality of caribou migrating through the area. In addition, it is uncertain if wildlife overpasses are effective at providing connectivity between populations due to wildlife avoidance of roads and higher mortality associated with roads. Finally, multiple wildlife crossing structures on a Forest Service Road (FSR) are not feasible.	No	Corlatti et al. 2009, BCGW wildlife species telemetry observations, DeMars and Boutin 2018, Dickie et al. 2016, Dyer et al. 2001, Dyer et al. 2002, Johnson and Collinge, 2004, Hebblewhite et al. 2010, Latham et al. 2011, LeBlond et al. 2011, Oberg 2001, Williamson-Ehlers 2001
			Close road seasonally during peak crossing times	High/Moderate. This mitigation measure will be moderately effective if effective closure methods can be used. It has been logistically difficult to maintain road closures in the Cariboo region previously. The public has attempted to destroy gates and get around gates. Gates have been left open or keys distributed widely. As stated above, caribou avoid inactive as well as active roads, although they avoid inactive roads to a lesser degree. Caribou have an average avoidance distance of 0.5 km of inactive roads, vs. 1.8 km average avoidance of active roads. Closing the road will not decrease predator use of the road, so predation risk to caribou attempting to use the migration corridor will remain high. Caribou have been shown to avoid cross-country ski trails, so are sensitive to disturbance. Since this area is primarily used as a migration corridor, any avoidance of the road will decrease migration as the road bisects the corridor.	Yes	Corlatti et al. 2009, BCGW wildlife species telemetry observations, DeMars and Boutin 2017, Dickie et al. 2016, Dyer et al. 2001, Dyer et al. 2002, Johnson and Collinge, 2004, Hebblewhite et al. 2010, Latham et al. 2011, LeBlond et al. 2011, Oberg 2001, Nellemann et al. 2001, Williamson-Ehlers 2001
Increased cumulative disturbance in caribou critical habitat leading to negative population, behavioral and physiological impacts	High	High. Roads that penetrate into remote, previously unroaded areas often lead to forest encroachment and destruction. Roads greatly faciliate human activity that cause disturbance and habitat loss such as hunting, recreation, timber harvesting, and human-caused forest fires. 95% of all deforestation and forest fires have been found to occurr within 50 km of highways or roads. Increased human disturbance within caribou range is correlated with increased risk of extirpation of caribou herds. Increased activity is expected along the existing roads that connect to the proposed road construction, not only the proposed construction and upgrade sections. Negative behavioral and physiological impacts to caribou from disturbance include increased movement rates, increased vigilance, decreased foraging, increased levels of the stress hormone cortisol and decreased levels of a hormone that indicates nutritional status, T3.	Close road seasonally during peak crossing times	High. As stated above, caribou avoid inactive as well as active roads, although they avoid inactive roads to a lesser degree. Caribou have an average avoidance distance of 0.5 km of inactive roads, vs. 1.8 km average avoidance of active roads. If closed during the winter, snowmobiliers are likely to use the road, which is known to negatively impact caribou behavior and increase caribou stress levels. A packed snow trail created by snowmobiliers may provide easier predator access than if the road did not exist, even if the road is closed. Closing the road during snow-free seasons will not decrease the use of the road by predators and primary prey.	Yes	Freeman 2008, Johnson et al. 2015, Laurance et al. 2001, Simpson and Terry 2000, Wasser et al. 2011

Table 3. Environmental Impacts and Mitigation (continued)

Habitat loss and fragmentation	High	High. Route 1 will cause 28,185 ha and Route 2 will cause 25,917 ha of direct and functional critical habitat loss in low elevation winter range, most of which is due to functional habitat loss. Caribou avoidance of roads causes functional habitat loss that affects large areas. Studies report varying distance effects, with an average linear avoidance effect of 1.8 km of active roads by woodland caribou, and 0.5 km avoidance of inactive roads. Avoidance also varies by season, and is highest during spring and summer, and lowest during the rut. Therefore, road avoidance may negatively affect access to forage and vital habitat during critical time periods such as calving. In addition, the road will negatively impact the "spacing out" caribou predator avoidance strategy, which requires connectivity and large unfragmented areas to accomodate extensive movements and large home ranges. Caribou that choose to still use disturbed habitat due to strong site fidelity may enter an ecological trap where they suffer the impacts of choosing risky habitat (increased risk of predation, harvest, disturbance) that reduces fitness or survival. For example, increased use of roads by female caribou is associated with decreased survival of that calves. Finally, the road will lead to increased cumulative disturbance impacts along the entire length of the road that will experience increased traffic, not only the sections that are proposed to be built and upgraded. The road is also likely to accelerate timber harvesting in the area due to improved access, which will lead to further critical caribou habitat loss.	Close road seasonally at peak crossing times	Moderate. Caribou avoid closed roads less (0.5 km avoidance distance) than active roads (1.8 km avoidance). However, closed roads, especially if they are closed during snow-free periods, will still increase predator use and hunting efficiency in the area, which may create an ecological trap for caribou.	Yes	DeMars and Boutin 2018, Dickie et al. 2016, Dyer et al. 2001, Dyer et al. 2002, Johnson and Collinge, 2004, Hebblewhite et al. 2010, Latham et al. 2011, LeBlond et al. 2011, Oberg 2001, Williamson-Ehlers 2001
			Restore linear features in other parts of caribou critical range	High. This would restore habitat in other areas, which is valuable, but will not offset the habitat lost where the Anahim Connector is proposed to be built. This is a unique and vital area for migration that connects the three caribou subpopulations to each other and there is no other area within the herd's range that functions as a corridor to connect the herds. In addition, this area contains some of the only remaining undisturbed low-elevation winter habitat in the range of this metapopulation. Any restoration work would take a while to be effective.	Recommend this is done to conserve The Chilcotin and Tweedsmuir caribou Local Population Units (LPUs), but it will not mitigate the habitat loss from the Anahim Connector road.	Seip and Cichowski 1996; Ministry of Environment and Climate Change Strategy, 2014
			Protect 100-250 km^2 interconnected blocks of forest to accommodate caribou predator avoidance	High. See above.	Recommends this is done to conserve The Chilcotin and Tweedsmuir caribou Local Population Units (LPUs), but it will not mitigate the habitat loss created by the Anahim Connector road.	Courtois et al. 2007, Courtois et al. 2008
Increased mortality from increased predation risk	High	High. Linear features increase the movement rate and hunting efficiency of wolves. Wolf predation is the leading cause of mortality for most caribou populations, and is known to be the leading cause of mortality for Itcha-Ilgachuz caribou. In addition, early seral habitat that will be created by clearing forest for the road right of way can attract predators by increasing densities of primary prey, such as deer and moose. Early seral habitat along roads is also likely to attact bears, a known predator on caribou calves. The road is 6.5 km at it's closest point from caribou calving grounds.	Close road seasonally at peak crossing times	High. If closed and not plowed during the winter, this may reduce predator use. However, snowmobiliers are likely to use the road and the packed snow trail may provide easier predator access. Closing the road to vehicle traffic in the spring or summer will not change the use of the road by predators and primary prey during the spring and summer, as they can move around gates or road blocks.	Not recommended to reduce predation risk but closing the road seasonally may reduce other impacts.	DeMars and Boutin 2018, Dickie et al. 2016, Dyer et al. 2001, Dyer et al. 2002, Hebblewhite et al. 2010, Latham et al. 2011, LeBlond et al. 2011, Oberg 2001; Williamson-Ehlers 2001
			Lethally remove predators from the area that prey on caribou and may benefit from increased early seral habitat, namely wolves, bears, cougars and coyotes	Moderate. Caribou adult survival has responded positively to predator removal in other parts of North America. However, predator removal is controversial and predator removal to mitigate road building through a key migration corridor is likely to be heavily criticized.	No	Hayes et al. 2003, Hervieux et al. 2014, Lewis et al. 2017
			Build curves into road to reduce sight distance at key crossing areas	High. Curves in roads increase wildlife road kill because curves reduce driver visibilityand the response times of animals to oncoming vehicles. Although decreasing sight distances may hypothetically help reduce mortality from human hunting on caribou, no research was found that has shown this to be effective at reducing human hunting rates, and any reduction in human hunting may be negated by increased road kill from vehicle collisions. In addition, there is no research that has found this to be effective at reducing predation rates of wolves on prey. Roads increase wolf use, and building curves into the road will not decrease wolf use of the roads.	No	Bashore et al. 1985; Goosem, 1997; Grilo et al. 2009; Ramp et al. 2005; Ramp et al. 2006

Table 3. Environmental Impacts and mitigation (continued)

Increased mortality from increased human harvest	Moderate	High. Roads will increase human hunting and poaching of caribou. The populations of all three caribou herds are small and declining and cannot sustain additional mortality, so this will increase the likelihood of this caribou metapopulation being extirpated.	Close road seasonally during peak crossing times	Moderate. Closing the road to human access would greatly reduce the hunting and poaching rate on caribou. However, enforcement of closures is problematic due to limited staffing and the remote nature of the area.	Yes	pers. Comm. Habitat and Road Engineering staff
Increased mortality from vehicle collisions	Moderate	High. Peak road crossing times of woodland caribou are during the daytime, which coincides with peak human use, therefore increasing the risk of road mortalities. Previous research has found that 75% of caribou road crossing occurr between 6 am and 6 pm, with peak crossing occurring between 8-10 am. In addition, caribou often travel in groups, which may increase the chance of multiple mortalities. Large animals that range over extensive areas and have low reproductive rates are especially vulnerabile to population decline from elevated mortality from road kill.	Build overpasses or underpasses at identified fatality hotspots and/or key crossing areas	Moderate. Wildlife crossing significantly reduce mortalities from vehicle collisions on roads. However, caribou will be exposed to increased predation risk near roads as well, as carnivores are well-documented to use wildlife overpasses and underpasses, and caribou avoid roads so are likely to avoid the area surrounding the road, which may make the overpasses and underpasses ineffective for caribou.	No	Bennet and Robinson 2000; Grilo et al. 2008
			Build bends and curves into road to reduce speed at key crossing areas	High. Curves in roads reduce driver visibility and the response times of animals to oncoming vehicles and increase road kill.	No	Bashore et al. 1985; Goosem, 1997; Grilo et al. 2009; Ramp et al. 2005; Ramp et al. 2006
			Place speed restrictions on road over sections that overlap key crossing areas	Moderate. Reducing vehicle speed is effective at reducing wildlife mortality, but enforcing speed limits in such a remote area will likely be difficult.	Yes	Bashore et al. 1985; Jones 2000; Clevenger et al. 2003; Grilo et al. 2009; Seiler 2005
			Build fences and wildlife crossings along the road to funnel wildlife to crossings	Moderate. Fences and wildlife crossings used in conjunction reduce wildlife mortality from vehicle collisions on roads. However, fences may further fragment and reduce connectivity between caribou populations. Predation risk for caribou near roads will likely still remain high.	No	Seiler 2005; Clevenger et al. 2001
			Close road seasonally at peak crossing times	Moderate. Caribou show regular use of this area throughout the year for connectivity, and higher use of the area during winter as low-elevation winter habitat. Rainbow caribou move across the corridor during spring to access calving grounds in the Itcha-Ilgachuz. Since the area is used year-round by caribou for connectivity, it is difficult to isolate a certain time period to close the road.	Yes	Seip and Cichowski 1996; pers. Comm D. Cichowski Oct 2018.

8.1 Table 3a. Definitions of the risks of impacts

Definition of criteria used to determine whether an impact has a high, moderate or low risk of causing further caribou population declines. The ability to mitigate various impacts, detailed in Table 3, and the extent of the impact on either a population or individual level was determined by evaluating published peer-reviewed scientific research on caribou and the effects of roads on wildlife. See the references section for a complete list of referenced studies.

Risk of impact leading to significant caribou population declines	Duration of impact	Ability to mitigate impact with recommended mitigation action	Extent of impact
High	Indefinite, as long as road is present	Low or moderate	Population - the impact will affect the majority of caribou within the local study area
Moderate	Indefinite, as long as road is present	Low or Moderate	Individual – the impact will affect individual caribou within the local study area; cumulative individual impacts may affect population trends
Low	Impact will cease in the future	High	Individual - the impact will affect individual caribou within the local study area; cumulative individual impacts may affect population trends

9 Table 4. Habitat Loss from Rainbow caribou herd habitat suitability model

Total area (ha) of direct and functional critical caribou habitat loss from the Anahim connector road route options calculated from 2001 habitat suitability models based on Resource Selection Functions (RSFs) of GPS collar data from Rainbow herd caribou (Apps 2001). Direct habitat loss is from the direct effects of habitat alteration and vegetation removal from the road construction (50 meter width), while functional habitat loss is caused by caribou avoidance of the road (average of 1.8 km).

Anahim Connector: OPTION 1A - 2001 Caribou Habitat Model

	Summer						Winter Alpine						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)					
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Best	-	-	-	-	-	-	-	-	-	-	21	-	30	17	8	3,023	878	77
Better	-	-	-	17	-	-	-	-	-	2	27	0	67	22	4	3,188	1,067	165
Good	-	-	-	68	-	-	-	-	-	8	80	0	72	31	18	5,130	2,040	745
Poor	269	216	82	21,268	13,989	4,769	269	216	82	21,343	13,860	4,769	99	146	52	10,013	10,004	3,783
Totals	***269***	***216***	***82***	***21,353***	***13,989***	***4,769***	***269***	***216***	***82***	***21,353***	***13,989***	***4,769***	***269***	***216***	***82***	***21,353***	***13,989***	***4,769***

Anahim Connector: OPTION 1B - 2001 Caribou Habitat Model

	Summer						Winter Alpine						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)					
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Best	-	-	-	-	-	-	-	-	-	-	21	-	30	17	8	3,023	878	77
Better	-	-	-	17	-	-	-	-	-	2	27	0	67	22	4	3,188	1,067	165
Good	-	-	-	68	-	-	-	-	-	8	80	34	72	31	22	5,130	2,040	902
Poor	269	216	108	21,268	13,989	6,114	269	216	108	21,343	13,860	6,080	99	146	74	10,013	10,004	4,970
Totals	***269***	***216***	***108***	***21,353***	***13,989***	***6,114***	***269***	***216***	***108***	***21,353***	***13,989***	***6,114***	***269***	***216***	***108***	***21,353***	***13,989***	***6,114***

Anahim Connector: OPTION 1C - 2001 Caribou Habitat Model

	Summer						Winter Alpine						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)					
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Best	-	-	-	-	-	-	-	-	-	-	21	-	30	6	2	3,023	435	292
Better	-	-	-	17	-	-	-	-	-	2	27	-	67	22	5	3,188	921	268
Good	-	-	-	68	-	-	-	-	-	8	66	-	72	29	25	5,130	1,956	917
Poor	269	199	108	21,268	12,809	6,424	269	199	108	21,343	12,695	6,424	99	141	75	10,013	9,498	4,947
Totals	***269***	***199***	***108***	***21,353***	***12,809***	***6,424***	***269***	***199***	***108***	***21,353***	***12,809***	***6,424***	***269***	***199***	***108***	***21,353***	***12,809***	***6,424***

Table 4 (continued). Habitat loss from Rainbow caribou herd habitat suitability model

Anahim Connector: OPTION 2A - 2001 Caribou Habitat Model

	Summer						Winter Alpine						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)					
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Best	-	-	-	-	-	-	-	-	-	-	21	-	23	10	7	2,404	918	77
Better	-	-	-	17	-	-	-	-	-	2	27	0	40	38	2	1,796	2,140	131
Good	-	-	-	68	-	-	-	-	-	8	80	0	65	61	4	4,074	3,873	361
Poor	217	269	44	16,574	18,692	2,083	217	269	44	16,649	18,563	2,083	88	160	30	8,385	11,761	1,514
Totals	***217***	***269***	***44***	***16,659***	***18,692***	***2,083***	***217***	***269***	***44***	***16,659***	***18,692***	***2,083***	***217***	***269***	***44***	***16,659***	***18,692***	***2,083***

Anahim Connector: OPTION 2B - 2001 Caribou Habitat Model

	Summer						Winter Alpine						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)					
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Best	-	-	-	-	-	-	-	-	-	-	21	-	23	10	7	2,404	918	77
Better	-	-	-	17	-	-	-	-	-	2	27	0	40	38	2	1,796	2,140	131
Good	-	-	-	68	-	-	-	-	-	8	80	0	65	61	4	4,074	3,873	372
Poor	217	269	65	16,574	18,692	3,276	217	269	65	16,649	18,563	3,276	88	160	52	8,385	11,761	2,696
Totals	***217***	***269***	***65***	***16,659***	***18,692***	***3,276***	***217***	***269***	***65***	***16,659***	***18,692***	***3,276***	***217***	***269***	***65***	***16,659***	***18,692***	***3,276***

Anahim Connector: OPTION 2C - 2001 Caribou Habitat Model

	Summer						Winter Alpine						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)					
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Best	-	-	-	-	-	-	-	-	-	-	21	-	23	-	1	2,404	474	292
Better	-	-	-	17	-	-	-	-	-	2	27	-	40	38	3	1,796	1,995	233
Good	-	-	-	68	-	-	-	-	-	8	66	-	65	60	12	4,074	3,789	546
Poor	217	252	69	16,574	17,512	3,756	217	252	69	16,649	17,398	3,756	88	155	54	8,385	11,255	2,685
Totals	***217***	***252***	***69***	***16,659***	***17,512***	***3,756***	***217***	***252***	***69***	***16,659***	***17,512***	***3,756***	***217***	***252***	***69***	***16,659***	***17,512***	***3,756***

10 Table 5. Habitat Loss from Itcha-Ilgachuz caribou herd habitat suitability model

Total area (ha) of direct and functional critical caribou habitat loss from the Anahim connector road route options calculated from 2017 habitat suitability models based on Resource Selection Functions (RSFs) of GPS collar data from Itcha-Ilgachuz caribou (Apps 2017). Direct habitat loss is from the direct effects of habitat alteration and vegetation removal from the road construction, while functional habitat loss is caused by caribou avoidance of the road.

Anahim Connector: OPTION 1A - Itcha-Ilgachuz 2017 Caribou Habitat Model												
	Summer Fall						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Very Good	-	-	-	-	-	-	-	-	-	-	-	-
Good	-	-	-	-	-	-	51	14	-	2,070	927	-
Moderate	-	-	1	57	-	-	152	48	22	10,999	3,825	874
Poor	26	3	7	3,235	282	132	74	130	60	8,348	6,812	3,606
Totals	***26***	***3***	***8***	***3,292***	***282***	***132***	***278***	***193***	***82***	***21,417***	***11,564***	***4,481***

Anahim Connector: OPTION 1B - Itcha-Ilgachuz 2017 Caribou Habitat Model												
	Summer						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Very Good	-	-	-	-	-	-	-	-	-	-	-	-
Good	-	-	-	-	-	-	51	14	-	2,070	927	-
Moderate	-	-	-	57	-	-	152	48	24	10,999	3,825	1,320
Poor	26	3	11	3,235	282	105	74	130	84	8,348	6,812	4,471
Totals	***26***	***3***	***11***	***3,292***	***282***	***105***	***278***	***193***	***108***	***21,417***	***11,564***	***5,791***

Anahim Connector: OPTION 1C - Itcha-Ilgachuz 2017 Caribou Habitat Model												
	Summer						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Very Good	-	-	-	-	-	-	-	-	-	-	-	-
Good	-	-	-	-	-	-	51	12	17	2,070	876	553
Moderate	-	-	1	57	-	-	152	36	28	10,999	3,162	1,653
Poor	26	3	7	3,235	282	132	74	128	62	8,348	6,449	3,763
Totals	***26***	***3***	***8***	***3,292***	***282***	***132***	***278***	***176***	***108***	***21,417***	***10,488***	***5,970***

Table 5. Functional and Direct Habitat Loss of Anahim Connector Routes from Itcha-Ilgachuz herd caribou habitat suitability model (continued)

Anahim Connector: OPTION 2A - Itcha-Ilgachuz 2017 Caribou Habitat Model

	Summer						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Very Good	-	-	-	-	-	-	-	-	-	-	-	-
Good	-	-	-	-	-	-	51	32	-	2,070	2,361	17
Moderate	-	-	-	38	13	-	148	63	20	10,381	5,041	595
Poor	-	30	1	1,377	2,011	24	27	125	23	4,501	7,417	1,352
Totals	**-**	***30***	***1***	***1,415***	***2,024***	***24***	***226***	***221***	***44***	***16,952***	***14,819***	***1,964***

Anahim Connector: OPTION 2B - Itcha-Ilgachuz 2017 Caribou Habitat Model

	Summer						Winter Forest Dwelling					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Very Good	-	-	-	-	-	-	-	-	-	-	-	-
Good	-	-	-	-	-	-	51	32	-	2,070	2,361	544
Moderate	-	-	-	38	13	-	148	63	47	10,381	5,041	1,249
Poor	-	30	-	1,377	2,011	24	27	125	18	4,501	7,417	1,356
Totals	**-**	***30***	**-**	***1,415***	***2,024***	***24***	***226***	***221***	***65***	***16,952***	***14,819***	***3,149***

Anahim Connector: OPTION 2C - Itcha-Ilgachuz 2017 Caribou Habitat Model

	Summer						Winter Alpine					
	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)			Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New	Existing	Upgrade	New
Very Good	-	-	-	-	-	-	-	-	-	-	-	-
Good	-	-	-	-	-	-	51	30	17	2,070	2,310	570
Moderate	-	-	-	38	13	-	148	51	27	10,381	4,378	1,398
Poor	-	30	1	1,377	2,011	24	27	122	25	4,501	7,054	1,496
Totals	**-**	***30***	***1***	***1,415***	***2,024***	***24***	***226***	***203***	***69***	***16,952***	***13,742***	***3,465***

11 Table 6. Functional and Direct Habitat loss from ECCC critical caribou habitat types

Direct and functional habitat loss (ha) from Anahim Connector route options with ECCC critical caribou habitat (ECCC 2017) for the Tweedsmuir, Itcha-Ilgachuz and Rainbow caribou herds. Direct habitat loss is calculated based on a maximum road running width and right of way of 50 meters. Functional habitat loss is 1.8 km, based on a summary of research on the avoidance of roads by woodland caribou in Canada (Table 1).

Anahim Connector: OPTION 1A - ECCC Critical Habitat (Draft 20171124)

	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status:	Existing	Upgrade	New	Existing	Upgrade	New
High Elevation Winter/Summer Range	-	-	-	528	-	-
Low Elevation Winter Range	396	216	82	29,561	13,883	4,714
Low Elevation Summer Range	-	-	-	-	-	-
Matrix Range	162	-	-	11,476	-	-
Totals	558	216	82	41,566	13,883	4,714

Anahim Connector: OPTION 1B - ECCC Critical Habitat (Draft 20171124)

	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New
High Elevation Winter/Summer Range	-	-	-	528	-	-
Low Elevation Winter Range	396	216	108	29,561	13,883	6,031
Low Elevation Summer Range	-	-	-	-	-	-
Matrix Range	162	-	-	11,476	-	-
Totals	558	216	108	41,566	13,883	6,031

Anahim Connector: OPTION 1C - ECCC Critical Habitat (Draft 20171124)

	Direct Habitat Loss (ha)			Functional Habitat Loss (ha)		
Road Status	Existing	Upgrade	New	Existing	Upgrade	New
High Elevation Winter/Summer Range	-	-	-	528	-	-
Low Elevation Winter Range	396	199	108	29,561	12,704	6,369
Low Elevation Summer Range	-	-	-	-	-	-
Matrix Range	162	-	-	11,476	-	-
Totals	558	199	108	41,566	12,704	6,369

Table 6. Functional and Direct Habitat loss from ECCC critical caribou habitat types (continued)

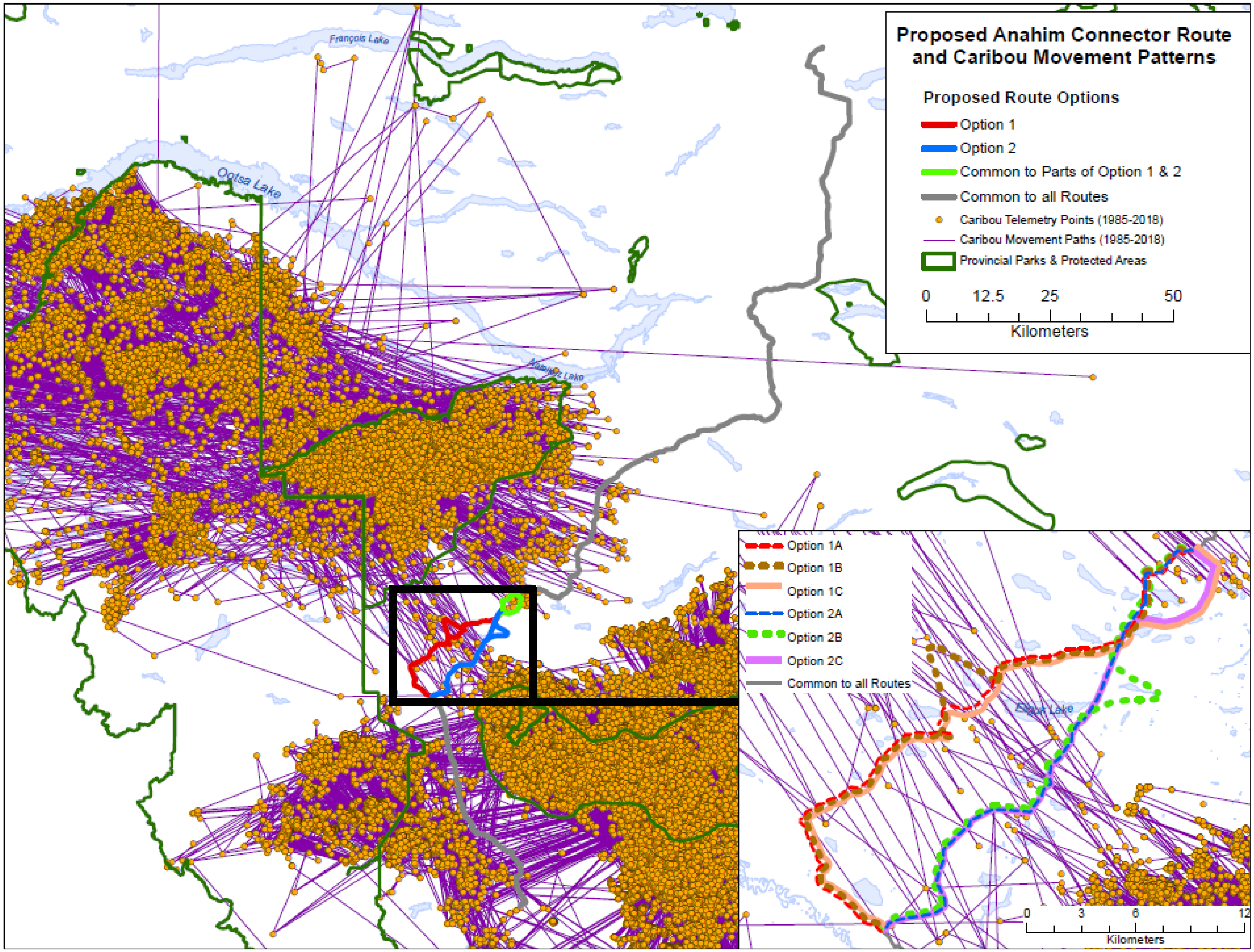
Anahim Connector: OPTION 2A - ECCC Critical Habitat (Draft 20171124)						
	Direct Habitat Loss (ha)			**Functional Habitat Loss (ha)**		
Road Status	**Existing**	**Upgrade**	**New**	**Existing**	**Upgrade**	**New**
High Elevation Winter/Summer Range	-	-	-	528	-	-
Low Elevation Winter Range	344	269	44	24,868	18,553	2,083
Low Elevation Summer Range	-	-	-	-	-	-
Matrix Range	162	-	-	11,476	-	-
Totals	506	269	44	36,872	18,553	2,083

Anahim Connector: OPTION 2B - ECCC Critical Habitat (Draft 20171124)						
	Direct Habitat Loss (ha)			**Functional Habitat Loss (ha)**		
Road Status	**Existing**	**Upgrade**	**New**	**Existing**	**Upgrade**	**New**
High Elevation Winter/Summer Range	-	-	-	528	-	-
Low Elevation Winter Range	344	269	65	24,868	18,553	3,276
Low Elevation Summer Range	-	-	-	-	-	-
Matrix Range	162	-	-	11,476	-	-
Totals	506	269	65	36,872	18,553	3,276

Anahim Connector: OPTION 2C - ECCC Critical Habitat (Draft 20171124)						
	Direct Habitat Loss (ha)			**Functional Habitat Loss (ha)**		
Road Status	**Existing**	**Upgrade**	**New**	**Existing**	**Upgrade**	**New**
High Elevation Winter/Summer Range	-	-	-	528	-	-
Low Elevation Winter Range	344	252	69	24,868	17,373	3,756
Low Elevation Summer Range	-	-	-	-	-	-
Matrix Range	162	-	-	11,476	-	-
Totals	506	252	69	36,872	17,373	3,756

12 Map 1. Anahim Connector and Caribou Locations

Anahim Connector and caribou GPS and census survey locations (Ministry of Environment and Climate Change Strategy, 2017). Consecutive points from the same animal are connected by the shortest straight-line movement path. Figure by Carole Mahood.



Map 2. New and upgraded road sections for the proposed Anahim Connector Routes. Figure by Carole Mahood.