A Review of the 2004 Diavik Diamond Mine Wildlife Monitoring Report Including the Analysis of Environmental Effects

Prepared for

Environmental Monitoring Advisory Board

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Prepared by

207 Edgebrook Close NW
Calgary, Alberta
T3A 4W5 Canada

Phone +1 (403) 241-8668
Fax +1 (403) 241-8679
Email: petr.komers@mses.ca

Review Summary

A review of the 2004 Diavik Diamond Mine Wildlife Monitoring Report (WMR) was conducted by MSES Inc. on behalf of the Environmental Monitoring Advisory Board. The review of statistical analyses was of particular interest to see how the data collected to date were transformed into meaningful information. Numerous adjustments of the monitoring program are suggested based on the information gained from the analyses.

- Overall, the effects of the mine on the **plants** and **animals** seem to be below predicted levels. To make sure that this is true, **more sampling** is needed within the different predicted Zones of Influence (ZOI) to better understand the effects of distance from the mine. For some parts of the monitoring program, more **control sites** are needed. How the effects from the mine might act in addition to **other projects** in the region needs to be better studied. For that purpose a larger region should be monitored.

- There has been a lot of information collected about **plants** but it has not been analyzed like it has been for animals. Instead of just presenting numbers in tables, the data need to be **explained**. More **monitoring** needs to be done and there should be more **control** sites.

- The amount of **caribou** habitat being lost is close to the predicted rates. The year and habitat type had the biggest influence on **caribou** distribution. There does not appear to be any mine effects at the scale the data were collected, but the effects of nearby **water bodies** may be influencing results because caribou seem to avoid aggregations of water bodies. The **caribou** ZOI was predicted to be 3 to 7 km but surveys are not fine-scale enough to cover this. Sampling has to increase within the ZOI or more satellite collars are needed (50-100) while getting rid of aerial surveys outside the ZOI. Because collared **caribou** data overlap with aerial survey data it is possible to change the approach while insuring the continuation and usefulness of past data collection by taking advantage of what is known from aerial surveys and satellite data to date. **Cumulative effects** with other mines and projects are a concern and can be better addressed by a combination of satellite data and increased sampling within the ZOI.

- The effects on **grizzly bears** seem to be limited to the 10 km predicted ZOI. There is weak evidence that bears are attracted to the mine, but the relationship is not statistically reliable. One bear death in 5 years of monitoring is not a population concern, but **cumulative effects** with other mines and development projects are a concern. There is no need to change the monitoring program for **grizzly bears**.

- As suggested in the WMR, for **wolverine**, more local knowledge should be used. DNA analysis would allow a better understanding of the population, but the study has to be set-up correctly.

- **Waste management** is improving, but it is still an issue. There needs to be a comparison of wildlife found at waste management areas to other areas to see if there is a difference. Waste management areas should not be attracting wildlife.

- **Falcons** are building more nests but having fewer chicks. There is no statistical evidence that the mine is having an effect on falcons, but there is a need to study this more and to continue with monitoring.

- The mine appears to be affecting the types of **waterfowl** being found, but there are no control sites set-up. Because there are no control sites, it cannot be understood if these changes are happening only at the mine or throughout the whole area.

List of Recommendations

1.) **General**: At the local scale, increased samples sizes and data density within the zones of influence (ZOI) are required. Control sites in the sense of before-after-control-impact approach need to be taken more seriously in future data collection (or potentially in analyses of existing data and actual determination of any cause-and-effect relationships). At the regional scale, a modernization of data collection and analysis is essential to allow for an understanding of effects in an area that is much larger than the current study area.

2.) **Vegetation**: We concur with the recommendations on vegetation community monitoring. In particular, more control sites need to be established in all vegetation communities. The increase of monitoring frequency is imperative.

3.) **Caribou**: We think that a higher density of observations needs to be secured, both for behaviour and for occurrence within the ZOI. Effects within versus outside of the ZOI have not been explicitly tested. It will not be possible to test them at the current resolution of data.

4.) **Caribou within ZOI**: There are two alternatives to adapt the monitoring program and to find a more adequate resolution of data. Either increase the sampling density within the ZOI and compare to control sites outside. Alternatively, use a much higher number of satellite collars to arrive at a sample size high enough. The required sample size can be estimated through power analyses, but we anticipate that 50 to 100 collars should be sufficient. The decision on whether an increase in collared caribou is acceptable to communities should be reviewed with community members in light of Recommendation 5.). Data from satellite collared animals can be compared between the ZOI and elsewhere.

5.) **Caribou in the region**: Again, there are two alternatives. Either the aerial surveys are expanded to a larger region (it is assumed that the transect density would need to be reduced in order to cope with the time required to fly larger transects). Alternatively, a sufficient number of satellite collars would provide a picture on caribou movements and their responses to developments in their entire range. We think that the latter is the preferred option because the program overall would be cheaper, more reliable, and provide more conclusive evidence on regional effects. Based on extensive experience of wildlife biologists in the region, it is assumed that collaring caribou would not harm the animals.

6.) **Caribou behaviour**: Behavioural observations within the ZOI should continue to increase the power of data that test the effects on behavioural, and hence energetic changes of caribou that are exposed to the mine. This is not an urgent point, however, as it is unlikely that differences in behaviour would be strong enough to warrant concerns of energetic loss in the population based on the Diavik mine alone. Nevertheless, regional effects may accumulate by adding the effects of numerous industrial developments. To gain an understanding of such potential regional effects, it is imperative that such behavioural observations be coordinated and compared among all industry projects in the range of the same caribou herd.

7.) **Grizzly**: We concur with the conclusions for monitoring recommendations in the 2004 WMR Section 6.5, namely that there is no apparent reason for changes.

8.) **Wolverine**: We concur with the conclusions for monitoring recommendations in the 2004 WMR Section 7.3, namely that local knowledge should be used and that a better understanding of regional population parameters should be gained by ways of DNA analysis.

9.) **Waste management:** Management actions that include, but are not limited to, education of an increasing number of staff at the mine are imperative to further the cause of minimizing or eliminating attractants. In order to understand what the numbers of animals on the waste sites mean, DDMI should entertain the possibility to compare these numbers with random points outside of the ZOI.

10.) **Falcons**: We concur with the recommendation in the 2004 WMR Section 9.3 that occupancy surveys need to continue. Consideration should be given to the collection or analysis of data that may relate to nesting success of Peregrines including breeding pair density, physical attributes of nest sites (exposure to weather and predation), and prey abundance. The design of data collection for occupancy and productivity analyses should receive careful review by ENR biologists.

11.) **Waterfowl and shorebirds**: In order to draw conclusions about mine effects on bird diversity, if any, it is imperative to apply to control sites the same data collection techniques as are currently employed near the mine. However, workshop participant reviewing the 2004 WMR raised the question whether it is still necessary to monitor waterfowl. We are neutral to that decision as the current monitoring program already showed the potential magnitude of effects on waterfowl. In absence of a control site the results can be arguably interpreted as the worst case scenario, assuming that a hypothetical control site would not show changes in bird communities over time, while the ones monitored by DDMI did.

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1 Introduction

The Environmental Monitoring Advisory Board (EMAB) for the Diavik Diamond Mine Project requested that MSES Inc. review and assess the procedures and results of the 2004 Wildlife Monitoring Report (WMR). The WMR communicates the findings of surveys as established in the Wildlife Monitoring Program v.2 (WMP) developed by Diavik Diamond Mines Inc. (DDMI) in August 2002 in response to comments and issues raised by EMAB and the Department of Environment and Natural Resources (ENR, formerly Resources, Wildlife, and Economic Development (RWED)).

Our review focuses on the monitoring results from data obtained in 2004 and their contribution to an analysis of environmental effects (presented in Appendix A of the 2004 WMR). The analysis has been performed as a result of comments put forth by EMAB, amongst others, in earlier reviews by MSES. It is therefore seen as a cornerstone of the progress of the monitoring effort that may contribute to conclusions reached about mine effects and the potential adaptive changes that may be suggested in consequence of the conclusions. Therefore, this review is structured as follows:

1. Conclusions from the statistical analysis in terms of effects on wildlife in light of the WMP,v.2.

2. Contribution of current data collection to these and potential future findings.

3. Recommendations to adapting the data collection in light of current findings.

2 General Observations

2.1 Current State of Knowledge

In previous reviews of WMRs we noted that the data which had been collected each year since the monitoring program began need to be analyzed in order to provide any information on the state of knowledge gained from the monitoring program. This point was in harmony with the objectives of the WMP, namely to evaluate impact predictions and to assess mitigation effectiveness. The analyses provided in Appendix A of the 2004 WMR serves that purpose and, in our view, represents the first rigorous effort to make the best use of the data collected thus far. The analyses provided a dramatically improved insight into the understanding of potential effects of the mine since its construction began. The analyses also exhibited areas where data collection needs to be altered in order to further future sound and rigorous environmental management.

The analyses included sophisticated statistical procedures that are credibly applied to the questions at hand. While we may suggest that some alternative statistical approaches may be considered by DDMI in some instances, we do not believe that these alternatives would greatly change the conclusions reached. We will therefore not impose the details of statistical jargon on the reader of this report, but merely open the possibility that such details may be discussed amongst the specialist researchers, if and when desired.

Based on the results of the analyses, we note that several aspects of the monitoring program should still be considered to further the understanding of potential effects of the mine. Effects of distance from the mine are a particular issue that needs to be reconsidered. This is because, as the analysis shows, some effects may be rather distant at a regional scale, while other effects may be limited to a narrow zone of influence that needs to be measured more accurately by increasing sampling density. We will discuss details of our observations and the resulting recommendations on adapting future data collection in the specific reviews below. However, we note in general that some data collection may not be at a scale fine enough to test effects within less than three or four kilometers away from the mine. This is particularly true for the large body of data collected on caribou. Other effects may be apparent at a regional scale for which the current study area and aerial surveys do not do justice.

2.2 Significance

The determination of significance of impacts, meaning the importance to stakeholders as opposed to statistical significance, is a task that cannot be done without exact definitions of thresholds against which a measured effect can be compared. The difficulty of accepting any given threshold is that each stakeholder may have a different view of what that threshold should be. MSES has been asked to review the WMR in light of potential significant effects. In absence of a definition of what significance thresholds to compare against, MSES adopts an ecological argument where thresholds are reflected in any abrupt changes in ecological parameters that may be the result of industrial activity. For example, the reaction of animals to sound

disturbance is nearly nil at low levels but at a given level their response such as flight or nest abandonment might increase abruptly. In our review we also incorporate the definition of sustainability, namely that future generations must have the opportunity to use the same natural resources as the current generation. This means that wildlife population viability must not be compromised in order to ensure the continued use of that population. The term "use" is understood here in a broad sense and includes harvest, viewing, and any inherent or perceived value that people might associate with that population. MSES understands that other participants in the assessment and impact review process may have other views of threshold levels.

The 2004 WMR has provided information on the potential effects of the Diavik Diamond Mine. The statistical analyses in Appendix A were essential in understanding the potential magnitude of the effects. There is no evidence that the mine resulted in either abrupt changes in ecological parameters or in a reduction of the viability of wildlife populations outside of the perceived zones of influence (2004 WMR, Figs. 3.2.2-1 and 6.3.1-1).

Effects within the perceived zones of influence may exist and appear to have been most pronounced during construction activities. This is reflected by several measurements including decreased feeding and resting activity of caribou, decreased presence of grizzly bears and decreased diversity of waterfowl species. Most measurements are indicative of a less-pronounced effect during the operations phase of the mine. Individual mine-related mortalities were also recorded for bears and wolverine and possibly for one caribou and one peregrine falcon. Relative to the large home-ranges and regional populations of these large vertebrates, and given the apparent re-bounding of these measures after the construction phase, there is no evidence that the measured effects represent significant effects in terms of reductions of population viability.

2.3 Interpretation

The meaning of the results needs to be interpreted in light of the objectives of the WMP v.2 which state that the accuracy of the assessment and mitigation effectiveness shall be verified. Without restating the details of the assessment predictions, we believe that it is reasonable to generally state that DDMI's intent of assessment and mitigation design was to minimize or negate effects on wildlife. Effects on wildlife can occur at various levels of organization represented by a hierarchy from ecosystems, to communities, species, and populations; the monitoring of effects should be done at all the levels (Burns and Wiersma 2004). This is because variation in ecological processes and structure occur at different spatial and temporal scales, which greatly challenges the measuring of environmental effects. Generally, the monitoring program, through the analyses of data collected over the past years, has covered the major cornerstones of this hierarchy through the representation of various ecological parameters. The measurements applied in the WMR are generally stronger at the lower levels of the hierarchy than the higher ones: the data reveal more information on the population and perhaps species level than at the community and ecosystem level. Examples of information provided by the WMR at the various levels of organization are discussed below.

2.3.1 Population

Because almost all aspects of the monitoring program measure numbers of individuals, population level effects can be best gleaned from the monitoring results. In all cases, the numbers of individuals affected, seen either as the number of caribou potentially avoiding the mine site, the number of bears or wolverine relocated or killed, or the number of falcons displaced are low. Where populations of the species in question number in the thousands it is unlikely that population level effects can be detected. A notable exception may be the grizzly bears in which only a low number of individuals removed yearly may result in declines of population viability (McLoughlin et al. 2003).

The WMR reviewed herein focuses on effects of the Diavik mine. The low population effects noted above are within the predicted magnitude and, in isolation from other effects, would not be of concern in terms of the persistence of resources. However, the mine does not exist in isolation and regionally these effects could accumulate over time. Possible accumulation of effects is discussed at the community and ecosystem levels below.

2.3.2 Species

The WMR provides information that is useful in assessing effects on sensitive or listed species, the peregrine falcon in particular. There is no evidence that the Diavik mine affects the persistence of this or any other listed species. Again, the caveat is that this is true only if the mine exists in isolation, but this effect could potentially be repeated in the region by a number of industrial developments.

2.3.3 Community

Understanding the effects on wildlife communities is best measured in groups of species that are readily observable if the community itself is understood as a valued ecosystem component (Lindenmayer et al. 2002, Root et al. 2003, White 2004). This is demonstrated on waterfowl and shorebirds where some measures of species composition and richness have been used. A reduction in species diversity has been detected that coincides with mine construction. While cause and effect relationships are currently unclear (see discussion of a need for control sites later), the monitoring of species bird diversity suggests that effects on the bird community are possible at the local level. Because changes in communities involve changes in a multitude of species and are integral to ecosystem function, the following questions need to be given serious consideration:

- If the waterfowl and shorebird communities can be affected, can other communities such as land birds or mammals also be affected?

- Moreover, if an effect on local communities is apparent, can wildlife communities in the region be affected by the accumulation of human disturbance throughout the region?

Community composition in wildlife is typically difficult to measure because of the associated challenges in observing wildlife. Plants are often more readily observed and community

composition recorded. Plant community monitoring may serve as the best option in the understanding of ecological changes that result from direct removal, dust or pollutants. The need for analyses of changes in vegetation communities (wildlife habitat) is addressed in the Specific Review (Section 3) below.

2.3.4 Ecosystem

It is apparent from the above that locally, within a zone of influence, the ecosystem is affected by the mine. The magnitude of that effect is below the predicted levels. However, just because local effects at all levels of organization from population to ecosystem are evident, it is imperative to understand how the addition of numerous additional local effects may alter ecosystem integrity in the region at multiple scales (Johnson and Boyce 2005). The current data collection and approach to regional ecosystem level integrity is unconvincing. It can only be improved if data are collected in a coordinated fashion for all activities, including mines, roads and outfitting industries. Currently, this type of coordination with respect to data collection is lacking.

We advocate that modern tools be applied to regional monitoring, including satellite tracking of wildlife, satellite remote sensing, and GIS modeling and spatial analyses. We argue that rigorous analyses must be performed and we point to the dramatic improvement in understanding of the Diavik mine effect through the provision of analyses as provided in Appendix A of the 2004 WMR. We are sympathetic to the challenges posed by coordination and administration of regional data and by the costs of satellite technology. However, much cost could be saved and coordination avoided if old methods such as helicopter surveys would be reduced in favor of improving the currently rather dismal sample size of satellite collars.

2.4 Synthesis

The ability to detect local effects of the mine at varying phases of development and at various levels of ecological organization gives credence to the monitoring program. An attempt has been made to address some of the measured ecological parameters at multiple scales. However, the data analysis has demonstrated that effects presumed to occur beyond the local zone of influence are still unconvincing. This is because the effects are either very small compared to caribou or bear range, because they are confounded by variables that are not yet integrated in the analysis, because sampling programs in the regional study area are not precise enough to detect effects, or because the study area is simply too small.

These shortcomings point to a need for monitoring at both local and regional scales as follows:

- At the local scale, increased samples sizes and data density within the zones of influence are required.
- Control sites in the sense of before-after-control-impact approach (BACI, Russek-Cohen and Christman 2004) need to be taken more seriously in future data collection (or potentially in analyses of existing data and actual determination of any cause-and-effect relationships).

- At the regional scale, a modernization of data collection and analysis is essential to allow for an understanding of effects in an area that is much larger than the current study area.
- Analyses that combine effects from various disturbance sources in the Slave Geological Province will further the understanding of cumulative effects and approaches to their potential mitigation.
- The combination of analyses at local and regional scales and of measurements of a suite of ecological parameters will allow for an understanding of effects at various levels of ecological organization.

The potential for adapting specific components of the monitoring program in light of the current data is discussed under the Specific Reviews (Section 3) below; a list of recommendations is provided at the onset of this report.

3 Specific Reviews

3.1 Vegetation and Wildlife Habitat

3.1.1 Information About Effects To Date

Analyses as completed in Appendix A are still absent in the vegetation monitoring program. It is encouraging that the data collection allows for the monitoring of permanent plots, but in absence of data analyses it is unknown whether effects have occurred. We believe that the vegetation monitoring potential represents the best opportunity for the analysis of diversity change in order to learn about potential changes at the community and even ecosystem levels. Analyses that are analogous to those performed on waterfowl and shorebirds could be done.

3.1.2 Current Data Collection

The yearly data collection on permanent plots appears to be useful in providing data that would serve the objective of the WMP v.2. However, an analysis must be performed to gain insights into any trends or changes. As a point in case, Appendix C is referred to on p. 18, saying that a comparison is provided. Unfortunately, it is impossible for the reader of this table to reach any kind of conclusions about what the outcome of a comparison might be. The data need to be transformed into information. With analyses and interpretation lacking, any required mitigation efforts are stalled and delayed.

3.1.3 Potential for Adapting the Monitoring Program

The collection of data on vegetation species cover should continue. We concur with the recommendations in Section 2.3 of the 2004 WMR. In particular, more control sites need to be established in all vegetation communities. The increase of monitoring frequency is imperative. We strongly urge putting high priority on the monitoring of vegetation as this may indicate the extent of changes in the availability of habitat, and of changes in communities and ecosystems. The proper design of control sites (see BACI, above) would permit the improvement of understanding regional ecosystem change and it natural variability in relation to human-induced changes. This information is also necessary in order to better understand zones of influence (ZOIs) on wildlife as currently it is assumed that ZOIs are the result of sensory disturbance. Depending on species, this may or may not be true.

3.2 Barren-ground caribou

3.2.1 Information About Effects To Date

The yearly contribution of new data from caribou surveys have now allowed for a meaningful analysis. The analysis presented in Appendix A demonstrates that most of the observed variation

is due to year and habitat type. This was expected, but the analysis of this information is important because it is required to understand the relative contribution of the mine effect to caribou habitat use and caribou occurrence. The statistical analyses adequately addressed the potential confounding parameters and teased them apart, thereby showing that distance from the mine also appears to have an effect, albeit a weak one.

Some results were surprising such as the finding that in two of three years, when behaviour was compared to the distance from the mine, caribou appeared to feed and rest more when closer to the mine. The finding that in four other years there was no relationship between behaviour and distance from the mine is also important in the context that behaviour indicates energy gains, as measured by the methods applied in the WMR, was sometimes positively, sometimes negatively, and sometimes not related to the distance from the mine. In addition, nursery groups were found more often near the mine than farther away indicating that females with young were not measurably affected by the mine. This is in contrast to concerns about disturbance effects on female ungulates, which are typically more averse to predation risk than males (Mooring et al. 2003), and may suffer reduced productivity in areas of high disturbance (Cameron et al. 2005). We believe that the analyses presented thus far credibly indicate that the mine effects on behaviour are minimal, if existing at al, at least at the scale that data were collected. The issue of scale is discussed below.

The analysis of the occurrence of caribou indicates that caribou occur more often further from the mine, but again the relationship is weak and is statistically reliable only in some years. Given that the observed effects are weak in all analyses, and are usually much weaker than effects of yearly variation or effects of habitat preferences, one needs to raise the question if the weak results of an apparent distance effect are not an artifact of other potential effects that have not been considered in the current analyses. The effects of water bodies on caribou movements could be a confounding factor in the distance analysis because there appear to be more large water bodies near the mine than farther away. Second, the effect of arriving and departing caribou could produce spurious distance effects. This is because as caribou arrive in the study area only the ones that first reach the outskirts of the area will be counted, while during departure the opposite is true, namely that the last ones still lingering at the outskirts would be counted. This effect would make it look like caribou are farther away from the mine than would be expected at random (this effect would be negated only if the herd would move through by covering the study area in a perfectly equal fashion).

The issue of scale is important in considering the potential effects. The prediction quoted in the WMR is that the zone of influence would be within 3 to7 km. There is only one transect line that can actually measure this effect, namely the line that runs through the mine site. The next closest line is 4 km away and hence cannot address this prediction. In support of the prediction, other studies have found effects on caribou within 4 km of human activities (Nellemann and Cameron 1998, Cameron et al. 2005). In order to detect effects within this distance, the monitoring should include a higher density of measurements in that zone and compare to measurements outside of that zone. However, the practicality of such measurements needs to be put into perspective of the objectives of the monitoring program. We will discuss this perspective below, in context of adapting the monitoring program.

3.2.2 Current Data Collection

The 2004 WMR contends that caribou habitat is being lost at about the predicted rate and is currently below the maximum. We have no particular concerns with this monitoring result.

The measurement of the zone of influence (ZOI) is somewhat problematic. It is evident from figure 3.2.2-1 that most of the ZOI covers water. In winter, most moving caribou were observed on frozen lakes, while in summer open water is presumably not conducive for caribou use. Observations on either distribution or behviour need to be considered carefully in light of the predominant landcover types. Perhaps the small amount of caribou habitat within the ZOI is a reason for the relatively poor success of behavioural observations. The results from scan sampling are not apparent in the 2004 WMR although it was noted that 14 groups were successfully observed for behaviour in 2004.

In the course of the monitoring program, 9 caribou groups were successfully observed within the ZOI. It seems that this would be a sufficient sample size to warrant analysis of which we expect that it will show no particular trends when corrected for habitat type.

Other than behavioural observations, data collected in 2004 were included in the statistical analyses discussed above.

3.2.3 Potential for Adapting the Monitoring Program

We have mentioned above that the analyses point towards some potential of either different behaviour or different occurrence within the ZOI as compared to farther away. It is evident that the current data collection does not allow for a resolution of data fine enough to compare the ZOI to elsewhere. We think that a higher density of observations needs to be secured, both for behaviour and for occurrence in the ZOI. While we believe that the data collected thus far supports some small effects on caribou, and that these effects can be measured as a function of distance from the mine, the hypothesis of higher effects within versus outside of the ZOI has not been explicitly tested. It will not be possible to test it at the current resolution of data.

We believe that there are two alternatives to adapt the monitoring program to find more adequate resolution of data. Either increase the sampling density within the ZOI, or use a much higher number of satellite collars to arrive at a sample size high enough that would allow for meaningful analyses. Although some believe that aerial surveys and satellite collar data are subtly complementary (Boulanger et al. 2004), it is evident that the quality of information is mostly overlapping in the two methods. So far the only real disadvantage of satellite collar data that was noted was the low sample size. Contrary to six years ago, a comparison now exists between caribou observed directly and caribou located by satellite. In the current situation a large enough sample size (this can be estimated through power analyses, but we anticipate that 50 to 100 collars should be sufficient for the region and for a representation of the population) of satellite collars would remedy essentially all shortcomings noted thus far, including comparisons of large scale versus small scale effects (Johnson et al 2004), increase of study area, resolution of data accuracy, and movements versus occurrence. Aerial surveys could be nearly eliminated and limited to the ZOI and some control areas. The decision on whether an increase in collared

caribou is acceptable to communities should be reviewed with community members in light of the cheaper and more effective data collection using collars as opposed to aerial surveys.

As to behavioural observations within the ZOI, they should continue. It is unlikely that, given current indication of behavioural data, differences in behaviour would be strong enough to warrant concerns of energetic loss in the population. Even if some weak trends in reduced feeding and resting as a result of the mine would be detected, the time that each individual caribou would be exposed this effect would be so minimal that the individual can easily recover that temporary loss in the course of a yearly cycle. However, we now see a benefit in the continuation of the scan sampling program because such weak trends could accumulate over the range of the population in the future scenario of industrial development. It will therefore be useful to have an understanding of how strong such accumulation can become by measuring the minute behavioural changes at each effect source in the region.

3.3 Grizzly Bear

3.3.1 Information About Effects To Date

Analyses of bear data presented in the 2004 WMR support the predictions that the mine effects, if any, will be within a zone of influence that is less than 10 km. It appears that the authors of the analysis used extreme caution in their interpretation of the data by concluding that a "relationship was weak" where an attraction effect to the mine could be observed (Appendix A, p.41). By applying this caution, the authors keep the possibility open that such an effect may eventually be measured when more and better data become available. We commend this approach which follows a precautionary principle, namely that even in the absence of evidence, potential effects are kept in mind by planners.

Statistically speaking, however, the relationship does not exist. Alternatively, if tests erroneously rejected its existence, then the relationship would be weak indeed, so weak that its ecological meaning would be difficult to interpret. This is because variability between years and across scales of patch use is far greater than the one that is caused by the mine effect.

The weakness of a potential mine effect is further supported by the one mortality observed in 2004. Although this observation appears to support the existence of an effect, it needs to be placed in the context of the five years of monitoring where only one mortality occurred and in context of population dynamics where it is estimated that six bear mortalities *yearly* could cause a population decline.

However, the importance of the precautionary principle comes into play where regional effects are considered. If five mines each in the region show the effect measured here, statistically, one bear per year would die. Additional developments in the region, including roads, could push bear mortalities in the region so that it would become measurable at the population level. Planners on each mine, therefore, must do their utmost to maintain the effects at such low levels, and to avoid sources of mortality at all cost. We discuss later the need for elimination of any organic waste material that might be accessible to wildlife.

3.3.2 Current Data Collection

The information collected for the bear monitoring program appears to be adequate to assess the potential effects as discussed above. For regional effects monitoring, other than that of mortalities in the region, satellite collared bears are the most efficient data source. The continuation of such monitoring is highly encouraged.

3.3.3 Potential for Adapting the Monitoring Program

We concur with the conclusions for monitoring recommendations in the 2004 WMR Section 6.5, namely that there is no apparent reason for changes.

3.4 Wolverine

3.4.1 Information About Effects To Date

Effects on wolverine are inherently difficult to measure because of the infrequent occurrence of their sign and visual observations. Track densities were recorded in the 2004 WMR but it appears that the analysis has been done on presence-absence data, analyzing the proportion of transects that showed tracks versus those that did not. This seems questionable because transects are of different length and hence would have an accordingly different probability each to contain tracks, if tracks were randomly distributed. In addition, presence-absence data forfeit information on relative differences. We sympathize with the difficulty in analyzing these data, but we could see an alternative by simply comparing the track density on the transect closest to the mine to the density on all other transects. From Figure 4.1-1 in Appendix A of the 2004 WMR it appears that that density could be higher than all others.

Nevertheless, the interpretation of such results on infrequent occurrences must proceed with caution. It may be cautiously suggested in this case that track density is higher closer to the mine, which could mean that the mine attracts wolverine. The two mortalities recorded thus far could be a result of such an attraction.

The argument on cautious planning holds for the wolverine as it was stated for the bear. Although it is likely that two mortalities in the course of five years do not affect population viability, a regional mortality of two wolverines per year per development may represent a measurable effect at the population level.

3.4.2 Current Data Collection

There is little that could be done differently to monitor wolverine. Radio collars could be a possibility; we agree with the argument in Section 7.2 of the 2004 WMR that rigorously testing the mortality prediction would be more intrusive than is warranted in light of current information on mine related mortality rates. We also agree that it is a useful next step to take

advantage of traditional local knowledge in combination with a DNA analysis to better understand the ecological parameters of the wolverine population.

3.4.3 Potential for Adapting the Monitoring Program

We concur with the conclusions for monitoring recommendations in the 2004 WMR Section 7.3, namely that local knowledge should be used and that a better understanding of regional population parameters should be gained by ways of DNA analysis.

3.5 Waste Management

3.5.1 Information About Effects To Date

The current information suggests that waste management techniques are successful in reducing the amount of attractants in waste areas, as there are fewer attractants in 2004 than there were in 2002. This is encouraging. However, wildlife are still attracted to waste areas, albeit apparently in low numbers. The argument on cumulative bear and wolverine mortalities that could potentially be regionally significant begs the question if attractants on waste sites could not be eliminated altogether.

3.5.2 Current Data Collection

Current information should be enhanced by the continuation of data from future years.

3.5.3 Potential for Adapting the Monitoring Program

Management actions that include, but are not limited to, education of an increasing number of staff at the mine are imperative to further the cause of minimizing attractants. Table 8.2-1shows that wildlife are still attracted which suggests that the success of management actions is only partial. Ideally, waste sites should show a lower abundance of wildlife than random points in the area. Can a comparison with random points be performed?

3.6 Falcons

3.6.1 Information About Effects To Date

The number of nest sites discovered increased almost yearly since 1995. Not surprisingly, weather has affected nesting success. More surprisingly, however, total productivity has declined in the operations phase as compared to baseline. The cause of this decline is unclear although the authors of the analysis suggest that a weak increase in nesting success farther away from the mine may be related to better habitat, but a disturbance effect nearer to the mine cannot be

excluded. As with grizzly bears, statistically speaking, this relationship does not exist because the tests do not reject the null hypothesis of no relationship.

Other explanations for the cause of decline may exist, including changes in prey abundance, or density dependence. In support of density dependence, there were two to three times as many nests occupied in 2004 than during the baseline case. Whether a density dependence effect exists is questionable, but at the current state of information this explanation is as plausible as that of mine effects or changes in prey abundance. The authors make logical arguments that deserve consideration in terms of future data collection and analysis.

3.6.2 Current Data Collection

Perhaps the most surprising finding in 2004 was that of a nest in the mine pit. Apparently, sensory disturbance from mine activities does not discourage some peregrines from nesting attempts. Such behaviour has some precedence as Peregrine falcons repeatedly nest in or near cities. Availability of nesting sites and prey appear to be the overarching factors in determining nesting attempts. Current data collection appears to do justice to the need for resolution of the above questions in terms of mine effects on nesting success. This data collection should continue and consider prey abundance (see below).

3.6.3 Potential for Adapting the Monitoring Program

We concur with the recommendation in Section 9.3 that occupancy surveys need to continue. Consideration should be given to the collection or analysis of data that may relate to nesting success of Peregrines including breeding pair density, physical attributes of nest sites (exposure to weather and predation), and prey abundance.

3.7 Waterfowl

3.7.1 Information About Effects To Date

The data analysis for species diversity and richness is well thought out. The choice of two different indicators is appreciated as there does not appear to be any one single measure of diversity that most truthfully describes biological diversity (Purvis and Hector 2000). In fact, multiple measures and multivariate analyses may eventually better serve the purpose of assessing changes in diversity over time.

The current analysis leads to the temptation of assigning effects to mine operations on waterfowl and shorebird diversity because the phases of constructions and operation coincide with lower diversities. However, no such conclusion can be reached as it is unknown whether such changes in diversity occur due to other factors that are unrelated to the mine. There should have been some control sites that would indicate whether or not such changes also occur elsewhere in the region.

As sophisticated as the analysis in Appendix A may be, we believe that the absence of control sites for bird monitoring is one of the gravest omissions in the monitoring program. No conclusive cause-and effect relationship, if any, can be made because of poor study design.

3.7.2 Current Data Collection

Aside of the lack of control sites, the current data collection appears to be useful for the assessment of changes in bird diversity over time, although the utility of this information is questionable as no meaningful comparisons to control site data can be made. This monitoring should continue and needs to be complemented by monitoring of control sites.

3.7.3 Potential for Adapting the Monitoring Program

In order to draw conclusions about mine effects on bird diversity, if any, it is imperative to apply to control sites the same data collection techniques as are currently employed near the mine.

4 Closure

The analysis in the 2004 WMR transformed much of the previously presented monitoring data into useful comparative information. Several instances were noted where the data collected thus far do not adequately address the predictions at hand, particularly at the regional scale. In this report, conclusions about the strengths and weaknesses of data collected to date, and subsequent recommendations could only be made as a result of the analyses. The inclusion of these analyses is therefore much appreciated and the reviewers strongly encourage the continued application of statistical analyses of future monitoring data and of data sets that have not yet been analyzed. The reviewers do not take credit for having pointed out the importance of statistical analyses in environmental monitoring. Rather, the application of statistical models and optimizations is a common tool in modern concepts of environmental monitoring (Burns and Wiersma 2004).

The review reported herein presents the conclusions arrived at by MSES. These views are submitted to EMAB for its consideration of potential recommendations and actions.

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