BEST MANAGEMENT PRACTICES FOR MITIGATING THE EFFECTS OF ROADS ON BARREN-GROUND CARIBOU

IN THE NORTHWEST TERRITORIES

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PRATIQUES DE GESTION EXEMPLAIRES POUR ATTÉNUER LES EFFETS DES ROUTES SUR LE CARIBOU DE LA TOUNDRA

AUX TERRITOIRES DU NORD-OUEST

Le présent document contient la traduction française du sommaire.

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Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

EXECUTIVE SUMMARY

In many parts of the Northwest Territories, roads provide access to communities and industrial developments, such as mineral exploration, mining, and oil and gas. As industrial development proceeds and expands across the Northwest Territories, and as the need for all-season roads increases due to climate change-induced shortening of winter road seasons, the need for careful planning processes for road development will become paramount.

The *Best Management Practices for Mitigating the Effects of Roads on Barren-ground Caribou in the Northwest Territories* (hereafter the Barren-ground Caribou BMPs for Roads) are intended to support developers who are planning or conducting road operations in barren-ground caribou (*Rangifer tarandus groenlandicus*) habitat in the Northwest Territories, as well as regulators and other parties reviewing road development proposals within the range of barren-ground caribou.

Barren-ground caribou are designated as Threatened under the *Species at Risk (NWT) Act* and were assessed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2016 and are under consideration for addition to Schedule 1 of the federal *Species at Risk Act*. Habitat loss and fragmentation from industrial development, particularly from roads, and increased predation/hunting pressures have been identified as the biggest threat to barren-ground caribou, both from an Indigenous knowledge and western science perspective. Roads impact barren-ground caribou and their habitat by removing or destroying vegetation and topography (i.e., direct habitat loss), reducing habitat suitability from sensory disturbance (i.e., indirect habitat loss), dividing high quality habitat patches into smaller patches (i.e., habitat fragmentation), reducing survival from injuries, fatalities or increased harvest (i.e., mortality), and reducing connectivity and movements between habitats (i.e., barrier to movement).

Mitigation through avoidance is the most effective in limiting adverse effects to barren-ground caribou and their habitat. Developers are expected to use existing disturbance, reduce their project footprint, and avoid sensitive habitat features to caribou. This approach is followed by the minimization of effects by reducing the intensity and length of exposure of barren-ground caribou to sensory disturbance and implementing awareness training for all workers. Mitigations to avoid and minimize impacts should be applied during all project phases (i.e., project planning, construction, operation, and closure). Developers are also expected to implement actions to restore impacted caribou habitat by rectifying on-site impacts after construction (e.g., revegetating disturbed areas, such as quarries), as well as reclaim disturbed areas and decommission infrastructure in accordance with the project's closure and reclamation plan during closure. The Barren-ground Caribou BMPs for Roads identifies road mitigation measures to be implemented by developers to avoid and minimize direct and indirect impacts of roads on barren-ground caribou during the project planning, construction, operation, and closure phases of a road development. The list of road mitigation measures was generated following a review of 60 industry reports, plans, and research articles as well as through 30 Subject Matter Expert (SME) interviews.

Prior to planning any activities in barren-ground caribou range, developers are encouraged to review the Barren-ground Caribou BMPs for Roads and contact GNWT Department of Environment and Climate Change (ECC) offices, Indigenous governments and Indigenous organizations, and renewable resources boards to obtain up-to-date information on barren-ground caribou in the project area. Developers are also strongly encouraged to work collaboratively with Indigenous governments and Indigenous organizations and all levels of government to identify road mitigation measures that effectively avoids and minimizes impacts of the proposed road development on barren-ground caribou during all phases of the project.

SOMMAIRE

Dans de nombreuses régions des Territoires du Nord-Ouest (TNO), les routes permettent d'accéder aux collectivités et aux projets industriels, comme la prospection ou l'exploitation minière, pétrolière ou gazière. Avec l'essor du développement industriel du territoire et le besoin croissant en routes toutes saisons, surtout depuis que le changement climatique raccourcit la durée des routes d'hiver, il va devenir essentiel de planifier minutieusement l'aménagement routier.

Les pratiques de gestion exemplaires pour atténuer les effets des routes sur le caribou de la toundra aux TNO ont pour objectif d'orienter les prospecteurs qui prévoient ou effectuent des travaux de voirie dans l'habitat de cette espèce (*Rangifer tarandus groenlandicus*) ainsi que les autorités de réglementation et toute autre partie qui évalue des projets d'aménagement routier dans ces zones.

Le caribou de la toundra figure sur la liste des espèces en péril aux termes de la *Loi sur les espèces en péril (TNO)* et sur celle des espèces menacées (2016) selon le Comité sur la situation des espèces en péril au Canada (COSEPAC). Par ailleurs, son inscription à l'annexe 1 de la *Loi sur les espèces en péril* du Canada est envisagée. Les savoirs autochtones et la science occidentale s'entendent à dire que les plus importantes menaces pour cette espèce sont la perte et la fragmentation de son habitat causé par le développement industriel, surtout l'aménagement routier, ainsi que la prédation et la chasse accrues. En effet, la construction de routes a une répercussion sur le caribou et son habitat : elle implique le retrait ou la destruction de la végétation et de la topographie (perte directe d'habitat), une baisse d'adéquation de l'habitat causée par des perturbations sensorielles (perte indirecte d'habitat), la division des grandes parcelles d'habitat de haute qualité en parcelles plus petites (fragmentation de l'habitat), la baisse des taux de survie aux blessures, aux incidents potentiellement mortels ou à l'augmentation des récoltes (mortalité) et la diminution des liens et des déplacements entre les habitats (obstacle aux déplacements).

Les mesures d'évitement sont l'approche la plus efficace pour atténuer les effets néfastes sur le caribou de la toundra et son habitat. Il est donc attendu des prospecteurs qu'ils utilisent les aménagements existants, réduisent l'empreinte environnementale de leur projet et évitent de causer du tort à cet habitat fragile. Ensuite, une autre approche est la réduction des effets : réduire l'intensité et la durée auxquelles les caribous de la toundra sont exposés à des nuisances sensorielles et sensibiliser tous les travailleurs. Ces mesures pour éliminer ou atténuer les répercussions d'un projet doivent être appliquées à toutes les phases (planification, construction, exploitation et fermeture). Les prospecteurs doivent également prendre des mesures pour restaurer l'habitat du caribou et, ainsi, remédier aux effets des travaux sur le site (par exemple, en revégétalisant les zones touchées, comme les carrières). Ils doivent également remettre en état les zones perturbées et faire déclasser les infrastructures, conformément au plan de fermeture et de remise en état du projet. Ces pratiques exemplaires présentent les mesures d'atténuation à mettre en œuvre par les prospecteurs pour éviter et minimiser les impacts directs et indirects des routes sur le caribou de la toundra pendant les phases de planification, de construction, d'exploitation et de fermeture d'un projet routier. Cette liste a été établie suivant l'étude de 60 rapports, plans et articles de recherche sur le secteur ainsi que de 30 entretiens avec des experts en la matière.

Avant de prévoir toute activité dans l'habitat du caribou de la toundra, les prospecteurs sont encouragés à étudier ces pratiques exemplaires et à communiquer avec le ministère de l'Environnement et du Changement climatique du GTNO, les gouvernements et organisations autochtones ainsi que les offices des ressources renouvelables pour obtenir des renseignements à jour sur le caribou de la toundra dans la zone concernée. Il leur est aussi vivement recommandé de collaborer avec les gouvernements et organisations autochtones et avec tous les ordres de gouvernement pour déterminer quelles mesures pourraient réduire ou éliminer efficacement les effets d'un aménagement routier sur le caribou, et ce, à toutes les phases du projet.

DISCLAIMER

These best management practices are intended to be implemented by developers to the greatest extent feasible. It is recognized that it may not be possible for developers to fully implement the best management practices exactly as written in all situations. Where the specific circumstances of a project require deviation from the best management practices, developers are expected to explain why and to propose alternate mitigation measures that would achieve a similar outcome.

These best management practices do not replace legislation or the terms and conditions of regulatory authorizations although the use and adoption of these best management practices could contribute to efficiency in the project assessment and regulatory process for a project. While every attempt has been made to provide up-to-date information, it remains the developer's responsibility to obtain the most recent information related to barren-ground caribou and their habitat, to ensure all regulatory requirements have been met, and to undertake appropriate consultation with territorial and federal governments, as well as Indigenous governments and Indigenous organizations. No parts of these best management practices are intended to infringe on asserted or established Indigenous and/or treaty rights.

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GLOSSARY

Anthropogenic disturbance: Disturbance caused by human activity.

Avoidance: First order in the mitigation hierarchy. Developers are expected to take all reasonable and practical measures to *avoid* impacts of development on caribou. This includes but is not limited to the investigation of less impactful alternatives to the project, including a "no project" option, reducing the physical footprint size, and adjusting the location or design of a road to prevent impacts from occurring in important caribou habitat, key water crossings, and land bridges.

Compensation or compensatory mechanisms: Last order in the mitigation hierarchy. Offsetting options that are not based on typical offsets and may be novel in nature. Compensatory mechanisms may include habitat banking, conservation covenants, or in-lieu payments that fund new research or ongoing programs.

Decommission: To remove from service. Road decommissioning can include the complete or partial demolition of a highway or road surface, including its authorization as an access route.

Developer: Any person, government, or any other legal entity owning, operating, or causing to be operated any development in whole or in part in the Northwest Territories, including any co-contractant of such owner or operator. The term "government" is intended to include municipal, territorial, federal, and Indigenous governments. This definition is adapted from the definition of "Developer" in Section 2.0 of the Inuvialuit Final Agreement available at: https://www.irc.inuvialuit.com/sites/default/files/Western_Arctic_Claim_Inuvialuit_FA_0.pdf

Development: For the purpose of these guidelines, development includes any proposed or existing development (including exploration phase activities) and means (a) any public, commercial or industrial undertaking or venture, including support and transportation facilities, related to the extraction of renewable or non-renewable resources, and any infrastructure related to transportation and utilities; (b) any use of land that requires a permit under the *Mackenzie Valley Land Use Regulations* or the *Territorial Land Use Regulations*; or (c) any undertaking that requires a license to use water or deposit waste under the *Northwest Territories Waters Act*. The term "public" is intended to include municipal, territorial, federal, and Indigenous governments.

Direct habitat disturbance: Footprint of land directly affected by a development activity that results in loss or physical alteration of habitat for a wildlife species.

Important caribou habitat / habitat importance: Important barren-ground caribou habitat identified through available traditional knowledge and western science during development of range plans (GNWT 2019a) or other management plans. This may include areas providing preferred vegetation, travel corridors, water crossings, land bridges, large undisturbed habitat patches, connectivity between large patches or between important areas.

Indirect habitat disturbance: Habitat that is not directly affected by development, but which is avoided or used less by caribou because of factors like sensory disturbance or predation risk.

Large habitat patch: A patch of undisturbed habitat that is at least 100 km^2 in size.

Minimization: Second order of the mitigation hierarchy. Impacts of a development which cannot be wholly avoided should be *minimized* as far as it is practical and reasonable. This includes actions that initially limit the magnitude of unavoidable impacts of a development, such as implementing operational procedures and timing work and activities to avoid ecologically sensitive periods.

Movement barrier: Cause for reduction in connectivity/movements by caribou between habitats.

Offsetting: Last order of the mitigation hierarchy. Process of creating measurable environmental benefits to compensate for the residual negative environmental impacts of development projects after all reasonable measures have been taken to avoid and minimize the losses (BBOP 2013).

Progressive reclamation: Select closure/reclamation activities that can be implemented before overall project completion.

Range plan: A plan describing how habitat disturbance from human development activity and wildfires will be managed to maintain adequate habitat to ensure a healthy and sustainable caribou population that offers harvesting opportunities for present and future generations (GNWT 2019a).

Reclamation: Process of returning a disturbed site to its natural state or which prepares it for other productive uses that prevents or minimizes any adverse effects on the environment or threats to human health and safety (MVLWB/AANDC 2013).

Restoration: Third order of the mitigation hierarchy. Process of assisting the recovery of a site that has been degraded, damaged, or destroyed by development activity.

Risk timing windows: Period of the year when industrial work or development can occur with a lower probability of impacting the ecological component for which the window was developed, in this case for barren-ground caribou.

Road project: A road construction or maintenance project, including any borrow sources or quarries necessary for construction and ongoing maintenance of road surfaces and embankments and their cleared right-of ways.

Semi-permeable movement barrier: Features that impede some movement of caribou across a landscape but are not impenetrable (i.e., when caribou hesitate before crossing a road or when a proportion of caribou avoid crossing).

Sensory disturbance: Activity that can be sensed by a wildlife species and elicit a behavioural change. For example, habitat adjacent to a project footprint, while remaining structurally unchanged, may become less effective for wildlife due to sensory disturbance (e.g., noise, light, dust, vibrations, human presence) associated with project activities.

Snow berm: Accumulation of snow that is pushed and shaped by a snowplow, creating a mound or bank of snow on roads.

Zone of influence: Area around a project development where the behaviour and relative abundance of caribou change in response to the project's activities (e.g., avoidance response to disturbance).

LIST OF ACRONYMS

BACI	Before-After-Control-Impact
BCRP	Bathurst Caribou Range Plan
BMPs	Best Management Practices
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRMP	Caribou Road Mitigation Plan
EIRB	Environmental Impact Review Board
EISC	Environmental Impact Screening Committee
ENK	Ekwǫ̀ Nàxoèhdee K'è
GNWT	Government of the Northwest Territories
GNWT-ECC	Department of Environment and Climate Change, GNWT
HTCs	Hunter and Trapper Committees
IGIOs	Indigenous Governments and Organizations
ILA	Inuit Land Administration
IQTK	Inuit Qaujimajatuqangit Traditional Knowledge
ITH	Inuvik to Tuktoyaktuk Highway
LWBs	Land and Water Boards of the Mackenzie Valley
MVEIRB	Mackenzie Valley Environmental Impact Review Board
NDVI	Normalized Difference Vegetation Index
NNL	No Net Loss
NPI	Net Positive Impact
NWT	Northwest Territories
NWT CIMP	NWT Cumulative Impact Monitoring Program
RRBs	Renewable Resources Boards
RSFs	Resource Selection Function Models
SARA	*Species at Risk Act*
SARA (NWT)	*Species at Risk (NWT) Act*
SME	Subject Matter Experts
TASR	Tłı̨chǫ All-Season Road
TCWR	Tibbitt to Contwoyto Winter Road
WEMP	Wildlife Effects Monitoring Program
WMIS	Wildlife Management Information System
WMMP	Wildlife Management and Monitoring Plan
ZOI	Zone of Influence

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1. INTRODUCTION

Barren-ground caribou (*Rangifer tarandus groenlandicus*) are an ecological and cultural keystone species and are a central part of Indigenous cultures across the Northwest Territories (NWT). Populations of barren-ground caribou (also referred to as "herds") are known through Indigenous knowledge and western science to have historically undergone large fluctuations in population size, cycling from periods of high to low abundance over several decades (Parlee et al. 2013; Morneau and Payette 2000). The causes of population fluctuations are complex and likely driven by interactions between forage availability, predation, parasites, climate change, wildfires, and industrial development. The *Species Status Report for Porcupine Caribou and Barren-ground Caribou (*Rangifer tarandus groenlandicus*) in the Northwest Territories* (SARC 2017) has identified habitat loss and fragmentation from industrial development and increased predation/hunting pressures as threats to barren-ground caribou, which have in part led to population declines throughout the distribution of barren-ground caribou in the NWT.

In light of the observed declines of barren-ground caribou and particularly from the Bathurst herd, the Government of the Northwest Territories (GNWT) published the *Bathurst Caribou Range Plan* (BCRP; GNWT 2019a) in 2019, which includes a recommendation that developers should take into consideration best management practices (BMPs) for mitigating the impacts of roads when planning, constructing, and operating roads within the annual range of the Bathurst herd of barren-ground caribou.

The *Best Management Practices for Mitigating the Effects of Roads on Barren-ground Caribou in the Northwest Territories* (hereafter Barren-ground Caribou BMPs for Roads) were developed to support developers who are planning, constructing or conducting road operations in following BMPs. BMPs should be used during all phases of a development, from planning to operation, while working in the annual range of barren-ground caribou, to reduce and mitigate direct and indirect impacts to barren-ground caribou and their habitat in the NWT.

The Barren-ground Caribou BMPs for Roads support the implementation of the *Bathurst Caribou Range Plan* (GNWT 2019a) and the *Wildlife Management and Monitoring Plan Process and Content Guidelines* (GNWT 2019b). The Barren-ground Caribou BMPs for Roads should be read in conjunction with, and as a complement to, these prior documents.

Prior to planning, constructing or operating a road, developers should review the Barren-ground Caribou BMPs for Roads and contact the GNWT Department of Environment and Climate Change (GNWT-ECC), as well as Indigenous governments and Indigneous organizations (IGIOs), and renewable resources boards (RRBs) to obtain the most up-to-date information on barren-ground caribou in the project area and for advice on mitigation measures to consider.

2. BARREN-GROUND CARIBOU

2.1. Distribution

Barren-ground caribou are migratory and on an annual basis travel thousands of kilometres from wintering grounds, often within the treeline, to calving grounds on the tundra of the NWT and Nunavut (SARC 2017). There are nine barren-ground caribou herds that reside partially or entirely in the NWT – Porcupine, Tuktoyaktuk Peninsula, Cape Bathurst, Bluenose-West, Bluenose-East, Bathurst, Beverly, Ahiak, and Qamanirjuaq (Figure 1). Barren-ground caribou require large annual ranges to support their seasonal migrations as migration is a key adaptive strategy allowing barren-ground caribou to respond to variability in environmental conditions, predation, and parasitism (SARC 2017). During the winter, barren-ground caribou are spread out in small to moderate sized groups. During calving, females congregate in an attempt to reduce vulnerability of newborn calves to predation.

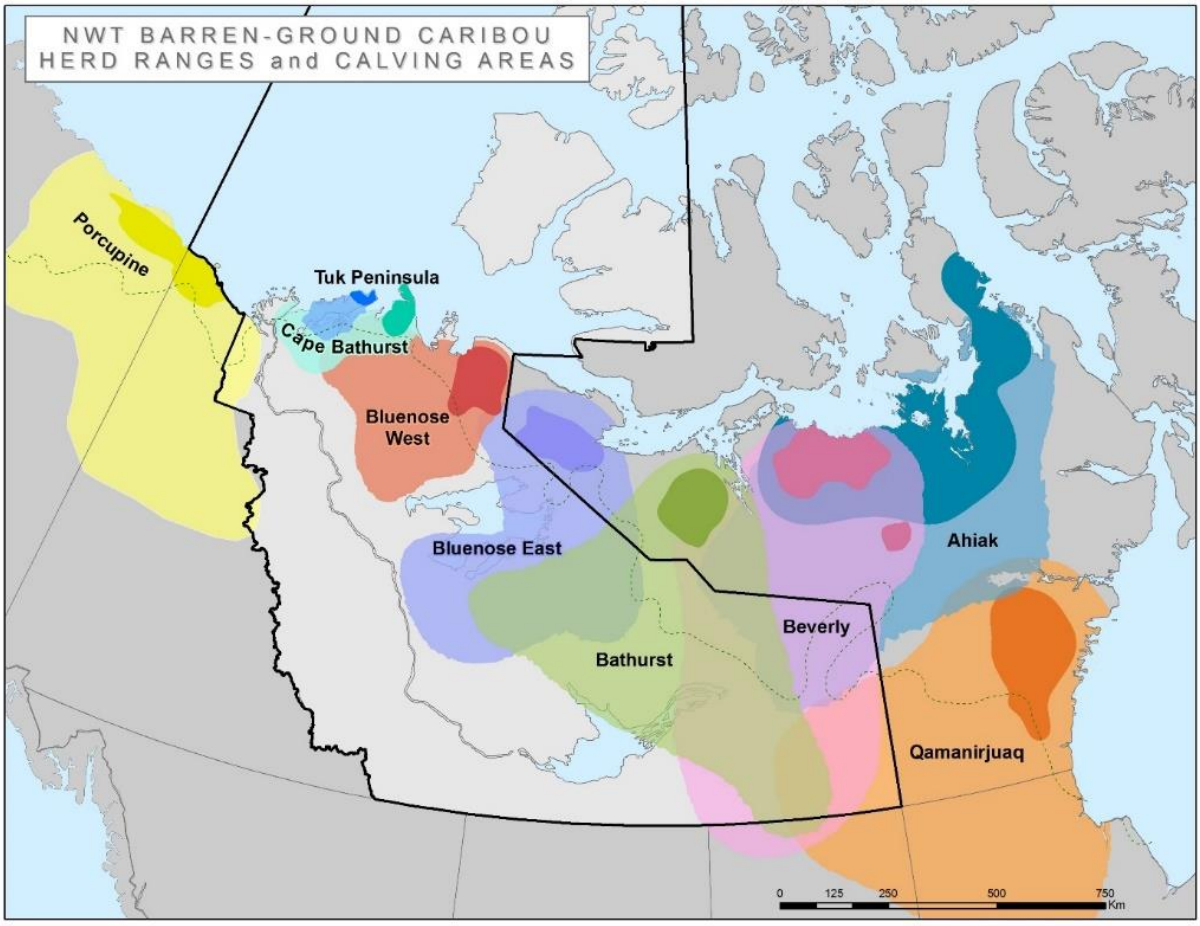

Figure 1. Barren-ground caribou herds found partially or completely in the Northwest Territories (NWT Species at Risk 2023). Annual ranges (pale colours) and calving grounds (dark colours) were derived using GPS collar data from the Government of the Northwest Territories, Government of Nunavut, Government of Yukon, and United States Fish and Wildlife Service.

2.2. Threats

Barren-ground caribou are affected by multiple natural and anthropogenic threats and each herd is exposed to these threats to varying degrees. Climate change, through changes in the timing of green-up, summer forage availability, rain-on-snow and icing events, thawing permafrost, and wildfire regimes, is considered a complex threat impacting both habitat and populations of barren-ground caribou (SARC 2017). Wildfires occurring in both the boreal forest (i.e., winter range) and tundra (i.e., summer range) can also drive habitat fragmentation and impact forage availability and movement.

The biggest threat to barren-ground caribou in the NWT is industrial development, both from an Indigenous knowledge and western science perspective (SARC 2017; Parlee et al. 2013). Industrial development activities, such as mineral exploration, mining, oil and gas exploration and development, and roads, vary over time and depends heavily on the global economy. Industrial development activities peaked in the 1990s and mid- to late 2000s (prior to the 2008 market crash), but for the most part, activities have been declining in the NWT.

2.3. Impact Pathways of Roads

Industrial development, particularly all-season and winter roads, may impact barren-ground caribou and their habitat in the following ways:

1) Direct habitat loss (i.e., removal or destruction of vegetation and topography);
2) Indirect habitat loss (i.e., reduction of habitat suitability from sensory disturbance);
3) Habitat fragmentation (i.e., dividing habitat patches into smaller patches);
4) Mortality (i.e., reduced survival from injuries, fatalities or increased harvest); and
5) Barrier to movement (i.e., reduction in connectivity/movements between habitats).

2.3.1. Direct Habitat Loss

Direct habitat loss involves the removal of vegetation communities, wetlands, unvegetated areas or topography through activities associated with industrial development. Direct habitat loss impacts barren-ground caribou by reducing habitat availability that is necessary to meet life-history requirements. Consequently, reductions in habitat availability lowers the carrying capacity of seasonal or annual ranges to support barren-ground caribou populations and are predicted to lead to reduced abundance or altered distribution. For example, cow caribou body mass influences recruitment rates through minimum body mass needed for pregnancy (Thomas 1982; Reimers 1993) and parturition (Cameron and Ver Hoeff 1994). Barren-ground caribou spend about 40% to 60% of their time feeding to meet the energetic demands of survival and reproduction (Duquette and Klein 1987; Witter et al. 2012; DDMI 2023). A habitat loss threshold of 40% has been predicted for declines in bird and mammal species (Andrén 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002), where a lack of high-quality habitat may lead to lower survival, pregnancy or calving rates and decreased abundance or shifts in distribution to locate high-quality forage elsewhere. For barren-ground caribou in the NWT, seasonal and annual ranges remain relatively pristine as existing industrial development is low but increased industrial pressures may lead to increased direct habitat loss and fragmentation of habitat.

2.3.2. Indirect Habitat Loss

Indirect habitat loss results from new environmental stimuli through the presence and distribution of noise, lights, smells, dust or the presence of people or activity outside of an industrial development that alter the level of habitat suitability by caribou on otherwise undisturbed habitat. Tłı̨chǫ, Yellowknives, Denesųłiné, and Inuit Elders have long highlighted concerns that new environmental stimuli from mining activity and haul roads negatively affect caribou and their habitat (GSCI 2015; Thorne and Barnaby 2016; GTC 2019; Łutsël K'é Dene First Nation 2020). These stimuli can result in reduced use (avoidance) of suitable habitat (Johnson et al. 2005; Thorne and Barnaby 2016; Plante et al. 2018; Łutsël K'é Dene First Nation 2020; Boulanger et al. 2021) or increased use (attraction; Boulanger et al. 2021). However, indirect effects are not well understood for impact to habitat availability (Flydal et al. 2019).

Changes in the quantity and quality of habitat within the extent of indirect effects to habitat can influence the number of caribou that the landscape is able to support (i.e., carrying capacity). If caribou strongly avoid industrial development, then less disturbed areas may experience greater use and higher densities of caribou. Changes to behaviour, such as decreased time spent feeding or increased time spent moving away from industrial development, within indirectly affected habitat areas can influence the energy balance of caribou and alter survival and reproduction. All of these changes can ultimately affect barren-ground caribou population size and distribution. Currently, the reported extent of indirect effects to barren-ground caribou habitat associated with roads are within 5 km (Johnson et al. 2005; GNWT 2019a; Prichard et al. 2022; Severson et al. 2023). Barren-ground caribou tend to exhibit avoidance behaviour around areas close to roads, particularly during the post-calving and insect harassment seasons, staying approximately 1-3 km away from roads to minimize disturbance (Severson et al. 2023).

2.3.3. Habitat Fragmentation

Habitat fragmentation is the division of continuous blocks of habitat into multiple smaller, isolated habitat patches and increased spacing between habitat patches through habitat loss. Landscape-scale fragmentation where there are small and isolated habitat patches may restrict caribou movements and behaviour which may negatively influence the survival and reproduction of caribou. For wide ranging species that need broad areas for their life history requirements, such as caribou, restricted movement and, therefore, restricted access to resources within a herd or range can increase extinction probability and reduce lifetime reproductive success (McLoughlin et al. 2007; Revilla et al. 2008). Similarly, in many caribou subpopulations, reduced movements have been associated with fragmented populations and subsequent genetic drift (Serrouya et al. 2012). Levels of habitat fragmentation within barren-ground caribou ranges in the NWT are likely low due to existing low levels of industrial development (GNWT 2019a).

2.3.4. Mortality

Mortality represents the loss of individuals from a population, which can influence population trend, survival, and availability of caribou as a country food. Barren-ground caribou have been observed bedding or travelling on roads at industrial developments. Road-related injury or mortality of caribou may arise from interacting with hazards (e.g., fencing, guard rails, debris, uneven road

surface) or through collision with vehicles. For example, a bull caribou's antlers became entangled in fencing at the Diavik Diamond Mine in 2005, and the caribou was subsequently killed by a grizzly bear (DDMI 2006). While caribou-vehicle collisions have been historically rare, five caribou mortalities occurred when they were struck by a commercial truck along the Tibbitt to Contwoyto Winter Road (TCWR) in the late 1990s (TCWR JV 2001).

In addition to mortality associated with collisions, roads provide access and higher encounter rates with caribou for both humans and predators, influencing harvest and predation rates on barren-ground caribou (Smith and Johnson 2023; Wray 2011). Many Elders have highlighted that roads open up areas that may have been previously difficult to access or inaccessible by vehicle or snowmobile, resulting in higher harvest pressures on caribou (EMAB 2012; Tłı̨chǫ Government 2013; GSCI 2015; Łutsël K'é Dene First Nation 2020). Large annual ranges and migration between seasonal ranges expose barren-ground caribou to industrial developments, even when industrial development sites are highly dispersed (Gunn et al. 2014). A core concern over caribou mortality is related to both the sustainability of continued access to healthy barren-ground caribou for harvesting, and trade-offs between industrial developments relative to the persistence of barren-ground caribou on the landscape (Gunn et al. 2014).

2.3.5. Barrier to Movement

Construction and operation of infrastructure, such as roads, can create physical and linear barriers to movement, reducing habitat connectivity. Many Elders have described roads as a major contributor to changes in caribou movement and migration, especially in the Bathurst and Beverly herd ranges (Parlee et al. 2013; GTC 2019). The physical structure of a road, such as the use of guard rails, road height, and slopes within the right-of-way or construction material, may influence movements across it. The height of snow berms along winter roads has also influenced barren-ground caribou movements (BHP Billiton 2011). Additionally, the presence of traffic may reduce crossing or influence caribou distribution or behaviour (Boulanger et al. 2024; Prichard et al. 2022; Smith 2022; Severson et al. 2023; Wilson et al. 2016). The current belief is that roads may function as a semi-permeable barrier to caribou, meaning they cause delays as barren-ground caribou hesitate to cross the road but are not absolute barriers (Boulanger et al. 2024; Plante et al. 2018; Wilson et al. 2016). The estimated Zone of Influence (ZOI) or extent of effects of roads on caribou movement ranges from 0 km (no influence) to 23 km (Boulanger et al. 2024; Plante et al. 2018).

Barren-ground caribou have been recently documented to exhibit noticeable behavioural changes in response to road traffic, tending to avoid areas with high traffic volumes (Smith and Johnson 2023; Severson et al. 2023; Boulanger et al. 2024). Road traffic can hinder caribou movement and access to essential habitats. On the Gahcho Kué Spur Road in the NWT, collared caribou were monitored over three years, and fewer crossings were observed in areas with higher traffic volumes (Smith and Johnson, 2023). This barrier effect can disrupt caribou migration patterns and habitat use, potentially affecting their survival and reproduction rates (Smith and Johnson 2023; Severson et al. 2023; Boulanger et al. 2024).

Severson et al. (2023) showed that caribou have a preference for areas with lower traffic volumes throughout the year, with the highest selection probabilities when traffic was less than five vehicles

per hour. The likelihood of caribou crossing roads decreased as traffic volume increased, particularly during seasons with high insect activity/harassment. However, Severson et al. (2023) found that the need to escape insects can override the avoidance of roads. Severson et al. (2023) suggests minimizing traffic volumes and creating traffic-free periods during critical times to help mitigate the negative effects on caribou movement and habitat use.

3. INFORMATION AND RESOURCES FOR DEVELOPERS

3.1. Statutory Requirements

3.1.1. NWT Legislation

All developers need to be aware of the prohibitions and requirements under the NWT *Wildlife Act* and *Species at Risk (NWT) Act* (SARA [NWT]). A summary of sections of the NWT *Wildlife Act* and SARA (NWT) that most commonly apply to development projects can be found in the most recent *Statutory Requirements for Wildlife in the NWT* available at the following link: https://www.gov.nt.ca/ecc/en/resources.

Under Section 95 of the NWT *Wildlife Act* and Section 13 of the Wildlife General Regulations, the Minister of Environment and Climate Change (ECC) can require a Wildlife Management and Monitoring Plan (WMMP) for developments that are likely to:

a) result in a significant disturbance to big game or other prescribed wildlife;
b) substantially alter, damage or destroy habitat;
c) pose a threat of serious harm to wildlife or habitat; or
d) significantly contribute to cumulative impacts on a large number of big game or other prescribed wildlife, or on habitat.

Where the Minister of ECC has determined that an approved WMMP is required for a development project, developers may not undertake or engage in the development until the plan is approved, and a developer may be fined for not complying with an approved WMMP, unless otherwise authorized to do so by the Minister of ECC. As defined in the Wildlife General Regulations, barren-ground caribou are considered both a big game species and prescribed wildlife for the purposes of Section 95 of the NWT *Wildlife Act*. Given the Threatened status of barren-ground caribou, and the link between habitat disturbance and declining barren-ground caribou populations, it is expected that projects that occur within barren-ground caribou range will trigger the requirements for an approved WMMP. Guidelines and resources to help developers prepare a WMMP can be downloaded at the following link: https://www.gov.nt.ca/ecc/en/services/wildlife-management-and-monitoring-plans.

Appropriate guidelines from BMPs should be incorporated into a WMMP when one is required. Developers may also be responsible for monitoring the effectiveness of implemented measures stemming from these BMPs and may need to adaptively manage for unanticipated project-related effects to barren-ground caribou and their habitat. Such monitoring would be part of a WMMP if one was required for the proposed project.

Developers should note that a Wildlife Research Permit is required to carry out any monitoring programs that involve researching, observing and/or handling wildlife in the NWT. More information on how to obtain a Wildlife Research Permit can be found here: https://www.gov.nt.ca/ecc/en/services/apply-research-observe-and-handle-wildlife-nwt.

3.1.2. Federal Legislation

A permit under the federal *Species at Risk Act* (SARA) is not required to disturb or destroy barren-ground caribou critical habitat on federally administered lands in the NWT. However, barren-ground caribou were assessed as Threatened by the COSEWIC in 2016 and are under consideration for addition to Schedule 1 of SARA. The listing of barren-ground caribou to Schedule 1 of SARA will trigger the development of a recovery strategy and identification of critical habitat by Environment and Climate Change Canada. It is the responsibility of the developer to obtain the most recent information related to barren-ground caribou under the federal SARA, which can be found at: https://species-registry.canada.ca/index-en.html#/species/1341-962.

3.2. Sources of Available Information and Data on Barren-ground Caribou

3.2.1. Project Planning and Engagement

Developers should consult applicable regional land use plans and community conservation plans, and seek input from GNWT-ECC, applicable land owners/managers, IGIOs, RRBs, and Hunter and Trapper Committees (HTCs) to identify the location of important habitat areas, undisturbed habitat patches, key water crossings, and key movement corridors, so that potential impacts can be avoided through good project planning. If this information is not available for a particular project location, developers should document baseline habitat conditions in that area before carrying out development activities.

Indigenous knowledge is a valuable and important source of information to effectively identify road mitigation measures that avoids and minimizes impacts of proposed road developments on barren-ground caribou. Developers are strongly encouraged to engage early and work collaboratively with affected communities and IGIOs in all aspect of their road development proposal (i.e., project planning, construction, operation, and closure). There are resources available to developers on best practices for collaborative engagement and project planning on the Mackenzie Valley Environmental Impact Review Board (MVEIRB) website at https://new.reviewboard.ca/en/guidance-documentation. Specifically, developers are encouraged to read the following guidance:

- *Guidelines for Incorporating Traditional Knowledge in Environmental Impact Assessment* (MVEIRB 2005);
- *Environmental Impact Assessment Guidelines* (MVEIRB 2004);
- *Socio-economic Impact Assessment Guidelines* (MVEIRB 2007); and
- *Guideline for an Optional Pathway for Major Projects to Enter Environmental Assessment* (MVEIRB 2024).

Developers are also encouraged to follow the Land and Water Boards of the Mackenzie Valley (the LWBs) *Engagement Guidelines for Applicants and Holders of Water Licences and Land Use Permits in the Mackenzie Valley* (LWB 2018) or Section 4.2 of the Environmental Impact Screening Committee (EISC) *Environmental Impact Screening Guidelines* (EISC 2021) in the Inuvialuit Settlement Region when planning engagement for their project.

3.2.2. Spatial Information

The NWT Species and Habitat Viewer is an online mapping tool that allows developers to view current spatial data related to barren-ground caribou in the NWT under the "Migratory Caribou" tab. Spatial data includes range boundaries, as well as wildfire and human disturbance footprints. Under this tab, the NWT Species and Habitat Viewer has two tools to allow developers to:

1) Calculate the changes in the amount of direct human-caused footprint and total human-caused habitat disturbance associated with a user-defined area of interest or uploaded footprint of a proposed development within the annual range of the Bathurst herd (i.e., Bathurst Habitat Disturbance Report); and
2) Identify whether a user-defined area of interest or uploaded footprint of a proposed development overlaps with the annual or seasonal ranges of barren-ground caribou and documented important water crossings for the Bluenose-East, Bathurst, and Beverly herds (i.e., Migratory Caribou Report).

The NWT Species and Habitat Viewer can be found at the following link: https://www.maps.geomatics.gov.nt.ca/Html5Viewer/index.html?viewer=NWT_SHV.

The Wildlife Management Information System (WMIS) is the GNWT online, geo-referenced wildlife database. WMIS provides a central repository for government staff, developers, researchers, and the public to store and access standardized wildlife observation data to support the conservation and management of wild species and their habitat in the NWT. Developers can submit a request for barren-ground caribou observation data within their area of interest or submit observations to WMIS by contacting the WMIS team at wmisteam@gov.nt.ca.

The NWT Cumulative Impact Monitoring Program (NWT CIMP) maintains a spatial database of development projects based on land use and water licence permit registry data from the LWBs. The NWT Inventory of Landscape Change Viewer allows users to explore spatial data related to human and natural disturbance. It can be used as a tool by developers to identify active or past projects that may overlap with their proposed development, identify opportunities to share access or re-use currently disturbed areas to minimize new habitat disturbance, or assist in assessing potential cumulative effects of a project in combination with other active or past projects. The NWT Inventory of Landscape Change Viewer can be found at the following link: https://www.maps.geomatics.gov.nt.ca/Html5Viewer_PROD/Index.html?viewer=CIMP_ILC_Webmap.ILC_Viewer.

4. BEST MANAGEMENT PRACTICES

4.1. Who these Best Management Practices are for and How Can They Be Used?

The Barren-ground Caribou BMPs for Roads are intended to be used by developers who are planning and/or conducting road operations in barren-ground caribou ranges in the NWT, and by regulators, communities, and other parties who review and make recommendations on proposals for development activities and/or issue authorizations for such activities.

Developers should use the Barren-ground Caribou BMPs for Roads when planning their road development projects and associated applications for land use permits or water licenses to identify specific mitigation measures that can be used to avoid, minimize or restore impacts of roads to barren-ground caribou and their habitat. It is important to recognize that developers may be unable to fully implement the Barren-ground Caribou BMPs for Roads exactly as written in all situations. For example, developers of public infrastructure corridors are not expected to implement mitigation measures that are applicable to private industrial roads (e.g. road convoying). Where the specific circumstances of a project require deviation from the Barren-ground Caribou BMPs for Roads, developers are expected to explain why and to propose alternate mitigation measures that would achieve a similar outcome. These BMPs may also be used to assist developers in demonstrating how conformity requirements or land protection directives related to barren-ground caribou in approved regional land use plans will be met, or how the guidance provided in community conservation plans was used. Further information on regional land use plans and community conservation plans can be found at: https://www.gov.nt.ca/ecc/en/services/land-use-planning-nwt.

Parties such as IGIOs, HTCs, RRBs, MVEIRB, Environmental Impact Review Board (EIRB), and territorial and federal government departments that review, comment and make recommendations on proposals for road development activities during environmental screening and assessment processes can use the Barren-ground Caribou BMPs for Roads to assess the adequacy of mitigation measures proposed by developers and to recommend specific mitigation measures that should be implemented by the developer.

Regulators such as LWBs, Inuit Land Administration (ILA), IGIOs, and territorial and federal governments that issue permits, licenses or other types of authorizations for development projects can use the BMPs to assess project applications for conformity with applicable requirements in approved regional land use plans, the application of guidance from community conservation plans, adequacy of management plans prepared by the developer, or to identify specific terms and conditions for barren-ground caribou to include in authorizations.

4.2. Mitigation Hierarchy

Developers are expected to rigorously apply the mitigation hierarchy to road mitigation strategies to reduce the residual effects of roads on barren-ground caribou in the NWT (Figure 2; IFC 2012; BBOP 2018). Mitigation should strive to achieve no net loss or net positive gains for barren-ground caribou

and their habitat. During the planning phase of new road projects, the mitigation hierarchy is to be used to avoid and minimize impacts to barren-ground caribou and their habitat through routing and planning processes. For example, avoiding critical habitats, important movement areas or key habitat features will be the most impactful mitigation measures for reducing adverse effects to caribou. During the construction, operation, and closure phases of new and current road projects, the mitigation hierarchy is to be used to minimize adverse effects to barren-ground caribou.

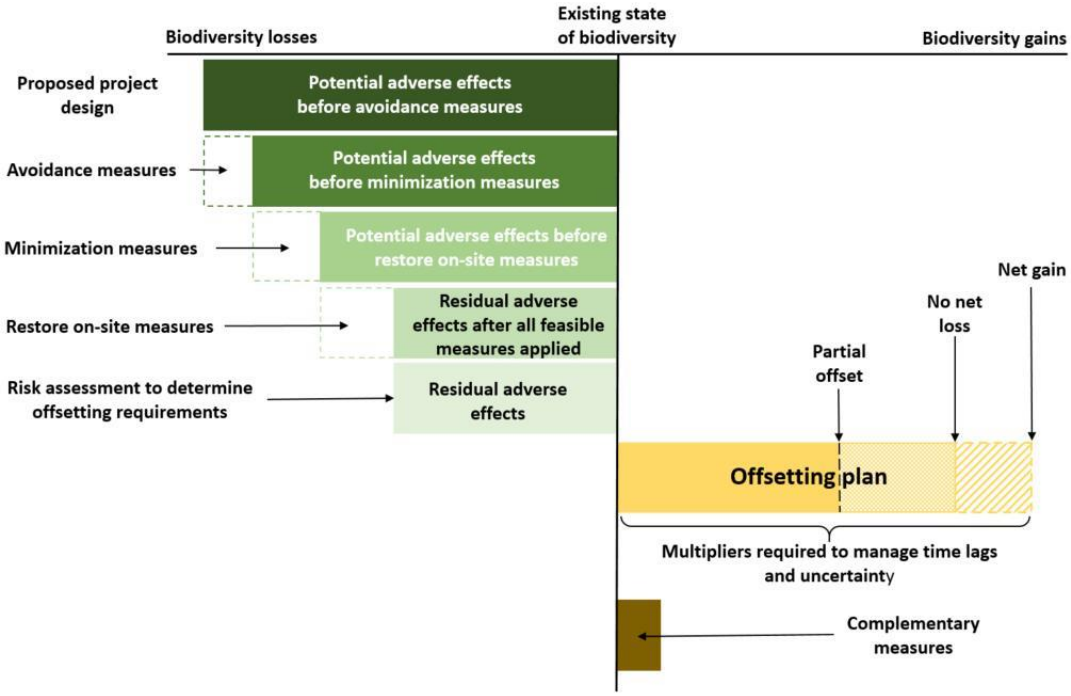

Figure 2. Visual representation of the mitigation hierarchy showing the residual impact on biodiversity (or caribou habitat) after the application of avoidance, minimization, and restoration measures (ECCC 2023; adapted from Barbé and Frascaria-Lacoste 2021).

In order of priority, mitigation for roads should progressively be designed to:

1) **Avoid** – Does not undertake certain activities or adjusts the location or design of the road to prevent impacts from occurring in important caribou habitat, key water crossings, and land bridges.
2) **Minimize** – Actions that initially limit the magnitude of unavoidable impacts of the road.
3) **Restore** – Actions to restore impacted caribou habitat to pre-disturbance state or otherwise eliminate the unavoidable impacts of the road, with priority given to actions that rectify on-site impacts (e.g., revegetating disturbed areas, such as quarries, after construction).
4) **Offset** – Measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse impacts after the first three levels of mitigation are implemented.
5) **Compensate** – Measures to make good or pay damages for loss when no net loss cannot be achieved after the first four levels of mitigation are implemented.

Offsets and compensation are considered the last step in the mitigation hierarchy after avoid, minimize, and restore (BBOP 2012). After rigorously applying the mitigation hierarchy, offsets are

used to mitigate any residual effects from a road to reach a No Net Loss (NNL) or ideally, Net Positive Impact (NPI) scenario (IUCN 2016). Offsets have a number of risks and uncertainties associated with them, including data limitations, time lags, and the risk of partial or total failure of offset measures to achieve outcomes; therefore, a clear articulation of adherence to the mitigation hierarchy prior to developing and implementing a road with an offset program is critical (Poulton 2019).

4.3. Current Road Mitigation Measures in the Arctic

A list of road mitigation measures to avoid and/or minimize direct and indirect impacts of roads on barren-ground caribou was generated following a review of 60 industry reports, plans, and research articles (see Appendix A and Appendix B) as well as through a Subject Matter Expert (SME) questionnaire (see Appendix C). The objective of the literature review and SME questionnaire was to identify mitigation measures applied in the NWT (but also throughout the Arctic) that were deemed effective as a BMP either through mitigation monitoring or by practitioners and/or expert opinion, including Indigenous knowledge. Current mitigation measures for roads in the Arctic, which are applied to both public and private industry roads, is summarized in Table 1.

BMPs for road mitigation are practices that have been established to be effective in achieving its intended outcome, which is avoiding and/or minimizing direct and indirect impacts to barren-ground caribou. Effectiveness can be established in a hierarchical order of strength of evidence:

- Quantitatively measured through mitigation monitoring;
- Qualitatively measured through practitioner and/or expert opinion (including Indigenous knowledge); or
- Assumed effectiveness.

Mitigation monitoring "consists of regular surveys or inspections by project personnel to determine whether mitigation designs, procedures and equipment outlined in a WMMP [or relevant guidelines] are being implemented as planned and are functioning as intended. It also includes surveillance to document and report on the presence of wildlife on-site, risks to wildlife and human safety and other wildlife incidents (injury, mortality, wildlife-human interactions) that require a management response" (GNWT 2019b). Mitigation monitoring is recommended for all types of development projects regardless of the need for a WMMP and may be the only type of monitoring required for small or short-term developments or mineral exploration programs in the NWT (GNWT 2019b).

Effects monitoring describes the relationship between an effect and a response by caribou. For example, a developer is interested in testing the relationship between traffic volume and caribou road crossing frequency. The relationship of traffic volume might be that caribou are more likely to cross a road as traffic volume decreases. While this result may lead to implementing mitigation measures, such as the use of a traffic volume limit or road closure, simply monitoring the relationship between traffic volume and caribou crossing frequency is not mitigation monitoring. Mitigation monitoring would correspond to the monitoring of a manipulated treatment (i.e., applied mitigation) or, in this example, the application of a limit of traffic volume or a road closure. Testing for mitigation effectiveness would be whether results of the mitigation monitoring indicate the measure achieved its intended outcome (i.e., caribou crossed the road when traffic was limited, or the road was closed).

Table 1. Current road mitigation measures in the Arctic, which are applied to both public and private industry roads.

Hierarchy	Mitigation Measure	Impact Pathway	Development Phase				Effectiveness Determination Method
			Planning	Construction	Operation	Closure[1]	
Avoid	Use of existing disturbance	Direct habitat loss / Indirect habitat loss	✓				Quantitative
Avoid / Minimize	Avoidance of sensitive habitat features	Direct habitat loss / Indirect habitat loss	✓	✓			Quantitative
Minimize	Reduced length and/or width of road footprint	Direct habitat loss	✓				Quantitative
Avoid / Minimize	Caribou crossings	Barriers to movement	✓				Assumed
Avoid / Minimize	Activity timing windows	Indirect habitat loss / Mortality		✓	✓	✓	Assumed
Avoid	Conservation zones (i.e., access restrictions)	Mortality / Indirect habitat loss			✓	✓	Assumed
Minimize	Blasting restrictions	Indirect habitat loss / Mortality		✓	✓	✓	Assumed
Minimize	Dust suppressants	Indirect habitat loss		✓	✓	✓	Quantitative
Minimize	Law enforcement or mobile enforcement units	Mortality / Indirect habitat loss			✓		Quantitative
Minimize	Speed limits (including triggers for different speed limits)	Mortality / Indirect habitat loss / Barrier to movement		✓	✓	✓	Assumed
Minimize	Traffic controls	Mortality / Barrier to movement		✓	✓		Assumed
Minimize	Traffic volume reduction	Mortality / Indirect habitat loss / Barrier to movement		✓	✓		Quantitative
Minimize	Right-of-way policy	Mortality		✓	✓	✓	Assumed

Hierarchy	Mitigation Measure	Impact Pathway	Development Phase				Effectiveness Determination Method
			Planning	Construction	Operation	Closure[1]	
Minimize	Employee education	Mortality / Indirect habitat loss		✓	✓	✓	Assumed
Minimize	Public education (i.e., stewardship workshops)	Mortality / Indirect habitat loss	✓	✓	✓	✓	Assumed
Minimize	Wildlife signs	Mortality		✓	✓	✓	Assumed
Minimize	Wildlife notifications	Mortality		✓	✓	✓	Assumed
Minimize	Traffic convoys	Indirect habitat loss / Barrier to movement			✓		Quantitative
Minimize	Road closures	Mortality / Indirect habitat loss / Barrier to movement			✓	✓	Quantitative
Minimize	Snow berm management	Barrier to movement			✓		Assumed
Restore	Progressive reclamation	Direct habitat loss		✓	✓		Assumed
Restore	Reclamation / Decommission	Direct habitat loss / Indirect habitat loss				✓	Assumed

[1] Closure refers to the active decommissioning phase.

4.3.1. Literature Review

The literature review is not considered exhaustive but is anticipated to be consistent with mitigation measures for roads within barren-ground caribou range across Canada and Alaska, and reindeer in Scandinavia. For each report and article reviewed, the following information was recorded:

- Source;
- Road type (i.e., all-season or winter road) and context (e.g., mine, community access);
- Type of road-related mitigation that was applied or recommended;
- Whether and how applied mitigation was monitored for effectiveness;
- Whether the monitoring concluded mitigation was effective or not; and
- When mitigation monitoring was not completed, whether effectiveness was determined qualitatively or assumed (not measured).

Details about mitigation design or monitoring outcomes were also recorded when stated. The results of the literature review are tabulated in Appendix B.

4.3.2. Subject Matter Expert (SME) Questionnaire

Following the literature review, mitigation measures identified as effective from monitoring or practitioners were included in these BMPs, whereas mitigation measures identified as ineffective were excluded from these BMPs. As monitoring for mitigation effectiveness is typically lacking and is assumed as noted in Golder (2007), mitigation measures from the literature review with assumed effectiveness were circulated to 30 SMEs to qualitatively assess whether these mitigation measures were effective or not.

On behalf of GNWT-ECC, WSP Canada Inc. surveyed SME knowledge on BMPs and effectiveness of current mitigation measures that are applied, or potential, mitigations used to address caribou impact pathways within barren-ground caribou ranges. SMEs were contacted from various bodies across Canada and Alaska, including but not limited to IGIOs, RRBs, territorial, provincial, and federal governments, regulators, academia, industry, and other parties who review and make recommendations on proposals for development activities or issue authorizations for such activities in barren-ground caribou ranges.

Thirty (30) SMEs were interviewed by telephone, video call or email, by which a response form was filled, and results were kept anonymous. Respondents were encouraged to provide anecdotal information to support their responses to the questions posed. The survey questions are included in Appendix C. Not all questions were answered by all participants, as participants chose to speak to their most relevant topic of knowledge.

All respondents (*n = 30*) had experience operating, managing, researching, commuting, or consulting along roads which interact with large mammals, including caribou, across Canada and Alaska. In Canada, the regions were primarily relevant to barren-ground caribou in Nunavut and the NWT, but also migratory caribou in Newfoundland and Labrador, Yukon, Quebec, Ontario, Manitoba, and Alberta. Specified geographic features were winter roads, all-season roads, and highways in National Parks throughout Western Canada. Respondents discussed on several all-season access roads to

industrial mining operations, Highway 3 (from Yellowknife to Behchokǫ), Highway 9 or the Tłı̨chǫ All-Season Road (TASR; providing all-season access to Whatì from Highway 3 west of Behchokǫ), the Tłı̨chǫ winter roads to Gamètì and Wekweètì, the Sahtú winter road to Great Bear Lake, the Inuvik to Tuktoyaktuk Highway (ITH), and the TCWR (including the Gahcho Kué Spur Road). In Alaska, geographic features were primarily of the Alaska North Slope and the range of the Central Arctic Caribou herd.

Respondents (16 of 25; 64%) previously employed BMPs for roads while carrying out activities or managing lands within caribou ranges or were aware that their organization has employed mitigation measures for caribou specifically to address roads or have made recommendations to clients operating in caribou areas. These actions included designing and reviewing monitoring and mitigation, in larger projects such as the TASR or National Parks such as Gros Morne National Park and Terra Nova National Park. The remaining respondents (9 of 25; 36%) were involved in academic research, or in formal or informal observations of caribou near roads through road use or local proximity. Recommendations from the participating survey respondents are compiled in the following Sections 4.3.2.1 to 4.3.2.6.

Additionally, SMEs recommended key literature to review and include in the Barren-ground Caribou BMPs for Roads. Scientific publications that were frequently referred to by interviewees and that explore the impact of industrial traffic on caribou movement and behaviour were included (i.e., Smith and Johnson, 2023; Severson et al. 2023; Boulanger et al. 2024). Although it is documented that barren-ground caribou have experienced population declines due in part to the cumulative effects of climate change and anthropogenic disturbance, understanding the behavioural response of barren-ground caribou to roads and road mitigations is less clear. A general lack of monitoring was stated by nearly all the 30 respondents.

Respondents were asked to suggest current available copies of legislation, guidelines, reports or articles related to the monitoring or effectiveness of mitigation measures implemented for roads within caribou ranges. Results were incorporated into Appendix B.

4.3.2.1. Feedback on Measures to Avoid and Minimize Direct Habitat Loss

Mitigation measures to minimize direct habitat loss from roads were presented to SMEs (n = 30). Mitigation options listed in Appendix B were previously used by respondents to minimize direct caribou habitat loss from roads (Table B-1 and Appendix C). Not all interviewees spoke to each mitigation, but rather chose to answer on topics they were familiar with. For instance, 19 of 22 respondents (86%) had used existing road access and existing disturbance for access (e.g., cutlines, right-of-way corridors, borrow areas) rather than new road corridors. At the same rate, 11 of 13 respondents (85%) minimized the width of roads or overall road footprint. Minimizing road width was used as a strategy in mining, subject to the mine's safety restrictions. More than half of respondents (8 of 11; 73%) indicated they had utilized cooperative planning / integrating land uses (e.g., road use agreements, sharing of roads) in caribou mitigation to avoid the development of new roads. Such cooperative planning also occurred with community involvement in road design.

Other recommendations provided by respondents (outside of the recommendations listed in Appendix B) were:

1) Avoidance of other wildlife features, wetlands, archeological sites, and denning locations for bears in road planning;
2) Designing roads to have a low overall height (~1 m) and at least 4:1 side slope with surface material from eskers or fine crush;
3) Building crossing structures;
4) Invasive plant monitoring on roadside;
5) Adaptive management;
6) Work suspension and road closure protocols;
7) Discussing plans accommodating the priorities and Indigenous knowledge of communities;
8) Contributing to research; and
9) Potential use of aircraft (i.e., helicopter and fixed wing). Reasons were not provided.

When asked if any of the measures used to minimize direct habitat loss have been monitored for effectiveness, responses varied from no monitoring to having implemented multiple data collections to determine caribou presence or absence near roads. Across all respondents, SMEs aligned that caribou collar data (ideally over a decade), seasonal range maps, Inuit Qaujimajatuqangit Traditional Knowledge (IQTK), habitat modelling information (i.e., topographic maps, vegetation maps and plant greening [NDVI]) are useful data to define high quality habitat for barren-ground caribou. It was explained more closely that identifying high-quality seasonal habitat use and movement corridors can be done through resource selection function models (RSFs), aerial viewing of caribou trails, and/or through community engagement/consultations and traditional knowledge.

Confounding factors must be considered, as data in the past revealed both use (crossing) and non-use of roads by caribou, which appeared dependent on adjacent habitats, traffic level and hunting regulations (explained further in Section 4.3.2.3). Industry appeared to have a large role in the monitoring process.

Respondents were also asked to rate the effectiveness of road mitigation measures for direct habitat loss using the categories in Table 2. The majority of respondents (15 high and 5 moderate of 21; 95%) suggested to use existing road access where possible. The use of existing disturbances (10 high and 7 moderate of 19; 89%) and cooperative planning/integrated land use (10 high and 5 moderate of 19; 79%) gathered similar interest. Reducing the width of road corridors was considered as having low effectiveness in barren-ground caribou habitat (10 of 17; 59%).

Table 2. Subjective rating of the effectiveness of mitigation measures for direct habitat loss. Not all respondents provided a ranking for all mitigation measures.

	Effectiveness		
Mitigation Measure	**High[1]**	**Moderate[2]**	**Low[3]**
Use of existing road access	15	5	1
Use of existing disturbances	10	7	2
Cooperative planning / Integrated land use	10	5	4

Reduction in footprint during initial planning	6	8*	6
Avoidance of high-quality habitat and sensitive habitat features	9	6*	3
Reduction in corridor width	2	5	10**
Other		• Active management of vehicles • Implementation of speed limits	

[1] Number of respondents that ranked the mitigation measure as effective to reduce the development footprint by >40%.
[2] Number of respondents that ranked the mitigation measure as effective to reduce the development footprint by 10 to 40%.
[3] Number of respondents that ranked the mitigation measure as effective to reduce the development footprint by <10%.
* Respondents felt that the extent of the road footprint was less critical for barren-ground caribou than the effect of the presence of the road or the activities on the road.
** Respondents commented that the width of corridors is less relevant in the tundra than in the boreal forest.

4.3.2.2. Feedback on Measures for Road Design

Mitigation measures that were implemented to minimize the effects of roads on caribou were commented on by respondents. There was variation across respondents' opinion on the effectiveness of mitigation measures for road design (Table 3). Road design features (height [9 of 16; 56%] and side slope [7 of 19; 36%]) and the use of seasonal roads [6 of 13; 46%] garnered the most interest as useful measures. Respondents tended to advise against the use of fencing (8 of 10; 80%) as fencing was considered a harmful physical barrier for caribou that does not allow for migration. Experience in the NWT is that fencing can lead to caribou mortalities as antlers can get caught in fencing.

Concerns were raised of the availability of data to determine the effectiveness of mitigation measures. To respondents' knowledge, there are few studies explicitly testing the effectiveness of the mitigation measures provided in Table 3. There were comments that industry conducts the monitoring of mine roads, but these data may not be collected at a fine enough scale needed to validate the effectiveness of the measure, nor is readily shared. Also, there was criticism that sufficient baseline data is not always collected before a road is developed, making the effectiveness of road design mitigation measures harder to evaluate when studied post-hoc. The most effective studies would have numerous baseline data before road development, or even exploration phases.

Road material, height, and slope were noted to have been monitored at some road developments in the NWT and Nunavut, using remote camera data. Monitoring typically involved measuring the frequency of caribou use of various road surfaces. Results indicated that material may be influential for caribou crossing, while height and slope have less of a barrier effect (within the normal parameters of constructed roads). For example, boulders (vs. granular material) inhibits caribou ability to cross the road structure. Remote cameras were also used to study roads at the Meliadine Mine. It was discovered that low berm and shallow slopes were effective for successful caribou crossings, and so was fine granular material (selection of slope by caribou could not be deciphered

as the road was consistently low berm for the entirety). Anecdotally, some respondents suggested that snow berm height along roads is unlikely to be a deterrent for barren-ground caribou given the natural topography they traverse within their winter ranges (5 of 9; 55%).

It was noted that the Ekati Diamond Mine has evaluated caribou crossing rates based on roadside slope, rock size, and presence/absence of caribou crossing structures using wildlife cameras (telemetry data did not appear to have fine enough resolution to be an effective monitoring tool). The Ekati Diamond Mine concluded there was no difference in crossing rates as a function of these features, although interviewees had expressed concerns that the monitoring program is not adequately designed to answer these questions. It was recommended that the benefit of the road monitoring presence should be weighed against the increased road activity to create and maintain the monitoring programs.

The low interest in the implementation of ramps by respondents may be due to the inconsistent evidence of the effectiveness of ramps. One respondent indicated monitoring of ramps at the Ekati Diamond Mine showed effectiveness, while in contrast, literature (Poole et al. 2021) did not record ramps to be selected. Monitoring of crossing ramps has been reported twice via camera and telemetry data suggest they may not be important.

Table 3. Subjective rating of the effectiveness of mitigation measures for road design. Not all respondents provided a ranking for all mitigation measures.

	Effectiveness		
Mitigation Measure	**High[1]**	**Moderate[2]**	**Low[3]**
Road design features – Height	9	5	2
Road design features – Side slope	7	6	3
Road design features – Line of sight	5	2	5
Caribou crossing ramps	1	1	8
Use of fencing	6	4	3
Use of seasonal roads vs. all-season roads	4	5	1
Route alignment	0	3	6
Reduction in snow berm height and breaks in snow berms	4	3	2
Other	• Caribou friendly – combination of low side slopes, low height, and fine granular material on side slopes		• Crush and material of side slopes / road surfaces

[1] Number of respondents that ranked the mitigation measure as effective to reduce the development effect on caribou movement by >40%.
[2] Number of respondents that ranked the mitigation measure as effective to reduce the development effect on caribou movement by 10 to 40%.
[3] Number of respondents that ranked the mitigation measure as effective to reduce the development effect on caribou movement by <10%.

4.3.2.3. Feedback on Measures to Reduce Sensory Disturbances

When respondents were asked which mitigation measures to reduce sensory disturbances their organizations have previously implemented and found effective, the respondents commonly indicated difficulty to answer with confidence, since there are gaps in effectiveness monitoring. For example, one respondent described that to really test the effectiveness of some of the mitigation measures in Table 4, you would need to manipulate traffic levels, vehicle speeds, and dust suppression on an experimental basis to see how caribou react. These variables can be quite difficult to measure, and especially difficult to study experimentally over long roads and large caribou ranges. In most cases, the study of these mitigation measures is done through measuring a ZOI to evaluate indirect habitat loss.

Despite uncertainty, the timing of activities and road closures were strongly supported by respondents (13 of 17 [76%] and 15 of 21 [71%], respectively) as effective for reducing sensory disturbance. There was a common concern that activities on roads, whether from traffic or hunting, pose a greater risk to caribou than the road structure itself. In recent years, mines have been encouraged to measure traffic levels and include them as a covariate in ZOI analyses to evaluate whether it changes ZOI. Several respondents recommended traffic convoys as an alternative to a steady flow of traffic (5 of 16, 31%), but some respondents indicated that mines do not seem willing to try it due to economic/productivity considerations. Other respondents indicated traffic convoys may not be feasible to organize (8 of 16; 50%), similar to limiting the types of vehicles on the road (6 of 10; 60%), especially on roads leading to more than one mine. Noise and light were described as major disturbances on winter roads for caribou. For instance, trucks (e.g., clanking of chains, loud brakes) are easily auditory for humans and must be even louder for caribou, which have more sensitive hearing. It was described from observation that caribou may try to move across the road at night, but noise and light disturbance from haul trucks are preventing caribou from crossing the road. Patrols are monitoring vehicle speeds, but currently are not monitoring the noise (e.g., air brakes).

Half of respondents (9 of 19; 47%) found that caribou having the right-of-way was an effective mitigation, and essential. Those opposed, questioned if stopping near the caribou would habituate animals to vehicles, or emphasized that caribou do not know they have the right-of-way and therefore will avoid the road regardless. Once a driver detects a caribou, that vehicle is already well within the animals' sensory range. There was concern that stopping traffic to let caribou cross, could inadvertently habituate caribou to vehicles making them more vulnerable to hunting.

Respondents suggested that limiting hunting access on roads and managing public access (using gates, signage or slash rollback) could be moderately effective for caribou (9 of 16 [56%] and 6 of 13 [46%], respectively). It was suggested that limiting access to high quality caribou areas could reduce indirect habitat loss, through controlling human activities, although it may not be legally or

geographically possible to restrict hunting of caribou. Hunters may be able to be deterred if they must set up their own camps, rather than being able to access permanent camps.

Respondents were not opposed to signage but indicated that signage has a moderate to low effectiveness [17 of 19; 89%). The effectiveness of signage, notifications, and operator responses on reducing sensory disturbance to caribou are extremely difficult to measure and most often not enforced. However, respondents felt these measures would improve the vigilance of drivers.

Table 4. Subjective rating of the effectiveness of mitigation measures for sensory disturbance or indirect habitat loss. Not all respondents provided a ranking for all mitigation measures.

	Effectiveness		
Mitigation Measure	**High[1]**	**Moderate[2]**	**Low[3]**
Timing of activities	13	3	1
Road closures / Seasonal closures based on threshold of caribou	15	2*	4
Animal right-of-way	9	3	7
Speed limits / Speed restrictions	5	10	4
Use of convoys or transportation (i.e., buses) for employees to reduce traffic volume	5	8	3
Limit vehicle types on road	2	6	2
Dust suppression	4	8	5
Noise reduction	3	8	3
Signage	2	8	9
Notifications	3	4	7
Operator response to wildlife	5	5	5
Limiting hunting access	5	9	2
Traffic activity restrictions	7	4	1
Manage public access (i.e., gates, signage, slash rollback)	5	6	2
Other	• Enforcement of all human behavioural restrictions is required	• Evaluation of habitat restoration to offset indirect habitat losses	

[1] Number of respondents that ranked the mitigation measure as effective to reduce the sensory disturbance or indirect habitat loss to caribou from the development.
[2] Number of respondents that ranked the mitigation measure as effective to reduce the sensory disturbance or indirect habitat loss to caribou from the development, but caribou still respond to the development.

[3] Number of respondents that ranked the mitigation measure as unlikely to reduce the sensory disturbance or indirect habitat loss to caribou from the development.
[*] Respondents commented that the effectiveness of road closures depends on timing (i.e., calving and migration) and location.

4.3.2.4. Feedback on Measures to Reduce Caribou Mortality

Industry respondents reported no or extremely rare instances of caribou-vehicle collisions along roads by operations' vehicles. Any mine-related wildlife strikes or injuries are carefully tracked, reported in Annual Reports, and corrective measures are implemented. This may not be the case with public road users, and collision data is likely unreported. Respondents which participated in patrols of the TCWR witnessed and reported driving infractions during the 2024 road season and were under the impression that truck drivers on the TCWR are not properly oriented on local regulations to protect caribou, and that monitoring for compliance is insufficient.

Three respondents (3 of 15; 20%) commented (despite not directly asked) that it is difficult to decipher whether few mortalities recorded in Annual Reports indicate that mitigations are working, or if this is an indication of caribou numbers declining so that they are struck less frequently or avoiding the road altogether. With a low frequency of caribou deaths, one respondent (1 of 15; 7%) suggested the mitigation is either effective or caribou are successful at avoiding collisions. The assumption is that these mitigations are effective at minimizing mortalities, but the influence of each mitigation cannot be assessed independent of the others. Traffic controls and road closures were considered the most effective measures (15 of 17; 88%) to reduce caribou mortality along roads. Timing restrictions and exclusion zone implementation prior to blasting activities were the second most selected option for effectiveness (11 of 13; 85%).

There is common discourse that vehicle collisions do not appear to be the main cause for caribou mortalities, although some collisions are reported. Roads allow public access to barren-ground caribou range and can increase hunting pressures. A respondent explained that GNWT-ECC conducts patrols along the TCWR for compliance with hunting regulations, but instances of illegal harvest and wastage are still occurring despite them. Illegal harvest appears to be the main problem identified by respondents. Respondents generally felt that without road access, these enforcements would not be as necessary.

Implementing signage (9 of 16; 56%), speed limits (9 of 17; 53%), employee and contractor awareness (8 of 16; 50%), and public education (8 of 13; 62%) were considered as moderately effective at minimizing caribou mortality. Despite the moderate support, these measures were considered very easy to implement and can reasonably be expected as effective. Speed limits were regarded less critical in tundra habitat than they may be in the boreal forest; increasing line of sight is important for preventing vehicle collisions (e.g. by increasing stopping distances). Education of drivers was highly regarded (9 of 14; 64%), but it was noted by respondents that education may not be as effective on drivers using public roads (i.e., highways).

Table 5. Subjective rating of the effectiveness of mitigation measures for reducing caribou mortality. Not all respondents provided a ranking for all mitigation measures.

	Effectiveness		
Mitigation Measure	**High[1]**	**Moderate[2]**	**Low[3]**
Signage	3	9	4
Speed limits	8	9	1
Employee / Contractor restrictions	9	3	2
Employee / Contract awareness	6	8	2
Public education	4	8	1
Field patrols	8	5	1
Vehicle collision reporting with follow-up measures	6	6	4
Traffic controls / Road closures	15	2	0
Timing restrictions / Exclusion zones prior to blasting activities	11	0	2
Other	• Communication and education should include rationale on why mitigations are planned/in place • Harvest management and enforcement is critical	• Wildlife right-of-way	

[1] Number of respondents that ranked the mitigation measure as effective to prevent vehicle collisions or harvest from the development.
[2] Number of respondents that ranked the mitigation measure as effective to discourage vehicle collisions or harvest from the development.
[3] Number of respondents that ranked the mitigation measure as ineffective to prevent vehicle collisions or harvest from the development.

4.3.2.5. Feedback on Measures for Mitigation within Calving Grounds

Three respondents (3 of 23; 13%) indicated that their organization operated roads within calving grounds of barren-ground caribou. One respondent specified that the calving grounds of the Qamanirjuaq herd has shifted to within 10 km of the Meliadine Mine, and therefore has shifted nearer to the existing mine. During the calving period, mine activities are partially shutdown and traffic is suspended. Another respondent explained that there are upcoming operating plans within calving grounds within the next five-years. In this circumstance all measures are being followed closely. In particular, all road crossing infrastructures, community meetings, employee awareness and education, and speed reduction measures will be implemented. Another respondent indicated that research will be guiding when operating in these areas and university research is currently being funded for better understanding of the project effects of roads on caribou.

4.3.2.6. Feedback on Measures Employed in Restoration/Reclamation Activities

Respondents were asked which specific measures their organization has employed to speed the reclamation and recovery of disturbed caribou habitats once a road is no longer needed (Table 6). Six of thirty respondents (20%) provided answers, and all indicated that longer term monitoring of the effectiveness of reclamation of decommissioned roads and quarries is lacking or still in the design phase. For example, some short stretches of roads at the Ekati Diamond Mine have been reclaimed, but the responses of caribou to the reclaimed road have not yet been measured.

Table 6. Subjective rating of the effectiveness of mitigation measures for speeding the recovery of disturbances within caribou ranges. Not all respondents provided a ranking for all mitigation measures.

	Effectiveness		
Mitigation Measure	**High[1]**	**Moderate[2]**	**Low[3]**
Road decommissioning	0	2	4
Restoration / Reforestation of areas no longer needed	2	0	2
Blocking physical access (i.e., berms, ditches, boulders)	1	2	3
Contouring, vegetation, placement of organic/inorganic debris	2	1	3
Other	• Engaging communities can enhance the effectiveness of the recovery process	• Lichen restoration (i.e., lichen transplants)	

[1] Number of respondents that ranked the mitigation measure as effective to remove the effects of the development following <2 years of treatment.
[2] Number of respondents that ranked the mitigation measure as effective to remove the effects of the development within 2-10 years of treatment.
[3] Number of respondents that ranked the mitigation measure as effective to remove the effects of the development following >10 years of treatment.

4.3.2.7. Shortcomings in Road Mitigation for Barren-ground Caribou

Shortcomings in BMPs of roads in barren-ground caribou range were brought forth by SMEs. Respondents emphasized the need for long term monitoring, continual innovative thinking in mitigations, and the need for increased involvement of Indigenous and territorial governments to identify solutions to prevent road-related caribou mortalities. Innovations in caribou conservation could sustain caribou populations while industrial expansion occurs in the NWT. Key topics of conversation are represented in Figure 3.

SMEs noted that it is critical to not-assume that all mitigation measures are effective and to follow up on the effectiveness of each mitigation, while considering the other potential effects of dust, predators, and hunting on caribou populations. The largest shortcoming may be that there is disagreement on measurable endpoints and significant effect sizes. From an ecologist's perspective,

quantifiable rates of survival and reproduction should be the key metric. Industry respondents support key metrics and mitigations, although seek clarity in the actions required to support caribou while also continuing operations. Respondents were seeking general guidelines from the GNWT to apply to a wide range of industries or activities operating in caribou ranges. Respondents were also seeking continued funding of research by government, which could be helpful in developing general and clear guidelines, as opposed to having the private sector navigating and proposing measures.

Figure 3. Word cloud of topics presented when respondents were asked about shortcomings in caribou best management practices; larger words indicate more frequent use of the topic.

SMEs were careful to distinguish that all-season roads and winter roads are separate entities that have different impacts on barren-ground caribou. All-season roads have a constant impact with no seasonal end on caribou and typically, the impact of an all-season road network grows exponentially (e.g. once the road is in place, more people build cabins). The area around Baker Lake and the Meadowbank Mine is a good example of this exponential growth. Initially, the community did not want any hunting on the all-season road, but now that road is built, people that normally would not go hunting are using the road for hunting. Caribou have started to veer away from that road (even though it is short [~115 km]), due to human disturbance, or even to avoid getting trapped by high snow and resultant snowbanks. In this example, it was observed that these caribou eventually moved further south, and even mixed herds. Implications on caribou may go far beyond the road.

It is very challenging to test the effectiveness of any of the mitigation measures listed in Table 1. It would require experimental manipulation or a Before-After-Control-Impact (BACI) study design, as well as exposing caribou to higher risk of injury or mortality to compare presence-absence of a mitigation measure, which may not be ethically acceptable. It was repeatedly suggested that there is limited knowledge of the effectiveness of any of these road mitigations. Current research indicates that in cases where the mitigation effectiveness was known (e.g., road traffic impacts), those effects have been far greater when analyzed thoroughly. Caribou are difficult to study, and there are many variables to consider in developing sound statistics and confidence around mitigation effectiveness.

For example, the influence of roads can be studied using counts from roads, yet the human (surveyors) sight line is likely <1 km while it must be considered that the ZOI of caribou is >1 km. This is another example of the difficulty in studying caribou, given how highly mobile they are and how readily they adjust course. When caribou data is available (i.e., collar data), very specific fine-grain measures (e.g., speed limit, road traffic volume, vehicle type) must also be collected to confirm if measures are useful.

Lastly, if mitigations are found to be effective, it is likely they need to be maintained to stay effective. In many jurisdictions, long term implementation can be challenging (e.g., if a road is gated to block access, often that road may be opened at some point, left open and then the mitigation is no longer effective). Some respondents were optimistic that caribou conservation is compatible with industrial development, with the right mitigation measures in place.

4.3.2.8. Innovations and Next Steps in Road Mitigation for Barren-ground Caribou

Guardianship programs and field based or "on the land" stewardship programs were suggested by SMEs as powerful community-based monitoring programs that 1) provide key information during the planning phase of road development projects, and 2) monitor and mitigate impacts of roads on barren-ground caribou (Figure 4). Since 2016, Tłı̨chǫ Government has been leading an ekwǫ̀ (caribou) monitoring program from July to October (i.e., summer and fall ranges) based out of Contwoyto Lake, Point Lake, and Lac de Gras, and more recently from February to April (i.e., winter range) along the Tibbitt to Contwoyto Winter Road. This program is called Ekwǫ̀ Nàxoèhdee K'è (ENK) and it is based on traditional knowledge of Tłı̨chǫ and Inuit Elders and harvesters. ENK uses a holistic methodology called "We Watch Everything" to better understand why ekwǫ̀ (caribou) has not returned to their communities and to monitor ekwǫ̀ habitat, health, presence of predators, and impacts of industrial developments on behaviour and movement. For example, ENK monitors noticed a low flying aircraft from Diavik Diamond Mine (Rio Tinto) in August 2022 that was conducting geophysical surveys over herds of caribou that would have otherwise not been detected and properly mitigated. These observations led to daily morning planning meetings with representatives from GNWT-ECC, Tłı̨chǫ Government, and Rio Tinto to determine appropriate mitigation measures based on the location of caribou to effectively reduce impacts of sensory disturbance on caribou.

Community-based monitoring programs along roads can also be effective in reducing disrespectful harvesting, wastage, and poaching of wildlife, as well as monitoring wildlife movement and behaviour, and were a common theme of discussion in the solution space (Figure 4). Guardianship programs can lead to better understanding of the issues, awareness, education, and justice surrounding caribou. Since 2020, winter road monitoring programs along the Tibbitt to Contwoyto Winter Road have been established independently by Tłı̨chǫ Government, the North Slave Métis Alliance, and the Yellowknives Dene First Nation to document harvest (including disrespectful and illegal harvesting), promote respectful harvesting, and ensure compliance of the Mobile Core Bathurst Caribou Management Zone by interacting directly with harvesters on the winter road. Utilizing these programs, independent from enforcement, creates accountability that scales up from the individual to the community.

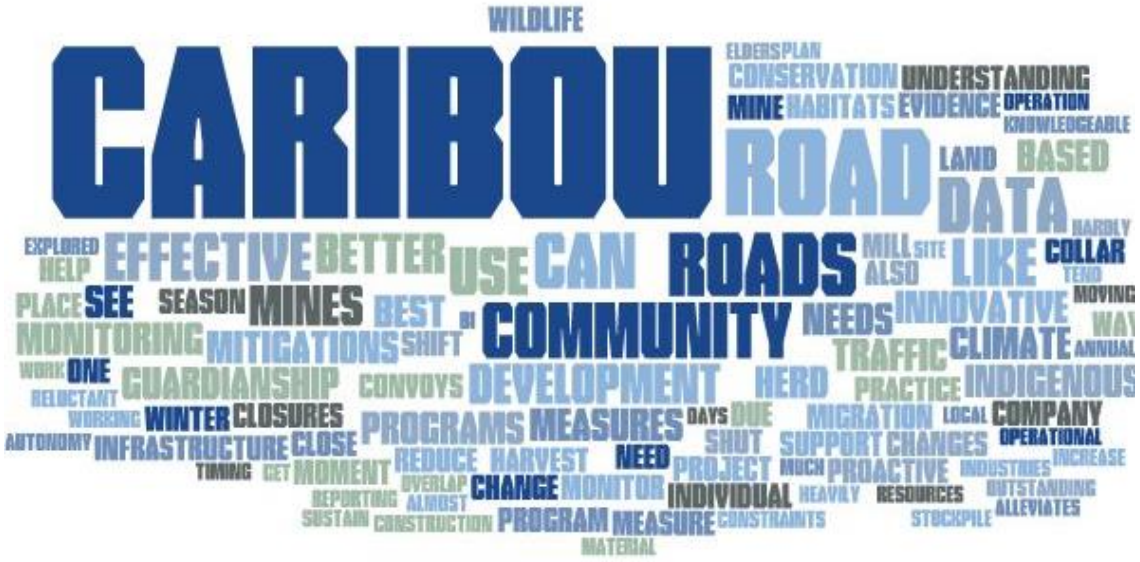

Figure 4. Word cloud of topics presented when respondents were asked for innovative techniques in road mitigation; larger words indicate more frequent use of the topic.

Historically, hunting closures for all parties were used when caribou migrated close to a road. This was to let the leaders of the group pass. Many respondents believe the practice was very effective, it allowed caribou to migrate and use areas close to roads. Exploring and applying legal tools to control public use of roads solely intended to support development projects could help to reduce some of the spin-off effects like increased harvest pressure. Having seasonal roads that only operate when barren-ground caribou are not in the area might also be effective (e.g., a summer all-season road to the diamond mines that is closed during the winter).

The use of convoys was suggested to be explored more heavily. SMEs suggested that mines can be reluctant due to operational constraints (i.e., shift work, shift overlap, moving resources). Similarly, bi-annual mill shutdowns (4-5 days) during caribou migration to increase autonomy between mill and mine site was also suggested. Better access to collar data or use of drones may help identify where the caribou are for proactive planning, and a fine-tuned understanding is required to clarify timing windows. Industrial funding of research and monitoring of caribou along roads is currently underway and the results are anticipated. SMEs are seeking continued support and collaboration with government to seek improvements in the BMPs for caribou. Over time, results of monitoring should feed into adaptive management of roads and mitigation to encourage caribou movement and reduced risk of mortality around roads.

4.4. Mitigation for Project Planning

Project planning is the most important phase of mitigating impacts to barren-ground caribou. Developers are strongly encouraged to use publicly available resources, such as the NWT Species and Habitat Viewer and data sharing agreements (i.e., GPS collar data). Developers are also strongly encouraged to engage early and work collaboratively with affected Indigenous communities and IGIOs to identify sensitive and important caribou habitat features and appropriate road mitigation

measures. This information can be applied to determine interactions of barren-ground caribou with a proposed road project and subsequently to design the road in a way that avoids or minimizes direct and indirect impacts to barren-ground caribou. While all mitigation measures could be committed to by developers during the planning phase, the following mitigation measures are related to the physical or spatial design of the road; thus, these mitigation measures should be explored and clearly articulated within a project plan.

4.4.1. Use of Existing Disturbance

A road project that overlaps with existing disturbance will either avoid or minimize direct and indirect habitat loss for caribou. Avoidance of direct habitat loss can be achieved when the physical footprint of a road project occurs entirely within an area of existing disturbance. For example, if a hypothetical project represents only a change in the road surface of an existing road (e.g., gravel to paved), then new habitat disturbance is avoided, and the amount of habitat available for caribou to use is unchanged relative to the baseline condition. Alternatively, if the hypothetical project included widening of an existing road, then direct habitat loss occurs, but would be minimized. This is because the existing road had already disturbed caribou habitat during the baseline condition and less than 100% of the hypothetical project would lead to newly disturbed habitat.

Indirect habitat loss can be minimized if the sources of sensory disturbance (e.g., noise, dust, lights, presence of people), magnitude, and extent predicted for a road project are the same or smaller than for the existing disturbance. If the physical footprint or sensory disturbances of a proposed road exceed those of an overlapping existing disturbance, then the mitigation hierarchy has achieved minimization. This is because the quantity and/or suitability of caribou habitat will be altered and less will be available for caribou to use.

TASR is an example where both direct and indirect habitat loss were minimized for caribou by using existing disturbance as mitigation measures. Direct habitat loss was minimized by routing the road through areas already disturbed by a pre-existing decommissioned winter road (GNWT 2017). Indirect habitat loss was also minimized as the decommissioned winter road route was actively used for land use activities during baseline conditions.

4.4.2. Avoidance of Sensitive Habitat Features

Sensitive habitat features for barren-ground caribou include historically and currently used water crossings, eskers (land crossings), land bridges, calving areas or other features in their annual range that are important to the caribou annual life cycle (GNWT 2019a). These habitat features are sensitive as they represent key aspects of the environment that caribou use to move between seasonal ranges regularly or their loss is anticipated to lead to reductions in survival and reproduction. Road projects, including any borrow sources or quarries necessary for its construction and ongoing maintenance of road surfaces and embankments, and their cleared right-of-ways, should avoid intersecting sensitive habitat features and thereby protect them from removal, fragmentation, or reduced use by caribou. By avoiding sensitive habitat features, these features will remain available for continued use by caribou. Sensitive habitat features can be identified for road projects through engagement with Indigenous communities or from data sources such as the BCRP (GNWT 2019a).

4.4.3. Reduce Footprint

Developers of road projects are expected to propose footprint lengths, widths, and other supporting areas that are designed to maximize project efficiency and minimize excessiveness and cost. Road footprints should be no greater than required to meet the road project's needs over its life. For example, the number and size of quarries should not exceed the construction or maintenance needs of a road project over its life span nor should a road be wider than necessary to meet safety regulations (and other regulatory requirements) for its intended purpose. By keeping the footprint compact, the amount of newly disturbed caribou habitat can be minimized. Compact roads may have other benefits to caribou such as minimizing indirect effects to habitat from dust as there is less road surface or disturbed area that may be subjected to wind erosion. Narrow roads also encourage drivers to reduce speeds. Developers can demonstrate quantitative reductions in footprints through alternatives analysis (e.g., Dominion Diamond 2014).

Developers must be aware that building a road that is routed to avoid sensitive caribou habitat may not always be the road with the lowest footprint as it may be longer and/or more costly in comparison to a road designed to maximize project efficiency and cost. During the project planning phase, developers should consider alternative route alignments and prioritize a route alignment that minimizes the impacts to caribou rather than the most efficient route (i.e., shortest route).

4.4.4. Caribou Crossings

The design of roads may include a raised driving surface above the surrounding terrain to meet safety regulations. The combination of the physical road design and traffic may result in roads functioning as semi-permeable barriers to caribou movements. Semi-permeable barrier effects occur when caribou approach roads and hesitate before crossing or when a proportion of caribou avoid crossing (Wilson et al. 2016; Boulanger et al. 2020; Poole et al. 2021). Designating caribou crossing areas for road projects is assumed to minimize barrier effects and facilitate crossing by caribou. Established design guidelines for caribou crossings do not exist but existing designs include road surface elevation of ≤1.75 m, low slope inclines (≤27°) between the surrounding terrain, and road surface with construction materials including smaller gravel-like (0.1 to 0.3 m) or esker-like material (Dominion Diamond 2016).

Agnico Eagle Mines Limited found small-scale differences in road height (0 m to 4 m) and road-side slope (6^{o} to 30^{o}) was not impactful on caribou crossings event frequency (Agnico Eagle 2022a). Caribou crossings were more frequent on esker material compared to quarry material or a combination of both materials. Underlying confounding variables that could not be addressed in the analysis were inter-annual route fidelity by caribou, traffic, and timing.

The size and number of caribou crossings for effective use by caribou is unknown but could be informed through baseline monitoring to identify high caribou use areas and through engagement with Indigenous communities as was done at the Ekati Diamond Mine (Dominion Diamond 2016).

4.5. Mitigation for Construction, Operation, and Closure

4.5.1. Activity Timing Windows

Risk timing windows are intended to help road developers plan the timing of their activities to avoid or minimize sensory disturbance to barren-ground caribou during more sensitive periods. In the NWT, the calving, post-calving, and summer periods are considered the highest risk activity periods for barren-ground caribou across all herds (Table 7). The extent and location of caribou seasonal ranges can be dynamic over time (Virgl et al. 2017). Developers should consider the most current seasonal range information available (e.g., collared caribou data).

As barren-ground caribou are migratory, the relative risk of activities should also consider where the road project is located relative to the location of seasonal ranges. For example, the calving range of the Bathurst herd occurs near Bathurst Inlet in Nunavut and road project activities that occur outside the calving range have a low risk of disturbing cows and calves during the calving season. Alternatively, road construction, operational or closure activities should be planned to occur outside the calving season if the project occurs within the calving range. Note that it may not be possible to reschedule or suspend all operational activities of roads. For example, snow removal is necessary for driver safety and would need to continue to meet this requirement.

Table 7. Risk timing window for activities within barren-ground caribou habitat based on sensitivity analyses conducted in the Bathurst Caribou Range Plan Supporting Report on Caribou Range Assessment and Technical Information (BCRPWG 2018).

Activity Period	Risk Window	Risk Category	Caribou Ecology / Rationale
Spring Migration	20 April – 1 June	Moderate	Females migrate to calving grounds; vulnerability during late gestation, period of higher adult female mortality; wider range of habitat types used during dispersal.
Calving / Post-calving	2 June – 28 June	**Very High**	Calves most susceptible to mortality during this period.
Summer	29 June – 6 September	**High**	Period of higher susceptibility to mortality for adult females; critical period for females to regain body condition; wider range of habitat types used during summer than winter.
Rut / Fall Migration	7 September – 30 November	Low	Disturbance during peak rut could result in lower pregnancy rates. More individuals susceptible to disturbance since they are in larger groups at this time of year.
Winter	1 December – 19 April	Low	Caribou shift towards greater use of older forest/wetland habitats, but still have relatively high daily movement rates in early winter. In later winter a narrower range of habitat types selected; increased energetic costs of moving through deep snow and late gestation vulnerability increase the risk.

4.5.2. Blasting Restrictions

Blasting of rock is often necessary for the development of infrastructure and is a high intensity, low duration disturbance to caribou. Blasting may also be necessary at supporting quarries during operations or to remove infrastructure during closure. Blasting has potential to cause sensory disturbance through production of blast overpressure (noise) and vibration, as well as injury and mortality from fly-rock. No blasting-related injuries or mortalities to caribou or other wildlife have been observed at operating mines in the annual range of the Bathurst herd (DDMI 2022; De Beers 2022a). However, there is currently no information about how caribou respond to blast overpressure and vibration. Current blast restrictions to minimize sensory disturbance to barren-ground caribou include the use of a 1 km blast exclusion zone where blasting is suspended if caribou are observed with 1 km of the blast site (De Beers 2022a, DDMI 2022) or if groups of caribou (i.e. > 50 caribou) are within 5 km of the site (Agnico Eagle 2022b). Blasting may resume after caribou are no longer present within the exclusion zone.

4.5.3. Dust Suppressants

Fugitive dust is produced during road construction through various sources including blasting and crushing of rock, removal of vegetation and exposure of underlying soils to wind, from use of heavy equipment and vehicle traffic. Fugitive dust is also produced from traffic and maintenance vehicles during operations and during closure from reclamation. Fugitive dust is a source of sensory disturbance to caribou and can alter vegetative communities in nearby areas of undisturbed caribou habitat (Watkinson et al. 2021). Fugitive dust emissions should be mitigated through the application of water (De Beers 2022a; Dominion Diamond 2020) or biodegradable chemical suppressants (GNWT 2013; Dominion Diamond 2020) on exposed soils, ground spoils, and roads during summer or non-frozen periods to minimize fugitive dust. Application rates and the frequency of water use will depend on environmental conditions. Periods of higher temperatures and less precipitation will require more frequent use. Application rates of 0.8 litres/m^2 of chemical suppressants with re-application every two weeks was found to limit fugitive dust production from traffic on a mine haul road (Dominion Diamond 2020). However, developers are encouraged to consult and follow chemical product manufacturer recommendations.

4.5.4. Speed Limits

The presence of construction, operation, and closure-related traffic increases the risk of vehicle collisions with caribou and speed is a key factor influencing this risk. Lower speed limits reduce the risk of wildlife-related collisions by increasing the reaction time of drivers (van Langevelde et al. 2009) or by reducing the stopping distance of vehicles (Huijser et al. 2009; Gagnon et al. 2019). Higher vehicle speed increases fugitive dust production and noise, which are sources of sensory disturbance to caribou; therefore, vehicles travelling at reduced speeds also minimize indirect effects to caribou habitat. Low vehicle speeds (e.g., ≤60 km/hr) should be posted and speed limits should consider a variety of factors such as visibility and driver safety. If caribou are known to be onsite at a distance less than 100 m from the road then maximum speed limits may also be altered (i.e. reduced from 50 km/hr to 30 km/hr), in addition to other restrictions (i.e., light vehicle traffic permitted; Agnico Eagle 2022a). While posting of speed limits may remind drivers about what the maximum allowable speed is, enforcement of speed limits may be necessary to influence driver compliance.

4.5.5. Traffic Controls and Volumes

Traffic controls may be implemented to reduce the risk of vehicle collisions and minimize barriers produced by roads. Circumstances that may require facilitating traffic controls include poor weather or visibility, during peak caribou migration periods, or when large groups of caribou are located near roads. Different traffic controls that may be implemented include reduction in total vehicle movements, restricting certain vehicle types (e.g., light vehicles only), and vehicle convoys to cluster traffic. During road closures, convoys can permit travel of essential vehicles. Pilot vehicle staff should be trained to determine if travel is safe, and vehicles following in a convoy may be instructed to stay a minimum of 1 km behind the pilot vehicle (Agnico Eagle 2022b). Work may also be suspended when large groups are observed near the mine.

Monitoring programs have shown that caribou will cross the road with relatively short breaks in traffic (Agnico Eagle 2022b). Recent tests of convoys in Alaska suggest that they are ineffective at facilitating movements (Prichard et al. 2022). Monitoring programs have measured the behavioural response of caribou following a disturbance is limited to three to six minutes following the disturbance; however, caution should be applied when extrapolating the results due to the study's small sample size (Agnico Eagle 2022a).

4.5.6. Right-of-Way Policy

A right-of-way policy refers to when drivers of vehicles or mobile equipment are required to slow down, stop or otherwise yield to caribou and other wildlife that are on or near the driving surface to avoid or minimize the risk of collision. This policy should include that drivers continue to yield until caribou are no longer at risk. A right-of-way policy can be applied to all project activity phases. For example, drivers may find caribou standing or bedded on roads to avoid or reduce insect harassment. In this situation, drivers should halt progress until caribou leave the road and are no longer at risk. Another example includes caribou foraging in a road right-of-way. In this case, drivers are expected to slow down but may proceed because the caribou are not in the direct path of the vehicle and moving past and away from the area may minimize the duration of sensory disturbance caused by the vehicle. Developers must adopt a right-of-way policy for their road projects and train workers on this policy as part of employee education. A right-of-way policy is typically used in combination with wildlife signs, wildlife notifications, caribou crossings, and speed limits to minimize mortality risks (Dominion Diamond 2017; GNWT 2019b; De Beers 2022a; DDMI 2022).

4.5.7. Employee Education

Developers must establish employee education programs to educate workers on wildlife-related policies and mitigation practices applicable to the project construction, operational, and closure phases. Educational programs avoid or minimize impacts to caribou by identifying how impacts are influenced by worker behaviour, such as the ways in which a project is designed to protect caribou. For example, staff that are trained on right-of-way policy will learn that caribou are a valued ecosystem component, that certain worker behaviours are expected and what response are required if caribou or other wildlife are encountered while driving vehicles or mobile equipment.

Educational programs should include, but are not limited to:

- Speed limits;
- Right-of-way policy (waiting until caribou move a specified distance from the road before proceeding at reduced speeds);
- Notification protocols when caribou are in proximity to the mine;
- Wildlife encounters and reporting requirements;
- No wildlife harassment and no feeding policies;
- No hunting policy;
- Spill response and reporting; and
- Waste management practices.

4.5.8. Wildlife Signs

Wildlife signs should be used by developers to demark and caution drivers about areas where caribou and other wildlife frequently cross a stretch of road or are frequently observed. They should also be erected in areas where caribou may be expected but visibility is obstructed. Their purpose is to reduce the risk of caribou-vehicle collisions and mortalities by making driver's more vigilant in areas of higher risk. The number and placement of signs will vary by road project but may be informed by monitoring caribou occurrence and movements, habitat selection, or in areas where there may be increased collision risk (e.g., several near misses). Placement of wildlife signs could also be informed through engagement with Indigenous communities.

Wildlife signs showing the varying levels of caribou presence can be used to inform drivers of changing risk levels (DDMI 2022), similar to those used to reflect the risk level of wildfires during summer. The level of these signs is updated using both local (e.g., site monitoring) and regional monitoring (e.g., collared caribou) sources, and reflects the approach of caribou. Wildlife signs should be used during the construction, operational, and closure phases for vehicle and mobile equipment traffic. Signs are typically used in combination with wildlife notifications, caribou crossings, right-of-way policy, and speed limits to minimize mortality risks (Dominion Diamond 2017; GNWT 2019b; De Beers 2022a; DDMI 2022).

4.5.9. Wildlife Notifications

Site-wide notifications of caribou and wildlife presence during construction, operational, and closure activities minimize impacts to caribou mortality and sensory disturbance. It does so, because workers become more vigilant about when and where caribou are located relative to the road project. This knowledge allows workers to trigger additional mitigation such as erecting signs, suspending activities or to expect encounters if working in certain areas cannot be avoided. For example, if a driver observes a caribou near a quarry, it should be reported and communicated to workers at the quarry so mitigation can be readied for implementation. This might include suspending blasts until the caribou is no longer present, shutting down a crusher or other noisy equipment. By suspending activities, sensory disturbances that result in indirect habitat loss are minimized. Because barren-ground caribou are migratory, it may also trigger the awareness that it is nearing the season when caribou observations will become more common.

Information on wildlife presence for notifications can be generated from required incidental reporting, regular monitoring for caribou observed or from other sources such as collared caribou. Based on established notification systems at operating mines (De Beers 2022a, DDMI 2022), notification systems are most effective when incidental observations are reported to staff that are responsible for maintaining a log of observations and for making site-wide communications via radio or other means to other departments or workers. Recorded sightings, over time, can also contribute to learning about where caribou more frequently cross a road and in turn inform placement of signage or other mitigation measures. In practice, wildlife notifications are typically used in combination with wildlife signs, caribou crossings, right-of-way policy, and speed limits to minimize mortality risks (Dominion Diamond 2017; GNWT 2019b; De Beers 2022a; DDMI 2022).

Thresholds for triggering wildlife notifications can vary among projects. Agnico Eagle Mine Limited has a three-level hierarchical guideline dictating mitigations based on the number, proximity, and time of year that caribou are located near the project (Agnico Eagle 2022a). Daily site notifications would be provided for five to ten days if one caribou is observed at 50 km and caribou greater than the group size threshold within 4 km of the road. If caribou greater than the group size threshold are within 1.5 km or 5 km during the calving season from the road then site notifications in combination with other site mitigation measures would be triggered (Agnico Eagle 2022b).

4.5.10. Aircraft Mitigations

In undeveloped or remote areas of the NWT, it may be necessary for road projects to be supported by rotary or fixed-wing aircraft use during construction or operation. The following are a list of mitigations related to aircraft use that can be found in the GNWT's *Flying Low?, Think Again* brochure:

- Avoid flying below 1,000 ft;
- Obey Transport Canada regulations;
- Avoid barren-ground caribou calving grounds during calving season (mid-May to July);
- Do not take-off or land in a calving area during calving season (mid-May to July); and
- Do not chase or harass wildlife by flying too close (i.e., proximity triggers animals to run).

It is available at: https://www.gov.nt.ca/sites/ecc/files/128-flying_low_brochure_proof.pdf.

4.5.11. Conservation Zones and Access Restrictions

Conservation zones are delineated areas where access or harvest restrictions are in effect to avoid and minimize caribou disturbance or mortality through harvest. A conservation zone is a management tool implemented by the GNWT for the protection of caribou and biodiversity in accordance with the NWT *Wildlife Act* and *Protected Areas Act*. Developers do not have the authority to implement conservation zones but may protect caribou and biodiversity through access and harvest restriction policies at their sites (GNWT 2019b; De Beers 2022a; DDMI 2022). GNWT may elect to implement conservation zones around roads during construction, operation, and closure or during post-closure if caribou require protection from access or harvest.

4.5.12. Road Closures, Convoying, and Reduced Traffic Volume

Traffic may be present on roads during the construction, operational, and closure phases. Scientific studies indicate that caribou respond to traffic by either avoiding active roads (Plante et al. 2018; Boulanger et al. 2020, 2024; Severson et al. 2023; Smith and Johnson 2023) or hesitating to move across roads near the road interface (Wilson et al. 2016; Boulanger et al. 2020, 2024). Traffic on roads can impact caribou through mortality from vehicle collisions, indirect habitat loss or disruption to movements from traffic sensory disturbances. However, vehicle collisions with barren-ground caribou are relatively rare (Dominion Diamond 2014; De Beers 2022b). Suspending traffic activity on roads (i.e., a road closure) can lead to reduced crossing time by caribou (Boulanger et al. 2020), presumably because traffic sensory disturbance is temporarily removed. Research by Severson et al. (2023) concludes the importance of managing vehicle traffic to reduce its impact on caribou. The study suggests minimizing traffic volumes and creating traffic-free periods during critical times to help mitigate the negative effects on caribou movement and habitat use.

Road closures for caribou are used in the NWT and Nunavut at existing mines on haul roads and all-season roads (Dominion Diamond 2017; DDMI 2022; Agnico Eagle 2019, 2022). Arbitrarily chosen triggers of road closures used include proximity thresholds of ≤100 m (Dominion Diamond 2017, Agnico Eagle 2022b) and caribou group size thresholds (Agnico Eagle 2019). While the roads are closed to industrial traffic, roads remain open for emergency vehicles for human safety needs (e.g., fire trucks, ambulances). Road closures are not always effective at facilitating crossing by caribou (Golder 2007).

The use of convoying and vehicle-related disturbance on roads in calving areas has been explored through research in Alaska (Prichard et al. 2022). This research conducted frequent road and aerial surveys of caribou near two oilfield roads, one with convoying and one without, over a 3-year period (during the pre-calving, calving, and post-calving periods). The results indicated that caribou reacted more strongly to traffic in an area with traffic convoying, possibly because of differences in traffic frequency. Groups of caribou with calves avoided roads during the calving period, and roads less strongly influenced caribou distribution during pre- and post-calving periods. Overall, it was determined that "convoying may reduce the amount of displacement during periods between convoys, which could improve crossing success" (Prichard et al. 2022).

4.5.13. Snow Berm Management

Snow clearing is a road maintenance activity during winter that is necessary to mitigate risk to human safety. Snow clearing is used on all-season and winter roads to support construction, operational, and closure activities of developments. Clearing snow from the road surface may result in deposition of snow adjacent to roads forming a snow berm. Depending on the snow berm's height, it may function as a barrier to caribou movement (BHP Billiton 2011). Monitoring of caribou snow tracks adjacent to the Ekati Diamond Mine's Misery Road indicated that there was a high likelihood of caribou deflection when snow berms were ≥1.6 m high (BHP Billiton 2011). Current practices to minimize caribou deflections from snow berms includes reducing snow berms to <1.6 m throughout the winter road season (Dominion Diamond 2017; De Beers 2022a). Creating breaks in snow berms and banks can also increase road permeability for caribou in winter. Developers are expected to mitigate snow berms to minimize barrier effects to caribou movements. Practices such as pushing

and spreading snow with a dozer when clearing the road can also be enacted to avoid the buildup of snowbanks on the side of the road (Agnico Eagle 2022ab; De Beers 2022a). Roads should be designed to include caribou crossings with flatter side slopes made of finer crushed rock to facilitate caribou movement (BHP Billiton 2011), when snow is not present. Practises of road building include construction of site roads with finer materials to facilitate caribou crossing (Agnico Eagle 2022b).

4.5.14. Progressive Reclamation

Progressive reclamation is rehabilitation of disturbed land, decommissioning of structures and equipment, and removal of waste that begins when a project component is no longer needed during the operational phase. Progressive reclamation minimizes direct and indirect habitat loss by beginning the restoration process of caribou habitat ahead of the project's closure phase. It minimizes direct habitat loss by reclaiming the area disturbed and sensory disturbances contributing to indirect habitat loss will cease once the area is no longer active. For example, worker accommodation sites needed during road construction can be decommissioned once the area is no longer needed. Similarly, reclamation can begin on smaller quarries once resources have been exhausted. The objective of reclamation is to improve the suitability of disturbed areas and begin its trajectory toward functional caribou habitat and its role in ecosystem function. Reclamation includes remediation of hazards, such as hydrocarbon contamination, so that disturbed areas are safe for wildlife and human use. Developers must include progressive reclamation mitigation, where feasible, to facilitate recovery of project-related disturbance.

Disturbed areas can be restored through passive reclamation and active reclamation. Passive reclamation corresponds to the rehabilitation of disturbed areas through vegetation communities re-establishing naturally over long periods of time. Active reclamation includes scarifying, recontouring, and sloping to make movements across reclaimed roads easier (DDMI 2017; De Beers 2020), as well as soil amendments, seeding or planting of vegetation to facilitate earlier growth. GNWT recommends the use of native seeds or plants when active reclamation is completed. Details of how and when progressive reclamation takes place can be outlined in a closure and reclamation plan (e.g., GNWT 2019b).

4.5.15. Reclamation and Decommissioning

At the end of a road project's life, developers will be expected to reclaim disturbed areas and decommission infrastructure in accordance with a project's closure and reclamation plan. Similar to progressive reclamation, the objective of reclamation during closure is to improve the suitability of disturbed areas and begin its trajectory toward functional caribou habitat and its role in ecosystem function. It will also be necessary to create a site that is safe for caribou and human use, and in some instance the road may be closed to discourage human use if no longer needed for a project.

Disturbed areas can be restored through passive reclamation and active reclamation. Passive reclamation corresponds to the rehabilitation of disturbed areas through vegetation communities re-establishing naturally over long periods of time. Active reclamation includes scarifying, recontouring, and sloping to make movements across reclaimed roads easier (DDMI 2017; De Beers 2020), as well as soil amendments, seeding or planting of vegetation to facilitate earlier growth. GNWT recommends the use of native seeds or plants when active reclamation is completed.

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APPENDIX B. SUMMARY TABLE OF ROAD MITIGATIONS

Table B-1. Summary of literature review results to develop the NWT barren-ground caribou mitigation guidelines.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
Agnico Eagle 2019, 2020a	All-season road and haul roads	Mine	Speed restrictions, road closures, use of convoys, animal right-of-way, speed limits, notifications, and reducing snow berm height	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities, Caribou behaviour surveys	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mitigation is not monitored independently. Caribou behaviour was monitored using remote cameras in relation to traffic. Caribou did not have any obvious signs of stress; however, the sample size of complete crossing events was small.
Agnico Eagle 2020b	All-season road and haul roads	Mine	Road closure	Barrier to movement	Minimize	Yes	Collared caribou movements	Road closures did not facilitate road crossing by caribou.	Ineffective	Study measured the duration of collared caribou spring movements within 4 km of mine roads relative to the duration of road closure, after accounting for the natural factors of lakes, terrain ruggedness and whether the collar was newly deployed (effect of collaring on behaviour).
Agnico Eagle 2022a	All-season road and haul roads	Mine	Speed restrictions, road closures, use of convoys, animal right-of-way, speed limits, notifications, reducing snow berm height, and road design features (i.e., road height and roadside slope)	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities, Caribou behaviour surveys	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Caribou will cross the road with relatively short breaks in traffic. Small-scale differences in road height (0 m to 4 m) and road-side slope (6o to 30^{o}) were not impactful on caribou crossings frequency. Caribou crossings were more frequent on esker material compared to quarry material or a combination of both materials. Underline confounding variables that could not be addressed in the analysis were inter-annual route fidelity by caribou, traffic, and timing.
Agnico Eagle 2022b	All-season road and haul roads	Mine	Speed restrictions, road closures, use of convoys, animal right-of-way, speed limits, notifications, and reducing snow berm height	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities, Caribou behaviour surveys	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mitigation is not monitored independently. Caribou with increase distance from infrastructure (>300 m) have lower proportions of response behaviours. Response behaviours from caribou following a disturbance subside after six minutes. Caribou are more likely to have response behaviours following vehicle traffic.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
Agnico Eagle 2022c	All-season road and haul roads	Mine	Speed restrictions, road closures, use of convoys, animal right-of-way, speed limits, notifications, and reducing snow berm height	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities, Caribou behaviour surveys	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mitigation is not monitored independently. Caribou show a behavioural response to disturbance; however, the response is limited to three to six minutes following the disturbance.
BHP Billiton 1999a, 1999b, 2002, 2003, 2004, 2005, 2006, 2008	All-season road and haul roads	Mine	Animal right-of-way and speed limits	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mortality mitigation is not monitored independently. Too few observations of caribou to test caribou response to haul road and/or test mitigations.
BHP Billiton 2009, 2010, 2011	All-season road and haul roads	Mine	Animal right-of-way, speed limits, and road closures	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mortality mitigation is not monitored independently. Snow berm height was found to be statistically significant in predicting frequency of road crossing by caribou groups with increased bank height reducing the likelihood of caribou crossing. Vehicle activity did not significantly influence likelihood of road crossing. Caribou deflected from the road when mean snow berm height was 1.6 m high but crossed the road when the mean snowbank height was up to ~0.5 m high.
BHP Billiton 2012, 2013	All-season road and haul roads	Mine	Animal right-of-way, speed limits, road closures, and reducing snow berm height	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mortality mitigation is not monitored independently.
Boulanger et al. 2020	All-season road	Mine	Road closure	Barrier to movement	Minimize	Yes	Collared caribou movements	Quantitative evidence that caribou are more likely to cross when the road is closed than when open. Note that during road closure only essential traffic would move down the road in slow-moving convoys.	Effective	Conditional logistic regression was used to estimate probability of road crossing when road was closed vs. not closed. Model results suggested that road closure was a significant predictor of probability of road crossing.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
Boulanger et al. 2021	All-season road	Mine	None assessed or recommended	Indirect habitat loss	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects. Zones of influence varied over time. Includes Mines and roads cumulatively.
Boulanger et al. 2024	All-season road and haul roads	Mine	Road closures	Indirect habitat loss and barrier to movement	Minimize	Yes	Collared caribou movements Road surveys	Road closures reduced, but did not eliminate, delays in migrations.	Effective	Study of effects. Individual analysis estimating time of crossing relative to the zone of influence with road closure as an additive fixed effect. Study results suggest that caribou exhibit behaviour changes to avoid roads, when possible, reduce movements around the road before crossing, or travel parallel to the road.
Cameron et al. 2005	All-season road	Oil infrastruc-ture	None assessed or recommended	Direct habitat loss and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects. Road development in caribou habitat resulted in decreased nutrient intake and calf production.
De Beers 2007, 2008, 2009, 2011, 2012, 2013, 2014a, 2014b, 2015a, 2015b, 2016, 2017, 2018	Winter road	Mine	Animal right-of-way, speed limits, notifications, and road closures	Indirect habitat loss and mortality	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mortality mitigation is not monitored independently.
Dominion Diamond 2014, 2015, 2016	All-season road and haul roads	Mine	Animal right-of-way, speed limits, caribou signs, notifications, road closures, and progressive reclamation	Indirect habitat loss, mortality, and barrier to movement	Minimize	Yes	Monitoring of vehicle-related injuries/mortalities	No caribou injuries or mortalities related to vehicles, therefore assuming that all these mitigations are effective at minimizing effects.	Effective	Each mortality mitigation is not monitored independently.
Dominion Diamond 2016	All-season road and haul roads	Mine	Caribou crossing ramps	Barrier to movement	Minimize	Yes	Remote cameras	Quantitatively shows that caribou used crossings but preference for crossings (comparison with non-ramp locations) was not studied.	Effective	0.1 to 0.3 m rock material may be used for ramp construction. Ramp slope between 18° and 27° with height between 1.18 m and 1.75 m were conducive to crossing. Studied recommended future paired camera monitoring of ramp and non-ramp locations.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
Dominion Diamond 2017a	All-season road and haul roads	Mine	Dust suppression, speed limits, and road closures	Direct habitat loss, indirect habitat loss, mortality, and barrier to movement	Minimize	No	Mitigation was not monitored	N/A	N/A	This is a caribou mitigation plan and does not include monitoring results.
Dominion Diamond 2017b	All-season road and haul roads	Mine	Caribou crossing ramps	Indirect habitat loss, morality, and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Ramp design includes flatter side slopes and finer crushed rock (6 inches or less).
Dominion Diamond 2020	All-season road and haul roads	Mine	Dust suppressant	Indirect habitat loss	Minimize	Yes	Fugitive dust collectors	Quantitatively show that dust suppressants reduced deposition rates.	Effective	Tested EnviroKleen and DL-10 products at ~ 1 litre/m^2.
Foster et al. 2021	All-season road	Exploration Utility ROW	Decommissioning, revegetation, blocking physical access, contouring, and placing organic/ inorganic debris	Indirect habitat loss and barrier to movement	Minimize Restore	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	This is a draft reclamation plan.
GNWT 2013a	Highway	Public	Use of seasonal roads, dust suppression, speed limits, road closures, and operator response to wildlife	Mortality and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	N/A
GNWT 2013b	Highway	Public	Speed limits	Mortality and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	N/A
GNWT 2013b	Highway	Public	Traffic volumes and hunting pressure	Direct habitat loss and indirect habitat loss	N/A	Yes	Collared caribou movements Harvest data	The presence of hunting activity correlated with reduced crossings, suggesting an interaction between traffic and hunting pressures.	Ineffective	This implies that industrial activities create physical barriers and amplify other disturbances, compounding the overall impact on caribou populations.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
GNWT 2019	All-season road	Industry Public	Limiting access, construction timing, route alignment, route consolidation, use of seasonal roads vs. all-season roads, road management plans, dust suppression, traffic management, road design features, and offsets	Direct habitat loss, indirect habitat loss, habitat fragmentation, mortality, and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	N/A
GNWT 2021	Highway	Public	Use existing disturbance	Direct habitat loss and indirect habitat loss	Avoid Minimize	Yes	Use of existing disturbance	Reduced overall habitat loss by quantifying existing and new disturbance by project.	Effective	Used 55 ha of existing disturbance for road project.
Golder 2007	All-season road Winter road	Exploration	Manage public access (e.g., gates, signage, slash rollback), minimize right-of-way width, reduce line-of-sight, seasonal closures, reclamation, traffic activity reduction, and breaks in snow berms	Mortality and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Mitigation audit study included assessing mitigation effectiveness for woodland caribou using a survey of 51 respondents from industry, government and subject matter experts. Report concluded most mitigations are not monitored for effectiveness and recommended experimental trials for those anticipated to have the biggest impact cumulatively for woodland caribou and a land use plan that identifies protected habitat.
Johnson et al. 2020	All-season road	Oil infrastruct-ure	None assessed or recommended	Indirect habitat loss	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects.
Joly et al. 2021	All-season road	Industry Public	Speed restrictions, road closures, seasonal use restrictions, use of convoys, and noise and/or dust suppression	Direct habitat loss, indirect habitat loss, habitat fragmentation, mortality, and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
Marathon Gold 2021	All-season road	Mine	Traffic reductions, transportation for employees to reduce traffic, speed limits, fences, snow berm height reduction and breaks, signs, animal right-of-way, limiting vehicle types on roads, and dust suppression	Direct habitat loss, indirect habitat loss, mortality, and barrier to movement	Minimize	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Mitigation and monitoring plan supplement to the Environmental Impact Statement.
Panzacchi et al. 2013	All-season road	Cabins	None assessed or recommended	Barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects.
Plante et al. 2018	All-season road	Industry Public	None assessed or recommended	Habitat fragmentation and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects.
Poole et al. 2021	All-season road	Mine	Caribou crossing ramps	Barrier to movement	Minimize	No	Collared caribou movements Ore haul truck traffic Ramp locations	Note that ramps were buffered by 150 and 300 m; not 100% confident that caribou using these buffers truly used the ramp.	Inconclusive	Sample size was too low to correlate ramp use with monthly ore truck traffic. The use of GPS collars did not give a representative estimate of how many caribou used the ramp (measured the amount of caribou that came within <300 m and <150 m) of ramp. Recommendations are to use remote cameras at ramp crossings to get a better representation if caribou are using the ramps to cross the road.
Severson et al. 2023	All-season road	Mine	Vehicle traffic volume	Indirect habitat loss and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Throughout the year, caribou reduced their use of habitat near high-traffic roads. Caribou exhibited reduced habitat use of roads in post-calving seasons and mosquito harassment seasons. Caribou movements and uses of preferred summer habitat was reduced. Caribou chose habitat with less traffic, but this habitat selection was also influenced by insect harassment.

Reference	Road Type	Road Context	Mitigation	Impact Pathway	Hierarchy	Monitored Mitigation	Monitoring Description	Outcomes	Effectiveness Determination	Notes
Smith 2022	Winter road	Mine	None assessed or recommended	Direct habitat loss, indirect habitat loss, mortality, and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study. The study tested caribou crossings as a function of traffic volume but did not manipulate traffic volume to test effects of mitigations.	N/A	Study of effects.
Smith and Johnson 2023	Winter road	Mine	Vehicle traffic volume	Indirect habitat loss and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study. The study tested caribou crossings as a function of traffic volume but did not manipulate traffic volume to test effects of mitigations.	N/A	Even a traffic barrier can hinder caribou movement and access to essential habitats. Collared caribou were monitored over three years and fewer crossings were observed in areas with higher traffic volumes. Any level of traffic on roads lead to caribou rarely crossing the road. Traffic level influenced the decision to cross the road. Caribou road crossings occurred more often when the road was not in operation (before opening the road and after the road closed) and during days with low levels of traffic such as during closures concerning weather.
Teck 2015	All-season road and haul roads	Mine	Dust suppression and road closures	Indirect habitat loss	Minimize	No	Fugitive dust collectors	Mitigation was not directly monitored in this study.	N/A	Report indicates a new dust suppressant will be used the following year.
Van Moorter et al. 2020	Not specified	Not specified	None assessed or recommended	Mortality and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects.
Wilson et al. 2016	All-season road and haul roads	Mine	None assessed or recommended	Mortality and barrier to movement	N/A	No	Mitigation was not monitored	Mitigation was not directly monitored in this study.	N/A	Study of effects.

APPENDIX C. INTERVIEW QUESTIONNAIRE

BEST MANAGEMENT PRACTICES – ROADS IN CARIBOU HABITAT

Date: mm-dd-2024	**Time (Start):**
Interviewer:	**Time (End):**
Respondent:	**Affiliation:**
Address:	**Department:**
	Position:
Tel:	**Email:**

The Government of Northwest Territories Ministry of Environment and Climate Change (ECC; Wildlife Management Division), is currently preparing a set of BEST MANAGEMENT PRACTICES FOR MITIGATING THE EFFECTS OF ROADS ON BARREN-GROUND CARIBOU. These best management practices are intended to be used by developers who are planning and/or conducting development activities in barren-ground caribou range in the Northwest Territories (NWT), and by regulators, communities, and other parties who review and make recommendations on proposals for development activities and/or issue authorizations for such activities. On behalf of the Wildlife and Management Division, WSP Canada is conducting a survey on best management practices and effectiveness of current mitigation measures which are applied, or could be applied, to mitigate roads within barren-ground caribou ranges.

The objective of this survey is to identify the types of mitigation measures currently in use to address impact pathways. This survey is also interested in any monitoring of mitigation measures, the effectiveness of each mitigation measure at minimizing impacts to caribou (both researched or observed). Telephone interviews and email survey responses are being used as the primary source of information to augment a literature review. Compiled results from all survey respondents combined with the literature review will be presented within a BEST MANAGEMENT PRACTICES FOR MITIGATING THE EFFECTS OF ROADS ON BARREN-GROUND CARIBOU document by the GNWT.

This survey takes around 0.5 hours to complete. The GNWT Wildlife and Management Division is encouraging respondents to provide anecdotal information to support their responses to the questions posed. The GNWT Wildlife and Management Division would like to emphasize that there are no right or wrong answers to the questions as the goal is to coalesce the experience and knowledge of field personnel from industry, government, land knowledge holders, academics. Your confidentiality as a respondent will be adhered to during the reporting process.

Please feel free to decline this interview. If you feel that you lack the experience to accurately discuss or rank the mitigation measures, your response will not be used during the compilation of results for that particular measure. You may in fact only be able to offer a few answers to our questions.

Questions:	
1.	Which geographical areas do you operate or manage roads which interact with large mammals/caribou?
2.	Have you employed best management practices for roads while carrying out activities or managing lands within caribou ranges, or are you aware if your department/company has employed mitigation measures for caribou protection specifically to address roads?
	YES NO
3a.	What specific measures has your department/company employed to minimize direct caribou habitat loss from roads? (*circle appropriate measures*)
	i. Use of existing road access
	ii. Use of existing disturbance for access or during construction of roads (e.g., cutlines, right-of-way corridors, borrow areas)
	iii. Cooperative planning / integrating land uses (e.g., road use agreements, sharing of roads)
	iv. Footprint reduction during planning process (e.g., central access corridors, footprint planning to reduce access needs, route consolidation)
	v. Road siting to avoid high quality caribou habitat and sensitive habitat features
	vi. Minimize width of roads
	vii. Other
3b.	Have any of the aforementioned measures to minimize habitat loss been monitored for effectiveness? If yes, provide details of monitoring and results from monitoring (*keep separate notes for each method*). Are there any specific considerations you would like to share for minimizing barren ground habitat loss from roads?

3c.	Based on your field or operational expertise, please provide a subjective rating of the effectiveness of the habitat loss road mitigation measures using the following categories: **High** (reduces the overall development footprint by > 40%), **Moderate** (reduces development footprint by 10 to 40%), **Low** (reduces development footprint by < 10%).			
		Effectiveness		
	Mitigation for Habitat Loss	*High*	*Moderate*	*Low*
	Use of existing road access			
	Use of existing disturbances			
	Cooperative planning/ integrated land use			
	Footprint reduction during initial planning			
	Avoid high quality habitat and sensitive habitat features			
	Reduced width of corridors			
	Other			
3d.	If your department/company is planning development within a barren-ground range in the NWT, what information sources do you use to define high quality barren-ground caribou habitat?			
4a.	What specific measures has your department/company employed during road planning and operations to minimize effects from roads to caribou movement? (*circle appropriate measures*)			
	i. Road design features – Height			
	ii. Road design features – Side slope			
	iii. Caribou crossing ramps			
	iv. Use of fencing			
	v. Use of seasonal roads versus all-season roads			
	vi. Route orientation			
	vii. Design measures to reduce line of sight			
	viii. Snow berm height reduction and breaks in snow berms			
	ix. Other			

4b.	Have any of the aforementioned measures to minimize effects based on road design been monitored for effectiveness? If yes, provide details of monitoring and results from monitoring (*keep separate notes for each method*). Are there any specific considerations you would like to share for minimizing barren ground effects from roads based on road design?

4c. Based on your field or operational expertise, please provide a subjective rating of the effectiveness of the road design mitigation measures using the following categories: High (reduces the overall development effect of roads on caribou movement by > 40%), Moderate (reduces development effect of road on caribou movement by 10 to 40%), Low (reduces development footprint effect on caribou movement by < 10%).

	Effectiveness		
Mitigation for Road Design	*High*	*Moderate*	*Low*
Road design features – Height			
Road design features – Side slope			
Caribou crossing ramps			
Use of fencing			
Use of seasonal roads versus all-season roads			
Route orientation			
Design measures to reduce line of sight			
Snow berm height reduction and breaks in snow berms			
Other			

5a. What specific measures has your department/company employed during construction or operations of roads to reduce sensory disturbance, or indirect habitat loss for caribou? (*circle the appropriate measures*)

i.	Timing of activities (timing of construction, truck/convoy scheduling)
ii.	Road closures / seasonal closures
iii.	Animals have right-of-way
iv.	Speed limits / restrictions
v.	Use of convoys or transportation (buses) for employees to reduce traffic volume
vi.	Limiting vehicle types on roads

	vii.	Dust suppression
	viii.	Noise and dust reduction measures
	ix.	Signage
	x.	Notifications
	xi.	Operator response to wildlife (e.g., Vehicle operators turning high beams off)
	xii.	Limiting access
	xiii.	Traffic activity restrictions (traffic volume)
	xiv.	Manage public access (gates, signage, slash rollback)
	xv.	Other

5b. Have any of these mitigation measures to address sensory disturbance or indirect habitat loss been monitored for effectiveness? If yes, provide details of monitoring and results from monitoring (*keep separate notes for each method*).

5c. Based on your field expertise, please provide a subjective rating of the effectiveness of the following mitigation measures using the following categories: **High** (removes sensory disturbance or indirect habitat loss to caribou from roads), **Moderate** (reduces the sensory disturbance or indirect habitat loss to caribou from roads, but caribou still respond to roads), **Low** (unlikely to reduce the sensory disturbance or indirect habitat loss to caribou from roads).

	Effectiveness		
Mitigation for Sensory Disturbance or Indirect Habitat Loss	*High*	*Moderate*	*Low*
Timing of activities (timing of construction, truck/convoy scheduling)			
Road closures / seasonal closures			
Animals have right of way			
Speed limits, speed restrictions			
Use of convoys or transportation (buses) for employees to reduce traffic volume			

	Limiting vehicle types on road			
	Dust suppression			
	Noise and/or dust reduction measures			
	Signage			
	Notifications			
	Operator response to wildlife			
	Limiting access			
	Traffic activity restrictions			
	Manage public access (gates, signage, slash rollback)			
	Other			

5d.	If your department/company employs traffic activity restrictions, or numbers/thresholds of animals that need to be by a road before traffic activity/work stoppage/operator restrictions are implemented, please provide details on what number/thresholds of traffic and or animals are used to trigger the mitigation.
6a.	What specific measures has your department/company employed to minimize caribou mortality associated with harvest of caribou and vehicle collisions? (*circle the appropriate measures*)
	i. Signage
	ii. Speed limits
	iii. Employee/contractor restrictions
	iv. Employee/contractor awareness session on caribou
	v. Public education
	vi. Field patrols
	vii. Recording of vehicle mortalities with follow-up mitigation at high collision areas
	viii. Traffic controls / road closures (including during poor weather or visibility, during peak caribou migration periods, or when large groups of caribou located near road)
	ix. Timing restrictions and exclusion zone implementation prior to blasting activities
	x. Other

6b.	Have any of these measures to reduce caribou mortalities been monitored for effectiveness? If yes, provide details of monitoring and results from monitoring (*keep separate notes for each method*).
6c.	Based on your field expertise, please provide a subjective rating of the effectiveness of the measures to reduce caribou mortality using the following categories: **High** (prevents harvest near roads and vehicle collisions), **Moderate** (discourages harvest near roads and vehicle collisions), **Low** (little to no effect at minimizing caribou mortality).

	Effectiveness		
Mitigation for Caribou Mortality	*High*	*Moderate*	*Low*
Signage			
Speed limits			
Employee/contractor restrictions			
Employee/contractor awareness			
Public education			
Field patrols			
Vehicle collision reporting with follow up measures			
Traffic controls / road closures			
Timing restrictions and exclusion zone implementation prior to blasting activities			
Other			

7a.	Does your department/company operate roads within barren-ground caribou calving grounds?
	YES NO

7b.	If yes, what strategies are utilized to minimize sensory disturbance and increased access impacts to caribou while on the calving grounds?
7c.	If yes, have these strategies for operating within calving grounds been monitored for effectiveness? If so, do you feel these measures are effective at minimizing impacts from roads to caribou during the calving season?
8a.	What specific measures has your department/company employed to speed the reclamation and recovery of disturbed caribou habitats once a road is no longer needed? (*circle the appropriate measures*)
	i. Road decommissioning
	ii. Restore and reforest areas no longer needed for operations
	iii. Blocking physical access (berms, ditches, boulders, other barriers)
	iv. Ontouring, vegetation, placement of organic/inorganic debris
	v. Other
8b.	Have any of the measures implemented to decommission, reclaim, or restore caribou habitat on roads been monitored for effectiveness? If yes, provide details of monitoring and results from monitoring (*keep separate notes for each method*).

8c.	Based on your field expertise, please provide a subjective rating of the effectiveness of the measures used to speed the recovery of disturbances within caribou ranges using the following categories: **High** (removes effects of the footprint following < 2 years of treatment), **Moderate** (removes effects of the footprint within 2-10 years), **Low** (requires > 10 years to remove effects of the footprint).

	Effectiveness		
Mitigation for Habitat Recovery	*High*	*Moderate*	*Low*
Road decommissioning			
Restore and reforest areas no longer needed			
Blocking physical access (berms, ditches, boulders, other barriers)			
Contouring, vegetation, placement of organic/inorganic debris			
Other			

9.	Based on your experience, are there any shortcomings of the caribou conservation best practices and road mitigation strategies?
10.	Does your company or department employ mitigation measures or other "innovative" measures which go beyond the best management practices mitigating effects of roads within barren-ground caribou ranges? Please provide examples of these mitigations. Based on your experience do you have any additional ideas on mitigation which may reduce the impacts of road development on caribou?

11.	Does your department/company have any available copies of legislation, guidelines, reports or articles related to the monitoring or effectiveness of mitigation measures implemented for roads within caribou ranges which could be used to supplement GNWT's publication?
12.	Can you recommend anyone else to speak with on the issue of road best management practices within caribou ranges?

If you have any further comments, please contact beke.brinkmann@wsp.com or paula.bentham@wsp.com