Memo

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Date:	**July 27, 2022**		

Subject: Review of the Diavik Exploratory Collared Caribou Movement Analysis Technical Memorandum

Plain Language Summary

In 2021, Diavik Diamond Mine Inc. (DDMI) committed to completing an exploratory analysis of caribou behaviour around their mine using satellite collar data from the Government of the Northwest Territories Environment and Natural Resources (GNWT-ENR). They submitted a report describing this analysis in June 2022. The Environmental Monitoring Advisory Board (EMAB or the Board) requested that Management and Solutions in Environmental Science Inc. (MSES) review the caribou behaviour analysis and provide comments to the Board. This review memo contains our general comments on the DDMI exploratory caribou behaviour analysis and specific questions we have about the study and how it will adapted for future reporting periods.

Following the approach used in a similar study looking at caribou behaviour relative to the Ekati Mine (Poole et al. 2021), DDMI evaluated if and how caribou behaviour changed when caribou came to within 3 km of the Diavik mine between 2010 and 2021. No formal statistical analyses were completed; however, DDMI did estimate how quickly caribou moved when close to the mine (movement speed), how long they stayed near the mine (residency time), and how often they made hard turns (turns greater than 60 degrees) when close to the mine. They compared behaviour metrics qualitatively between collared caribou located close to the mine and those located 30 km from the mine. It is assumed that the behaviour of caribou 30 km away is not influenced by mine-related activity since it is outside the previously estimated zone of influence around the Ekati and Diavik mine complex (Boulanger et al. 2012, 2021).

The number of caribou movement pathways near the mine increased in the last five years of the study which coincides with a shift in the winter range of the Bathurst caribou herd. The DDMI study found that residency time for caribou near the mine varied by herd, season and year. Most of the collared caribou

that came within 3 km of the mine did so in winter. Movement speed and turning angles were similar among caribou near the mine and reference caribou 30 km from the mine. DDMI used their behavioural scan data to understand what caribou were doing when in proximity to the mine. They concluded that caribou near the Diavik mine exhibited foraging and bedding behaviour to explain the observed lower speeds and higher proportions of hard turns. This is in contrast to a similar study around the Ekati mine that interpreted lower movement speeds and more hard turns as an indication of behavioural responses to haul roads (delayed/modified movements). DDMIs study suggested that habitat quality and availability were more important than the influence of disturbance on caribou behaviour.

Unfortunately, this study did not have sufficient sample sizes to reach definitive conclusions based on the geo-fence collar data. There was also insufficient data to relate caribou behaviour to mine-related disturbances (e.g., blasting schedules or traffic volumes and timing). DDMI's focus on caribou movement within 3 km of the mine limits the broader understanding about caribou movement around the mines that could be gathered if movement in other zones (between 3 and 30 km from the mine) were also analyzed. More complete pathways could be related to previously estimated historical caribou movement routes to understand if caribou use different pathways around the mine than in the past. Further, the DDMI study did not explicitly evaluate caribou behaviour in relation to increasing distances from the mine (i.e., potential zone of influence (ZOI) effects). They only focused on behavioural changes within 3 km of the mine, but previous studies have shown that the ZOI around Diavik occurs between 7 and 14 km away from the mine. How do caribou behave at other distances from the mine? Are there any differences in behaviour relative to previously observed ZOIs? It would be helpful if a broader analysis of the caribou movement paths was incorporated (i.e., a range of distances from the mine) to understand if and how caribou behaviour changes with distance to the mine site.

The approach taken to the exploratory analysis of caribou movement does provide useful insights into caribou behaviour as they approach the Diavik mine, but the lack of statistical analysis limits the strength of any conclusions that can be reached based on the data. DDMI notes the limitations of small sample sizes and lack of sufficient sensory disturbance data, but it remains unclear if any further efforts to measure sensory disturbances with more detail will be undertaken to inform future analyses.

Introduction

The Environmental Monitoring Advisory Board (EMAB or the Board) for the Diavik Diamond Mine Inc. (DDMI) Project requested that Management and Solutions in Environmental Science Inc. (MSES) review the following report prepared by DDMI:

Exploratory Collared Caribou Movement Analysis Technical Memorandum

The report (DDMI, 2022) was prepared in July 2022 in response to a comment from the Government of the Northwest Territories Environment and Natural Resources (GNWT-ENR) regarding DDMI's Tier 3 Wildlife Management and Monitoring Plan (WMMP). DDMI has submitted this technical memorandum as an addendum to their 2021 Wildlife Management and Monitoring Plan (WMMP or Diavik 2021). We will refer to it as the 'Addendum' or 'Technical Memorandum' in this memo. As part of their zone of influence monitoring, DDMI committed to completing an exploratory analysis of caribou behaviour around the mine, using geo-fence collar data. In the November 2021 WMMP, Diavik committed to completing these analyses in 2022, at the end of closure, and once during post closure (Diavik, 2021, 2021, pg. 5-10).

The Terms of Reference from EMAB, requested that this technical review completed by MSES comment on the:

- Methodology and quality of data collected
- Adequacy of analysis and discussion of results, and
- Defensibility of conclusions and recommendations

MSES was also asked to consider ongoing discussions between MSES, EMAB, Golder, Diavik and ENR about the terrestrial monitoring and management of the Diavik mine.

In the following sections, we provide a general overview and discussion of the methods and findings outlined in Diavik's technical memorandum on caribou movement behaviour. This is followed by specific comments on elements of the study where we request further information or recommend further analyses.

Technical Memorandum Overview and General Comments

Few details on the scope or analytical approach for the proposed caribou geo-fence collar exploratory analysis were provided in the November 2021 WMMP. The July 2022 Technical Memorandum or Diavik Addendum describes the purpose, methods, and results of DDMIs exploratory assessment of caribou movement behaviour within 3 km of the mine from 2010 to 2021. For the Addendum, DDMI incorporated methods and movement behaviour metrics recently used by Poole et al. (2021), who completed the first exploratory analysis of caribou behaviour and interactions with Ekati mine using geo-fence collar data.

The Poole et al. (2021) study looked at the behaviour of collared caribou from the Bathurst and Beverly/Ahiak herds between 2010 and 2019 within 30 km of the Ekati mine. Using consecutive 3 km zones around the mine, they estimated caribou movement metrics including residency time, speed, and the proportion of hard turns (turning angles >= 60°) between movement 'steps' (i.e., gps collar locations, reported once per hour within 30 km of mine). The focus of their conclusions was based on how caribou behaved within 3 km of the mine and in response to encountering the Sable and Misery Roads. Poole et al. (2021) concluded that caribou were negatively impacted by roads because they had lower speeds and more hard turns, which were interpreted as a delayed response to crossing haul roads.

The purpose of DDMIs exploratory analysis was to assess the movement behaviours of caribou from the same two herds but focusing on encounters with the Diavik mine. DDMI used the same geo-fenced caribou collar dataset, but DDMIs analysis spanned a longer time period (from 2010 to 2021) and only focused on behaviour within 3 km of the mine. DDMI compared movement metrics near the mine to samples taken 30 km of the mine to see if there were any differences in behaviour as a result of the mine. Due to sample size limitations, only qualitative comparisons were possible.

In addition, DDMI utilized data from their caribou behaviour scan monitoring program to correlate with the geofenced collar data to understand what caribou were doing when movement metrics were estimated from the collars. This provides some insight into what caribou behaviours (e.g., foraging, running) were represented by the movement metrics (e.g., movement speed, turning angles) estimated from the collar data. Based on the correlation of scan sample observations and collar data metrics, DDMI concluded that geofence collar data showing caribou making hard turns or slowing down could be related

to foraging or bedding behaviour in suitable habitats. This stands in contrast to the findings of Poole et al (2021) who concluded that hard turns and lower speeds represented a negative response to haul roads. However, Poole et al. (2021) did not correlate behavioural scan data to the collar data used in their analysis. We concur with both Poole et al. (2021) and DDMI that utilizing field observations on caribou behaviour to support conclusions based on the geofence collar data, an integrated approach, is necessary to fully understand the impact of human activity on caribou. However, given the insufficient data to conduct statistical tests and the different ecological context at Diavik compared to Ekati (e.g., fewer connecting haul roads) it is difficult to reach any definitive conclusions about caribou behaviour inside the zone of influence (ZOI) around the mine.

While some of the estimated movement metrics were similar between the DDMI and Poole et al. studies, the authors reached different conclusions about the response of caribou to development that will require further analysis. There is some behavioural scan data to support DDMIs inferences about foraging and bedding behaviour, but they also chose to only focus on the zone within 3 km of the mine and did not analyze movement data at any other distances from the mine as in Poole et al. (2021). We think it would be useful to include these other distance zones in the analysis because it would provide important context about how the animals were moving before they got close to the mine. Furthermore, previous studies have identified a ZOI around the mine that varies between 7 and 14 km (Boulanger et al. 2012; 2021); looking at caribou movement metrics in other distance zones would shed light on if or how caribou movement changes in the other parts of the study area that correspond with a ZOI effect. For example, does caribou movement differ 3-6 km from the mine compared to 15-18 km from the mine? This would be useful insight to begin understanding how and why the ZOI varies in space and time.

Specific Comments

Issue: No analysis of movement behaviour between 3 and 30 km from the mine

Comment: Poole et al. (2021) examined caribou movement behaviour around the Ekati mine in 3 km zones radiating out from mine infrastructure, out to 30 km where the geo-fence was set for the collars. While the Diavik Addendum used some similar methods to the Poole et al. (2021) study, importantly DDMI chose to focus on only the inner 3 km zone around the mine. They did this in part because that was where many of Poole et al.' observations occurred as well. However, movement behaviour in the other zones within 30 km of the mine would provide important context for how the collared animals were moving before getting close to the mine. In addition, current movement pathways within 30 km of the mine could be compared to known historical movement pathways around the Diavik mine to see if human activity has changed use of any of these pathways (as shown in Figure 2 from Poole et al. (2021), copied below for reference).

Understanding movement behaviour in zones farther than 3 km from the mine could also further our understanding of the potential mechanisms behind the ZOI effect, variable as it may be (See comments on sensory disturbance data below), that Boulanger identified ranging from 7 to 14 km depending on the year (Boulanger et al. 2012, 2021). Does caribou movement behaviour change at distances further out from the mine that are more in line with the previously identified ZOI distances? This would be useful information that could be applied to the ongoing discussion about the presence or absence of a ZOI around the mines.

Recommendation:

a) **We recommend including an analysis and discussion of caribou movement metrics in distance zones between 3 and 30 kms to provide further depth to our understanding of caribou movement as they approach Diavik. Evaluate how metrics vary among distance zones inside and out of previously identified ZOIs around the mine.**
b) **We recommend including an analysis and discussion about current use of historical movement pathways (as noted above and in Poole et al. 2021, DDEC, 2015) around the mine.**

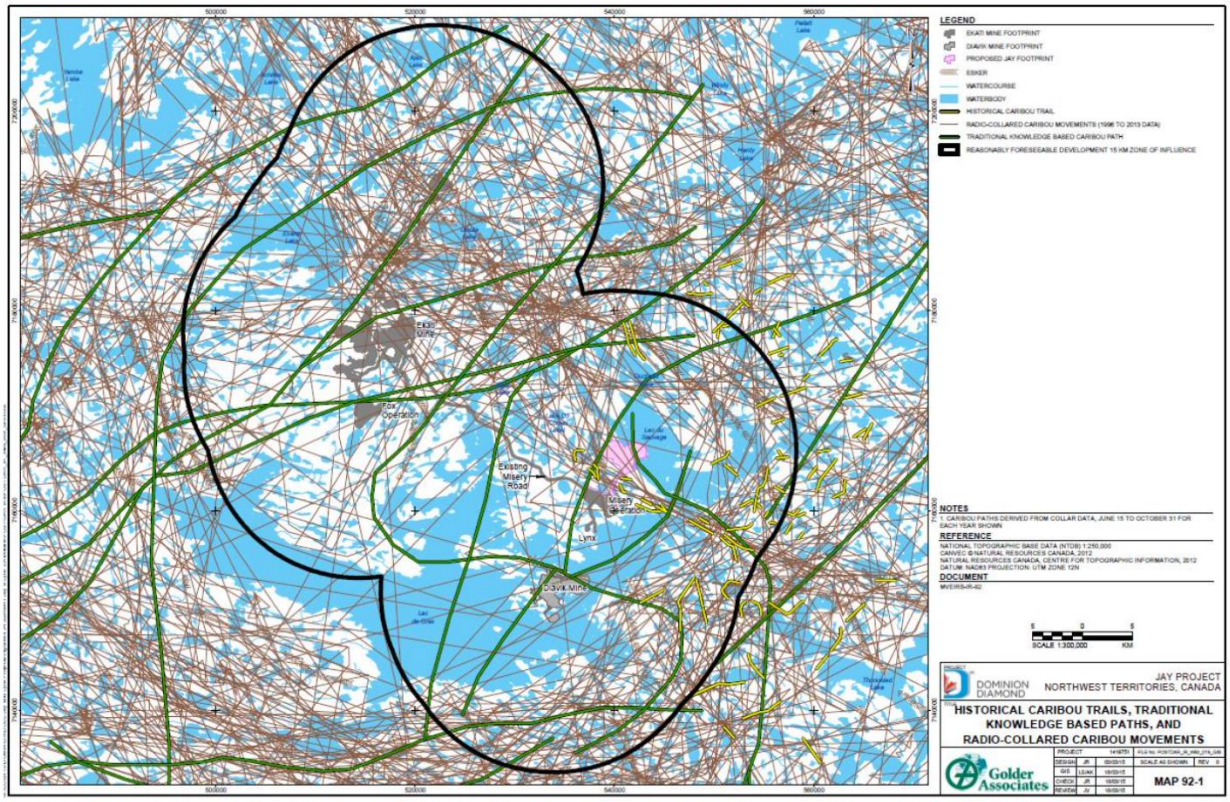

Figure 2. Main caribou paths within the Ekati mine area based on Traditional Knowledge and satellite collar pathways (Map 92-1 from DDEC 2015).

Issue: GPS Collar fix rates

Comment: Inside 30 km around the Ekati and Diavik mine complex, the geo-fenced caribou collars change from collecting location data once a day to collecting locations every 1-8 hrs, depending on the particular collar. This shorter frequency data was used to estimate movement metrics such as movement speed, residency times in an area, and turning angles. Where possible, this data was then compared to DDMI behavioural scan survey data to try to relate the geo fence collar results to observed caribou behaviour. DDMI found that in highly suitable caribou habitats the geo fenced collar data correlated with behavioural scans showing the caribou were primarily foraging, walking, standing and bedding down. The behavioural scan data is helpful in explaining some of the results from the geo fence collar analysis but given the relative scarcity of collar data inside DDMIs focal study area (i.e., 0-3 km from the mine) we

wonder if it is possible to increase the collar fix rates as caribou approach the mines. Currently they ping more frequently inside 30 km, as caribou approach the mines. Is it possible to increase fix rates further, say within 7-14 km, the currently estimated ZOI around the mines (Boulanger et al. 2012, 2021). More frequent location/movement data would allow for stronger inferences about caribou behaviour to be made.

Recommendation:

a) **We recommend EMAB discuss the utility of shorter GPS collar fix rates for caribou nearer the mine complex with ENR. Questions for ENR could include: Can multiple 'geo-fences' be set for the collars? Would more frequent fixes be feasible in terms of collar operability (e.g., battery life)? Would such an approach yield useful behavioural data to guide management actions?**

Issue: Insufficient data on potential sensory disturbances

Comment: Data on the timing and magnitude of potential sensory disturbances (e.g., blasting, vehicle traffic) is insufficient for understanding the relationship between sensory disturbances, caribou behaviour and movement. The Addendum seems to reach many of the same conclusions as Poole et al 2021 regarding the need for better vehicle data. We recommend DDMI develop monitoring methods sufficient to correlate caribou movement behaviour with mine-related activity. This is recognized by all involved (DDMI, 2022; Poole et al. (2021)). There is currently a deficiency in the level of vehicle and traffic data available to coordinate with the geofence collar and behavioural scan data.

Recommendation:

a) **We recommend including a discussion about how this sensory disturbance knowledge gap will be filled before closure.**

b) **We recommend exploring the utility of deploying Acoustic Recording Units (ARUs) at different distances to the mine. Evaluate whether ARUs be sensitive enough to record vehicle traffic or blasting sounds, and whether they could record sufficiently representative samples of industrial noise to strengthen the correlation with caribou movement behaviour.**

References

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