DEC Review of Response to United States Geological Survey (USGS) Comments (dated 8 July 2005) on the April 2005 Draft DMTS Fugitive Dust Risk Assessment

No.	Comment	Priority	Recommendation	Response	DEC Remarks
USGS -1, -2	***1. Was the risk assessment unbiased and based on good science? What are the shortcomings?*** The risk assessment appears to be based upon valid science and follows best practices for evaluating ecological risk, relying heavily on site-specific and selected published data. This risk assessment is based on specific regulatory guidance that does not necessarily generate information that is of specific significance to the unique ecology of the CAKR. For example, extrapolation from benchmark data from unrelated species to organisms unique to this arctic habitat may introduce inaccuracies not fully anticipated by regulatory guidance. In addition, regulatory guidance can lead to a narrowly focused assessment that may include data gaps and introduce uncertainty and bias to resource management plans developed for Park Service lands. For example, the most sensitive receptors may not be the charismatic higher-order receptors that normally receive regulatory attention. Standard benchmark criteria may also introduce uncertainties and bias. For example, it may be misleading to assume that median values for accumulation factors for certain metals in biota are conservative in comparison to metal concentrations in sediment or soil. Also, in following regulatory guidance, some components of the ecosystem, such as soils, soil dwelling invertebrates, mosses and fungi, are primarily considered to be sources of contamination in the food chain rather than as receptors of contaminant impact. From an ecological perspective, soils and associated vegetation communities may be the most sensitive receptors in the system at risk, especially within the context of long-term sustainability. While food chain analysis is commonly used by regulators, reliance on a generalized food-chain analysis for characterizing risks may not adequately consider other potentially more critical receptors (e.g., soil biota and vegetation) in the unique tundra systems. Concerns of the Park Service for managing their resources may not be considered in regulatory approaches, since these do not adequately forecast risks nor provide sufficient foundation for addressing long-term resource management needs. Furthermore, *Exponent's* assessment of risks to mammals that frequent the haul road region is based on assumptions about metals accumulation in the food web that may be unrealistic for this ecosystem. Their assessment includes no biological measures of sub-lethal chronic effects in higher-level organisms, nor consideration of cumulative impacts of all metals to which the organisms are potentially exposed.	High	Please provide response regarding how soil invertebrates, mosses, and fungi (i.e., lichens) were handled in the ecological risk assessment (ERA). Please provide response to criticism that sub-lethal chronic effects and cumulative impacts were not assessed Please respond to other criticisms of the overall ERA approach as warranted.	Exponent agrees that this risk assessment uses good science to make the best estimate possible of risk to ecological receptors. However, we recognize that, as in any ecological risk assessment, there are uncertainties that reduce the accuracy of risk estimates. For example, the comment notes that uncertainty may arise as benchmark data are extrapolated from unrelated species. This is a common issue in most ecological risk assessments, is not restricted to assessments conducted in arctic habitats, and reflects the general lack of screening benchmark values or toxicity reference values (TRVs) for species other than those commonly evaluated in laboratory toxicity studies. However, uncertainty associated with benchmark values was minimized in this risk assessment by selecting a conservative value from among the available choices. Therefore, unless arctic species are much more sensitive to the chemicals of potential concern (CoPCs) than other species, then the benchmark values used in this assessment are valid approximations of likely effect thresholds for the receptors evaluated. Uncertainties associated with the benchmark values and toxicity reference values, and possible implications for risk conclusions, were discussed at length in the uncertainty analysis of the assessment. To further address uncertainty with toxicity reference values, the following paragraph was added after the third paragraph of Section 6.6.5.4): *As mentioned above, efforts were made to select the best available TRVs, based on appropriate exposure studies and most relevant endpoints. For example, if both drinking water and dietary exposure studies were available, the dietary exposure study was selected preferentially. EPA (2005) recommended a mammalian lead NOAEL TRV of 4.7 mg/kg-day. The mammalian NOAEL for lead recommended by USEPA (2005) was based on a drinking water study, and was therefore not an appropriate TRV based on the selection criteria. Additionally, deriving TRVs from exposure studies that are focused on chemicals dissolved in drinking water, which are highly available, is overly conservative and would overestimate exposure. For lead, a dietary exposure study was available, and therefore the mammalian NOAEL TRV used in this risk assessment was based on the more appropriate dietary study.* *As mentioned above, efforts were made to select the best available TRVs, based on appropriate exposure studies and most relevant endpoints. For example, if both drinking water and dietary exposure studies were available, the dietary exposure study was selected preferentially. EPA (2005) recommended a mammalian lead NOAEL TRV of 4.7 mg/kg-day. The mammalian NOAEL for lead recommended by U.S. EPA (2005) was based on a drinking water study, and was therefore not an appropriate TRV based on the selection criteria. Additionally, deriving TRVs from exposure studies that are focused on chemicals dissolved in drinking water, which are highly available, is overly conservative and would overestimate exposure. For lead, a dietary exposure*	Response is acceptable.

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				study was available, and therefore the mammalian NOAEL TRV used in this risk assessment was based on the more appropriate dietary study. Similarly, U.S. EPA (2005) recommended an avian lead NOAEL TRV of 1.63 mg/kg-day. The avian NOAEL for lead recommended by U.S. EPA (2005) was based on a paper that used Japanese quail as the receptor and the number of eggs produced as the relevant endpoint. Japanese quail have been bred specifically to have unnaturally high egg-laying rates, and therefore the relevance of "egg production" as the endpoint for wild birds is unclear. The meaning of extrapolating any apparent reproductive "effect threshold" in quail to wildlife receptors is unknown and highly questionable, because of differences in reproductive physiology. Therefore, a NOAEL TRV was selected that was derived from a study (Pattee 1984; see Section 6.5.2.9) that used wild species (American kestrels), dietary exposure, and the relevant endpoints included body weight, food consumption, clutch initiation, interval between eggs, clutch size, fertility and eggshell thickness. Thus, it should be noted that if the U.S. EPA (2005) NOAEL had been used, the NOAEL hazard quotients would have been higher. Comments that the risk assessment focused on charismatic higher-order receptors and may have not adequately considered more critical receptors are unfounded and appear to be confusing the approaches used in the preliminary screening evaluation and the subsequent baseline risk evaluation. In the screening assessment, we conducted simple food-chain exposure analyses to identify CoPCs to wildlife receptors. However, we also used comparisons of metals concentrations in media (soil, water, sediment) to identify a separate list of CoPCs for other receptors (e.g., tundra plants, invertebrates, etc.). In the subsequent baseline assessment, in addition to conducting more detailed, site-specific food-chain analyses, we also conducted extensive evaluations of risk to plant communities in tundra, freshwater and coastal lagoon habitats, and evaluations of freshwater and coastal lagoon invertebrate communities, and developed risk characterizations for these receptors independent of characterizations for wildlife receptors. Several of the other comments noted here are also incorrect. Median values for metals accumulation factors were not used in the risk assessment. At the screening phase, in the absence of site-specific tissue data, we used 90th percentile biota-sediment accumulation factors for some metals to estimate tissue concentrations for screening purposes. For the subsequent baseline risk assessment, we collected site- specific tissue data and used mean or 95 percent upper confidence limit on the mean concentration in food web models. The claim that sub-lethal chronic effects in higher-level organisms were not considered is also incorrect. The TRVs selected for wildlife receptors were either no-effect levels or lowest adverse effect levels for studies where test animals were chronically exposed to chemicals and effects on growth, survival, or reproduction were measured. Therefore, use	

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				of these TRVs in food web models presents an evaluation of the likelihood of chronic effects occurring in wildlife. The risk assessment did not evaluate cumulative impacts of all metals to wildlife. In the wildlife uncertainty section (Section 6.6.5.4), we provided a discussion of the reasons why a simplified approach of summing hazard quotients as a measure of cumulative effect is inappropriate for estimating additive impacts on wildlife. Without a thorough understanding of the mechanisms by which individual metals elicit toxicity and the synergistic and antagonistic interactions between those metals, a simple summation of hazard quotients could either underestimate or overestimate additive effects and conveys little useful information beyond that presented in the individual chemical hazard quotient results. For other receptors, results of vegetation community surveys, stream benthic invertebrate surveys, and sediment toxicity tests provide an indication of the magnitude of effects from cumulative exposure to multiple metals in soil, sediment, or water, as well as other anthropogenic or natural stressors. The last paragraph of Section 6.6.5.4 was revised as follows: *The modeling technique used in the risk assessment evaluates each chemical individually, because the TRVs used for evaluating the ecological significance of exposure are also chemical-specific. Chemical-specific hazard quotients calculated by this method permit identification of specific chemicals that may cause adverse effects in ecological receptors. Simultaneous exposure to multiple chemicals could produce cumulative effects that are greater than the effects predicted for individual chemicals. Simple approaches such as summation of individual hazard quotients to calculate a hazard index are sometimes used to estimate cumulative effects; however, this assumes effects are additive, which may not be true based on the chemical-specific modes of action, and may be an overly-conservative approach if some metals act antagonistically. Although it is possible that interactions between combinations of metals could result in differences in bioavailability and/or toxicity relative to individual metal exposures, these potential interactions have been poorly characterized in the literature, at best. Furthermore, the effect of the interaction could be positive or negative. For example, zinc can reverse cadmium-induced toxicity (Peraza et al. 1998). Without a thorough understanding of the mechanisms by which individual metals elicit toxicity and the synergistic and antagonistic interactions between those metals (e.g., mode of action and target organ for each chemical in each receptor), a simple summation of hazard quotients could either underestimate or overestimate additive effects, which would convey little useful information beyond that presented in the individual chemical hazard quotient results.* Peraza et al. 1998. Effects of micronutrients on metal toxicity. Environ Health Perspect. 106 Suppl 1:203-16.	

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				The risk assessment provides an estimate of risk to ecological receptors based on current conditions at the site. Insofar as those current conditions may persist into the future, the risk assessment provides an adequate evaluation of the likelihood of future risks. However, the risk assessment document clearly identified some uncertainties that limit our ability to accurately evaluate risks, such as possible effects on plant communities greater than 1,000 m from the DMTS. As such, there may be a need to evaluate possible additional actions to address risks identified by the risk assessment. Additional studies designed to minimize outstanding uncertainties will be considered during development of the risk management plan, as stated in the risk assessment document. Results of any supplemental studies would provide additional information for the Park Service to use in managing these public resources.	
USGS -3	***3. What is most at risk and what are the risk levels?*** The ecosystem factors most at risk of injury are the organisms unique to the arctic tundra for which there are limited information regarding body burdens of metals or their toxicological significance. Representative species considered as part of the food-chain analysis may not be adequate to predict exposure to the wide range of species which may be of interest to the Park Service. For example, tundra vegetation and invertebrates are undervalued in the RA, and are primarily evaluated as a derivative source of contamination. In reality, these components of the tundra ecosystem are also receptors of the contamination. Limited benchmark data for these species also increases uncertainty with any characterization of risk. Adverse effects in soil and vegetation communities are inadequately considered because benchmarks might not be relevant to those of tundra soils.	Medium	Please respond regarding the level of evaluation (and value) given to tundra vegetation and invertebrates. Please respond to comments on available benchmarks and resulting uncertainty. Ensure that this issue is adequately discussed in the uncertainty section of the revised ERA.	Soil fauna were not evaluated directly in the risk assessment, but rather were evaluated assuming that if there were adverse effects due to presence of chemicals in tundra habitats, the effects would be apparent in plant communities. The basis for this approach is that ecological screening benchmarks for soil are typically much lower for plants than for soil fauna, and therefore, the results of the terrestrial plant community analysis would also be protective of the soil fauna community. This discussion was included in Section 6.2.4 (Risk Characterization for Tundra Soil Fauna), and is appended below: *The structure and function of tundra soil fauna communities are not evaluated quantitatively in the ERA. Ecological screening benchmarks for soil are typically much lower for plants than for soil fauna (Table 3-19). Therefore, it is anticipated that if there were adverse effects due to the presence of chemicals in tundra habitats, these effects would be apparent in plant communities at concentrations where no effects would be seen on soil fauna. For this reason, it is assumed for purposes of the baseline risk assessment that results of the terrestrial plant community analysis will be protective of potential adverse effects to soil fauna. Sampling conducted in 2004 indicated the presence of a diverse terrestrial invertebrate community at the site and reference locations. Figure 6-7 shows the composition of soil invertebrate samples collected in pitfall traps at site and reference stations. A photograph of a typical sample of invertebrates is included in Appendix J.* The extent to which ORNL values reflect screening benchmarks for tundra soil fauna communities is unknown, as the benchmarks are typically derived from species common to soils of more temperate regions of North America. However, as there are no screening benchmarks specific to tundra communities, the ORNL values represent the best information available for screening purposes. The discussion of ORNL values was included in Section 3.5.1 (Terrestrial Tundra Environment), and is appended below:	Response is acceptable.

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				Tundra soil data were compared to Oak Ridge National Laboratory (ORNL) toxicological benchmarks for effects on terrestrial plants (Efroymson et al. 1997a) and earthworms and microbial heterotrophs (Efroymson et al. 1997b). There are very few screening benchmarks available for nonvascular plants and therefore they were not used in the ecological screening assessment. The ORNL screening benchmarks approximate the 10th percentile of lowest-observed-effect concentrations reported in studies that examined the effects of chemicals on vascular plant growth or production (yield) (Efroymson et al. 1997a), earthworm survival, growth, and reproduction (Efroymson et al. 1997b), or soil microflora community functioning, including carbon mineralization, nitrogen transformation, and enzyme activities (Efroymson et al. 1997b). Soil screening benchmarks are presented in Table 3-19. Therefore, as noted in the response to the previous comment, Exponent disagrees that tundra vegetation and invertebrates are undervalued in the RA, as the baseline risk assessment included a comprehensive and focused evaluation of these communities. Also, please refer back to the response to the previous comment regarding the relevance of benchmarks used in the risk assessment.	
USGS -4	***4. Future research focus*** It is critical to develop monitoring plans amenable to long term management goals envisioned by the Park Service. This includes selection of relevant biota and endpoints as well as appropriate temporal and spatial sampling plans. This monitoring would also be useful in evaluating the success of dust management efforts. Biomarker and other measures of sublethal impacts may provide weight-of-evidence information about receptors and pathways and "ground truth" the findings of risk assessments because sub-lethal chronic effects are difficult to predict from COPC analysis and risk assessment modeling exercises. Within the context of developing monitoring plans amenable to long term management goals envisioned by the Park Service, selected biomarkers complementary to those measures of effect could serve as sensitive indicators of effects that may develop through time. The risk management plan should focus on those components of the system at risk by addressing questions related to bioavailability and undervalued resources such as soils and vegetation. In addition, comparison of toxicity and differential bioavailability of ore concentrates versus weathered mineral outcroppings could help differentiate mining inputs from ambient environmental exposures, if studies were designed to address the question. Such studies could also provide insight as to pathways of ore concentrates to biological receptors, and serve to refine exposure models employed in the food-chain analysis captured in the RA.	High	Please provide response regarding the usefulness of implementing the suggested monitoring studies to address the stated concerns. Consider incorporating the suggested studies into future monitoring plans and/or the risk management plan for the site.	Regarding bioavailability, please see the response to comment USGS-8. The need for future study of vegetation and soil communities, and bioavailability, will be evaluated during development of the risk management plan. The risk management plan will define what actions need to be taken based on the findings of the DMTS risk assessment, thereby focusing priorities where the greatest potential risks were predicted.	Response is acceptable.

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	I. Overview:				
USGS -5	The RA generally concludes that there are no significant impacts to biota associated with the operation of the Red Dog Mine. The process of a standardized regulatory risk assessment compares metals concentrations in soils, sediment, and water, and tissues of plants and animals with toxicity information from existing data bases and regulatory criterion concentrations. Assimilation of metals from dietary and environmental pathways is also based on assumptions on dietary assimilation and area use. Numerous assumptions, consistent with these standardized procedures were made to reach conclusions regarding bioavailability, uptake and toxicity of metals to various organisms in areas adjacent to mine operations. Certain conclusions are made without sufficient supporting documentation. For example: 1. Conclusions about confounding impacts of metals and dust on plant communities reflect limited sampling and information about soil quality. 2. Conclusions as to the lack of impacts to populations are unsupported even though voles and shrews are clearly exposed. 3. Conclusions about metals concentrations in soils are not supported by information about the soils such as pH, cation exchange capacity, total organic carbon, or nutrient levels. 4. Uncertainties were not clearly discussed relative to impacts to the unique arctic ecosystem of the Cape Krusenstern National Monument (CAKR).	High	The ERA should be revised so as not to include the unsupported conclusions listed in this comment.	The risk characterization section of the ecological risk assessment (ERA) has been modified in response to comments from USGS and other reviewers regarding the likelihood or extent of impacts to wildlife populations. Revisions to the text of the ERA are described in the latter part of this response. The plant community surveys conducted in support of this risk assessment evaluated trends in frequency and cover for total mosses and total lichens. At this level of resolution, the assessment was able to discern trends with distance from dust sources and differences between site and reference areas that suggested that fugitive dust is adversely affecting moss and lichen communities in the study area in addition to effects due to metals. Had extra resources been devoted to speciation of mosses and lichens in the field, the overall conclusions of the risk assessment for terrestrial plants would likely stand. However, as noted in other comments, species-level data would identify the most sensitive components of the moss and lichen communities (the species most at risk). Also, pH data were collected in association with the vegetation community transect locations. However, cation exchange capacity, total organic carbon, and nutrient level data were not collected in this preliminary effort to characterize vegetation effects. This information, as well as species-level data for mosses and lichens, could be useful for elucidating the cause of the observed effects (e.g., metals toxicity or physical effects) and will be considered for inclusion in future monitoring plans. The need for future study of plant communities (including nonvascular species), including in areas within CAKR, will be evaluated during development of the risk management plan. There is little reason to believe that habitats within CAKR are any more unique than the habitats throughout the DMTS corridor that were evaluated in the ERA. Screening evaluation included samples in numerous locations in the terrestrial, stream, and tundra pond environments within CAKR (see Figures 3-9, 3-10, 3-11). Transects sampled near the port (TT2 is adjacent to and partially within CAKR), and in the middle portion of the road (TT8 to the northeast of CAKR), are representative of the communities found within CAKR, as are the ptarmigan that were sampled within CAKR (Figure 4- 1). As such, risk conclusions in the report are equally pertinent to CAKR, as to areas outside CAKR. ____ Section 7 has been revised to include the following changes: *The risk assessment process defined in the DEC risk assessment procedures manual (DEC 2000) and 18 AAC 75.340 provides for the calculation of site-specific risk-based alternative cleanup levels (alternative to the default DEC cleanup levels) if site conditions are not "protective of human health, safety, and*	Response is acceptable.

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				welfare, and of the environment," as indicated by a site-specific risk assessment. However, because the DMTS is an active facility (rather than a closed facility typically dealt with by the contaminated sites program guidance), and conditions are expected to change over time, it would be most practical to develop alternative cleanup levels following mine closure, where appropriate. In the meantime, changes in conditions and in potential human and ecological exposures over the life of the operation can be addressed through implementation of risk management, control, and monitoring activities, as illustrated in Figure 1-1, which is based on the decision-making framework from DEC et al. (2002). A risk management plan will be developed to more clearly define the actions to be taken. *This is a prudent and health-protective approach because:* *1. Human health risks were not found to be elevated, precluding the necessity of calculating human-health-based action levels. Nevertheless, conditions may change over time. The risk management plan will provide the means to monitor changes in conditions, and trigger additional actions, if needed, to control risks.* *2. Although some ecological effects were identified and potential risks were predicted for some receptors, these issues are not well addressed by environmental cleanup levels. The risk management plan will provide a variety of tools to monitor and minimize changes in conditions and pursue environmental improvements.* *Specifics about the risk management plan are described below.* ***Risk Management Plan*** *A risk management plan will be developed to address the issues identified by this risk assessment. The plan will include evaluation of risk management options within the general categories of institutional controls, engineering controls, monitoring, and remediation/restoration. The plan will identify the most appropriate combination of actions to minimize risk to human health and the environment over the life of the mine.* *A variety of actions have already been taken to reduce risk of metals exposure from fugitive dust. For example, many measures have already been undertaken throughout mine, road, and port operations to reduce fugitive dust emissions, including significant improvements in engineering controls and operational procedures, as described in Section 2.2.4 (Fugitive Dust Control Measures). Soils containing elevated metals concentrations have been recovered and recycled to reduce the potential for exposure to occur or dust to be generated from these soils (Exponent*	

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				2002b). In addition, studies have been undertaken to evaluate areas of uncertainty, such as bioavailability (Shock et al. 2007) and weathering potential of metals in fugitive dust (Teck Cominco 2007b, c). Teck Cominco uses its environmental management systems program to define objectives and track progress for continuous improvement on their environmental performance, including with respect to fugitive dust emissions (e.g., see Teck Cominco 2007a). Current efforts in the mine area are summarized by Teck Cominco (2007d) and reported regularly at http://www.dec.state.ak.us/air/reddog.htm. *As described previously, human health risks are not significantly elevated. However, some ecological risks were identified, as described in Sections 7.2. As a result, monitoring of metals concentrations in environmental media will be an important part of the risk management plan. The frequency of monitoring could potentially be increased or decreased in response to increases or decreases in the rate of change in concentrations. For example, in response to increased mining activity (potential increase in rate of change), or improved dust control (potential decrease in rate of change). In this way, increases or decreases in human and ecological exposures (relative to exposures evaluated in this risk assessment) can be closely monitored and managed through a decision process tied to these changes.* *Development of the risk management plan will be a collaborative process involving DEC and other stakeholders throughout the process of identifying and evaluating options and methodologies, and determining an agreed-upon course of action.* *The risk assessment process defined in the DEC risk assessment procedures manual (DEC 2000) and 18 AAC 75.340 provides for the calculation of site-specific risk-based alternative cleanup levels (alternative to the default DEC cleanup levels) if site conditions are not "protective of human health, safety, and welfare, and of the environment," as indicated by a site-specific risk assessment. However, because the DMTS is an active facility (rather than a closed facility typically dealt with by the contaminated sites program guidance), and conditions are expected to change over time, it would be most practical to develop alternative cleanup levels following mine closure, where appropriate. In the meantime, changes in conditions and in potential human and ecological exposures over the life of the operation can be addressed through implementation of risk management, control, and monitoring activities, as illustrated in Figure 1-1, which is based on the decision-making framework from DEC et al. (2002). A risk management plan will be developed to more clearly define the actions to be taken.* *This is a prudent and health-protective approach because:* *1. Human health risks were not found to be elevated, precluding the necessity of calculating human-health-*	

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				based action levels. Nevertheless, conditions may change over time. The risk management plan will provide the means to monitor changes in conditions, and trigger additional actions, if needed, to control risks. *2. Although some ecological effects were identified and potential risks were predicted for some receptors, these issues are not well addressed by environmental cleanup levels. The risk management plan will provide a variety of tools to monitor and minimize changes in conditions and pursue environmental improvements.* *More specifics about the risk management plan are described below.* ***Risk Management Plan*** *A risk management plan will be developed to address the issues identified by this risk assessment. The plan will include evaluation of risk management options within the general categories of institutional controls, engineering controls, monitoring, and remediation/restoration. The plan will identify the most appropriate combination of actions to minimize risk to human health and the environment over the life of the mine.* *A variety of actions have already been taken to reduce risk of metals exposure from fugitive dust. For example, many measures have already been undertaken throughout mine, road, and port operations to reduce fugitive dust emissions, including significant improvements in engineering controls and operational procedures, as described in Section 2.2.4 (Fugitive Dust Control Measures). Soils containing elevated metals concentrations have been recovered and recycled to reduce the potential for exposure to occur or dust to be generated from these soils (Exponent 2002b). In addition, studies have been undertaken to evaluate areas of uncertainty, such as bioavailability (Shock et al. 2007) and weathering potential of metals in fugitive dust (Teck Cominco 2007b, c). Teck Cominco uses its environmental management systems program to define objectives and track progress for continuous improvement on their environmental performance, including with respect to fugitive dust emissions (e.g., see Teck Cominco 2007a). Current efforts in the mine area are summarized by Teck Cominco (2007d) and reported regularly at http://www.dec.state.ak.us/air/reddog.htm.* *As described previously, human health risks are not significantly elevated. However, some ecological risks were identified, as described in Sections 7.2. As a result, monitoring of metals concentrations in environmental media will be an important part of the risk management plan. The frequency of monitoring could*	

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				potentially be increased or decreased in response to increases or decreases in the rate of change in concentrations. For example, in response to increased mining activity (potential increase in rate of change), or improved dust control (potential decrease in rate of change). In this way, increases or decreases in human and ecological exposures (relative to exposures evaluated in this risk assessment) can be closely monitored and managed through a decision process tied to these changes. *Development of the risk management plan will be a collaborative process involving DEC and other stakeholders throughout the process of identifying and evaluating options and methodologies, and determining an agreed-upon course of action.* The revised ecological risk assessment conclusions are included in the risk assessment, and the revised text from Section 8 (Conclusions) is provided below. First, the introductory paragraph was revised as follows: *The results of the risk assessment provide a snapshot of risk under current conditions that will help risk managers to determine what additional actions may be necessary to reduce those risks now and in the future. The following subsections summarize the findings of the human health and ecological risk assessments.* In Section 8.2.1, the second, third, and fifth bullets have been revised: • *Bullet 2: Differences between reference plant communities and plant communities beyond 1000 to 2000 m from the DMTS road, specifically the 2- to 4.5-fold decrease in lichen cover (Figure 6-4 and Tables 6-10 and 6-11), may be a result of fugitive dust deposition. Further study would be required to define the full nature and extent of lichen effects related to fugitive dust deposition from the DMTS port, road and Red Dog Mine and identify the causative agent(s) of lichen decline.* • *Bullet 3: In port facility areas, particularly in the area immediately downwind of CSB1, the presence of stressed and dead vegetation appears to be primarily related to fugitive concentrate dust deposition.* • *Bullet 5: Adverse effects to herbivorous birds (e.g., ptarmigan) are possible in individuals foraging near the port and mine, particularly the most highly exposed individuals. These effects, if occurring, could result in population-level effects in areas near the port or mine. However, the likelihood of adverse effects to herbivorous birds foraging along the length of the road is low, as 95 percent UCL on the mean exposures did not exceed NOAEL and/or LOAEL TRVs.*	

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				The second bullet in Section 8.2.4 (Coastal Lagoons) has been revised: • *Plant community structure was similar at site and reference lagoons. Natural variability among and within lagoon plant communities likely accounts for the few differences that were observed. However, only fringing wetland vegetation was assessed for coastal lagoons, while plant communities with abundant lichen cover were assessed in the terrestrial coastal plain transects.*	
USGS -6	In summary, the draft risk assessment is well presented but questions remain regarding the ecological relevance of measurement endpoints and receptors to the CAKR ecosystem. Most generally, reliance upon benchmark criteria while sufficient for the regulatory framework of this Risk Assessment may not be sufficiently protective of biota of concern to surrounding resource management agencies.	Medium	Please respond regarding the overall protectiveness (i.e., conservativeness) of the ERA approach and design. Please revise the ERA as necessary to clearly describe weaknesses in the overall approach.	As stated above, Exponent strongly disagrees that the conclusions of the risk assessment rely primarily on broadly applicable benchmark criteria, as this comment fails to recognize the extensive and comprehensive site- specific data collected in support of the risk assessment, including tissue chemistry data, plant community, invertebrate community analyses, and media chemistry data. Despite this, there remain some uncertainties with regard to risk conclusions, as extensively detailed in the risk assessment. Possible actions to address identified areas of risk and uncertainty will be considered during development of the risk management plan, and future work that follows from that plan (e.g., monitoring) will help to provide a more accurate evaluation of risk to ecological receptors.	Response is acceptable.
	II. Data gaps and Uncertainties:				
	Metals Toxicity to Resident Biota:				
USGS -7	1. The estimated toxicity of metals to species existing at the mine site, haul road, and port facility are based on published information derived from other species that may be less sensitive or of greater sensitivity than organisms native to site potentially impacted by mine operations. For example, use of bovine data may be more applicable to caribou and muskoxen than rodent data. 2. The benchmark data base used to predict toxicity to endemic organisms does not likely reflect the most sensitive life stage for the target species. 3. The benchmark data base does not consider the potential for impacts to physiological or behavioral functions that might limit essential life functions. 4. In addition, the toxicity data base does not consider multiple stressor interactions that might occur at the mine site that could additively increase injury to the target species. 5. As per regulatory guidance, cumulative risk estimates should be considered because several chemicals that were eliminated from the listing of contaminants of potential concern (COPC) could be expected to occur. Furthermore, exposures to the metals mixture would likely have additive impacts to the organism, even when the individual metals affect different biochemical pathways.	High	Please provide a response to each of the five shortcomings listed under *Metals Toxicity to Resident Biota* and, if possible and necessary, revised the ERA to address them.	1. The uncertainties associated with extrapolating TRVs from laboratory species to wildlife species and implications for risk conclusions are discussed in detail in the uncertainty analysis in Section 6.6.3.5 of the report. While in general we agree with the comment that bovine data may be more applicable for caribou and muskoxen, the scarcity of appropriate long-term chronic bovine toxicity values for the metals being evaluated necessitates use of rodent data as a surrogate. 2 and 3. The benchmarks used in the screening evaluation are broadly applicable values developed using a variety of test species and experimental conditions that may not be representative of the receptors and site-specific environmental conditions. Therefore, application of these generic values adds uncertainty to the screening risk assessment because these values may not be directly relevant to environmental conditions at the site. However, since screening is intended to be a conservative process designed to avoid elimination of chemicals that may present unacceptable risk to ecological receptors, the result of these uncertainties is most likely the retention of chemicals for subsequent evaluation that actually pose no unacceptable risk. 4. Results of vegetation community surveys, stream benthic invertebrate surveys, and benthic invertebrate toxicity tests conducted as part of the baseline assessment provide an indication of the magnitude of effects from cumulative exposure	Response is acceptable.

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				to multiple metals in soil, sediment, or water, as well as other anthropogenic or natural stressors. However, as documented in the risk assessment report, it is difficult to distinguish among multiple effects and assign causality to any specific chemical or non-chemical stressor, as illustrated in the case of evaluation of effects to plant communities along the DMTS road. 5. As noted in the response to comment 4, cumulative effects to vegetation and invertebrate communities were evaluated by the nature of the site-specific studies conducted for these receptors. Please see the response to comment USGS-1 regarding evaluation of cumulative risk to wildlife receptors.	
	Metals Speciation/ Toxicity and Biological Availability:				
USGS -8	1. The metals data reflect total metals concentrations without regard to the ionic state (or species) of the metal. Metals speciation plays a significant role in biological availability and toxicity of the metal. For example, lead sulfate is more toxic than lead sulfide and *Exponent* acknowledges that oxidation of metals sulfides to metal sulfates is likely to occur. Thus, the environmental chemistry influencing toxicity of metals at the site may not be fully understood.	Medium	Please provide more discussion of metals speciation in the revised ERA, specifically how the uncertainties in this area affect risk estimates and interpretation.	100% bioavailability was assumed in the ERA. For a discussion of uncertainties related to TRVs, please refer to the responses to comments USGS-1 and 2, which include the revised text regarding uncertainty.	Response is acceptable.
USGS -9	2. The soils of the Arctic are likely to have chemical characteristics quite different from those of soils compiled in the Oak Ridge data base which is used extensively in this RA. Such differences may greatly influence the toxicity and availability of metals in sites adjacent to the Red Dog Mine. The presumed confounding effects of dust versus metals could be resolved if soil characteristics are considered.	Medium	Please provide additional discussion of these issues in the uncertainty section and/or other sections of the ERA as warranted.	Please see the response to comment USGS-7 regarding the appropriateness of screening benchmarks. Also, it should be noted that despite concerns about the Oak Ridge screening benchmarks, when site-specific soil concentrations were compared to these benchmarks, 15 metals failed the screening and were retained for further evaluation in the baseline risk assessment, so the likelihood that chemicals in soil were incorrectly screened out on the basis of comparison to benchmark values is minimal. Regarding the compounded effects of dust versus metals, the possible need for additional work to evaluate this will be considered during development of the risk management plan.	Response is acceptable.
USGS -10	3. Conditions might exist at the site to increase (or decrease) the bioavailability of the metals by altering the chemical speciation of the metals. This could be a function of redox potential of the soils/sediment, aerobic/anaerobic conditions, acid-volatile sulfides, ion exchange capacity, humic acids, water quality, and pH. The soil gradient from pH 8 to pH 4 observed over 1000 meters of the haul road could significantly influence speciation and resultant bioavailability of certain metals. There could also be localized chemical characteristics that could alter metals speciation. Humic acids associated with mosses and other vegetation could also concentrate metals for uptake by browsing organisms. Furthermore, ore concentrates are often apparently transported to the port with residues of the flotation chemicals such as xanthates, which themselves are relatively toxic (Xu and others, 1988) and which also may influence the biovailability of the primary COPCs. Although these xanthate flotation chemicals will reportedly decompose in most environments in a few days, which reduces long-term	High	Please provide response regarding the numerous concerns expressed above (e.g. speciation and bioavailability, floatation chemicals, speciation differences between the site and reference areas, etc.) and revise the affected sections of the ERA as warranted.	Regarding speciation and bioavailability, the ERA made conservative assumptions, as described in the response to comment USGS-8. The following discussion was added to the end of the uncertainty discussion in Section 6.6.5.1.5 (Measured CoPC Concentrations in Environmental Media and Prey): *Xanthates were not measured in the ore concentrate; however, the uncertainty associated with xanthates is limited. Xanthates are typically water soluble with short environmental half-lives, ranging from 2.5 to 4 days (Xu et al. 1988), which reduces long-term environmental concerns. Xanthates have potential to induce toxicity by complexing with heavy metals, such as cadmium and lead, thereby resulting in increased concentrations of metals in organs and tissues in organisms (Boening 1998). While it is possible that residual xanthates (or other factors such as humic acids) may increase the availability of metals for uptake by plant or animal receptors, any such effect would be reflected in the media concentration data that were collected for the risk*	Response is acceptable.

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	environmental concerns, they have been completely ignored in this RA. The lack of information about the speciation of metals from reference and mining sites might also result in a biased view that the metals from these sites are of comparable availability. Metals in ore concentrates could be more available than those from exposed deposits because of the smaller particle size, the presence of xanthates, and the chemical form of the metal in the ore concentrate.			*assessment. Therefore, the potential for xanthates to potentially affect any receptor groups would already be inherently accounted for in the exposure calculations. In addition, the bioavailability of all metals except lead was assumed to be 100% in the ERA and HHRA. For lead, risk estimates were made using site-specific bioavailability information as well as EPA default values. The site-specific lead bioavailability information was developed from a 1993 National Toxicology Program study using Red Dog lead concentrate (Arnold and Middaugh 2001). Bioavailability data from this study would have incorporated any effect on bioavailability of residual xanthates in the concentrate.*	
USGS -11	4. The bioavailability of metals incorporated in tissue may likely differ from metals in surface dusts. Biological concentration factors for metals in some plant species can be considerable and may provide a greater input in dietary pathways than food chain pathways would indicate. For example, willows, a food source for ptarmigans, concentrate cadmium. Lichens concentrate metals including lead.	Medium	Please provide adequate discussion of these issues in the revised ERA.	We agree with this statement, and that is the reason why, in the baseline risk assessment, we collected site-specific plant and animal tissue data and analyzed metals concentrations in those tissues as opposed to trying to predict concentrations using generic uptake factors. Also, in all food web models, metals in tissues were conservatively assumed to be 100 percent bioavailable, thus maximizing the modeled receptor exposure to metals via food intake.	Response is acceptable.
USGS -12	5. The draft RA does little, if any, analysis and characterization of risks as those vary with time. For example, seasonal influences of metals exposure and availability relative to the presence of sensitive organisms or life-stages have not been considered. Season variation in exposure and biological effects may be critical to the evaluation of risks characteristic of early spring snow melt and release of metals loads accumulated on snow-covered ground consequent to winter hauling of ore concentrates. Previous studies by USGS (2004) indicated that metals were accumulated in snow cover across drainages in CAKR. Depending on metal loadings in drainages that occurred over winter, metals potentially already accumulated in Aufeis, and the rapidity of snow melt, seasonal releases of metals to soil and to seasonally active streams could lead to exposure and subsequent adverse effects on biota at critical stages in their life history. For example, pulsed exposures to metals could impair (1) seasonal growth of vascular and nonvascular plants, (2) early life stages of plants, including germination, root elongation, and early seedling survival for vascular plants, (3) soil biota, and (4) sensitive larval stages of stream invertebrates or larval insects dependent on ephemeral water bodies.	Medium	Please provide response regarding the seasonal elements of risk identified above and need for additional studies to address them. Discuss this issue in the uncertainty section of the ERA.	The potential for elevated concentrations to occur in snowmelt has been preliminarily assessed in a USGS study by Brabets (2004). The study found no exceedances of drinking water or aquatic life standards in stream water or snow samples. This information will be added to the uncertainty discussion in the risk assessment. The possible need for future studies will be evaluated during development of the risk management plan. The following paragraph was added to the end of Section 6.5.1.3 (Time Use): *The potential for elevated concentrations to occur during the period of snowmelt has been preliminarily assessed in a USGS study by Brabets (2004). The study found no exceedances of drinking water or aquatic life standards in stream water or snow samples. Therefore, wildlife that utilize the DMTS during periods of snowmelt would not likely be acutely affected through dietary exposure. Nevertheless, the possible need for future studies will be evaluated during development of the risk management plan, as described in Section 7.3.* Uncertainties associated with the timing of the field event are discussed in Section 6.6.4.1.3 (Field Sampling Methods). Revisions to the text are shown below: *Timing of the field event may have affected cover, frequency, and richness measurements. Plant community surveys took place over the course of a month, during which time many plants began to flower or, alternatively, finished flowering and went to seed. Thus, some plant species such as grasses lacked distinguishing characteristics early in the field program but were more readily identifiable later in the season. The field notes indicate that based on the results of the survey at reference station*	Response is acceptable.

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				TS-REF-12, which was sampled late in the program, some grass species may have been missed in the characterizations of coastal plain plant communities at TT5-1000 and TT5-2000, which were sampled early in the program. However, great attention to detail was placed on species identification. Vouchers were retained, and those relative few for which identification was uncertain were reassessed during the course of the field program to confirm results. Overall, the effect of uncertainty associated with the timing of the surveys on survey results is expected to be insignificant.	
	Limited Residue Data:				
USGS -13	1. Assumptions about metal residues in biota were largely based on limited samples of resident biota. Small sample sizes could result in a high degree of variability that may obscure differences in residue concentrations between organisms from exposed and reference sites.	High	Please include in the revised RA a discussion of the trade offs between sample size and statistical power and how it affects site-to-reference comparisons. Clearly indicate any instances where chemicals may have been inappropriately eliminated as COPCs and rectify the problem.	Biota sample results were generally consistent with the patterns and gradients of concentrations known from prior sampling work. Also, despite concerns about reference-based screening, 15 of the 22 CoPCs evaluated were retained for further evaluation in the baseline risk assessment, so the likelihood that CoPCs in soil were incorrectly screened out on the basis of comparison to reference values is minimal. Had additional resources been devoted to data collection, the findings of the risk assessment would likely be unchanged. Regardless, the possible need for additional data collection to address areas of uncertainty will be considered during development of the risk management plan. Implications of uncertainties associated with reference area selection and for CoPC selection are discussed in Sections 6.6.1 and 6.6.2, respectively. Uncertainties associated with representativeness were discussed in the Section formerly referred to as Section 6.6.3.3 (Representativeness of Sampling Locations), but now referred to as Section 6.6.5.3. Uncertainties associated with sample size are discussed in the uncertainty analysis, in new Section 6.6.4.1.4 (Sample Size), which is appended below: ***Sample Size*** *To explore whether a sufficient number of microplots was evaluated to adequately characterize the vegetation at a given station, the cumulative number of vascular plant species identified at a station was plotted over the total area surveyed (up to 10 m^2, equivalent to the area inside 10 microplots) as shown in Figure ME1. Each graph summarizes the results for one plant community type (e.g., coastal plain mesic tussock tundra), and each curve on the graph shows the cumulative number of vascular plant species identified in successive 1-m^2 microplots assessed at a given station (e.g., TT5-0010). The data are plotted along the x-axis in the order in which the microplots were evaluated in the field.* *The species-area curves for the coastal plain community suggest that ten microplots were sufficient to capture most species (Figure ME1). In fact, no new species were identified after the fifth microplot at station TT5-2000, after the sixth microplot at*	Response is acceptable.

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				station TT5-1000, and after the eighth microplot at stations TT5-0100 and TT5-0010. Similarly, the species-area curves for stations on tundra transects TT3 and TT8 seemed to plateau, with few new species added with increasing area. Coastal lagoon communities had low species richness compared to terrestrial plant communities, and most or all species were identified in the first few microplots examined. At hillslope stations, however, the species-area curves suggest that ten microplots were not adequate to characterize these diverse communities. *Based on the discrepancies between species richness and area richness estimates (summarized in Table 6-14), it appears that ten microplots may not always have been sufficient to capture all the species observed at a survey station, particularly in disturbed sites near the road and port facilities and in the diverse hillslope community. Species that were observed in the general vicinity of the survey line but were not captured in microplots included forbs at station TT5-0010 (e.g., lousewort and buttercup), primarily shrubs at station TT5-0100 (e.g., blueberry and Labrador tea), and forbs, grasses, and willows at stations TT3-0010, TT3-0100, TT8-0010, and TT8-0100 (e.g., polar grass and bog willow). Plants are not evenly distributed in nature, and richness estimates based on microplot counts may miss rare species or species with patchy distributions. Species richness estimates were used in statistical calculations, because they were standardized measures and therefore comparable across stations. However, the approximate area richness estimates show that species richness values underestimate the number of species present in the community. While this uncertainty does not alter overall trends in species richness with distance from the road, it does affect site and reference community comparisons in a few cases. For example, based on species richness, hillslope stations TT6-0010 and TT6-0100 appear to have about the same number of species as the reference station, TS-REF-11 (25 and 23, respectively, as compared to 24; Table 6-29). However, based on area richness estimates, the site stations have lower species richness than the reference station (29 species at either site station, as compared to 35 species at the reference station; Table 6-29). Likewise, lagoon station PLNL appears to be less rich than reference station CL-REF-1 based on the species richness values but is actually more species-rich based on the area richness values (Table 6-14).* *Natural variability in tundra communities may obscure differences related to fugitive dust effects, given the small number of replicates in this study. Plant communities along the DMTS shifted in response to changes in topography, drainage, aspect, elevation, local geology, or other environmental factors. The single coastal plain transect at the port and two tundra transects in the central portion of the road were distributed many miles apart, where elevation changes and other environmental factors likely influenced vegetation patterns to some degree. No*	

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				replicates were sampled in the hillslope community near the mine. The three reference stations evaluated in coastal plain and foothills mesic tussock tundra environments may not have been sufficient to account fully for natural variation in characteristics, such as the relative dominance of plant functional groups or the commonness of individual species. Only one reference station was evaluated in the hillslope mesic open shrubland community, and two reference coastal lagoons were surveyed. Because of small sample sizes, real differences between site and reference communities or differences in communities with distance from the DMTS road may not have been detected in statistical tests; therefore, a less stringent p-value of 0.10 was used in the tests to compensate for the low number of samples. Thus, comparisons between site and reference stations must be approached with caution, and in this risk evaluation were interpreted in context with other lines of evidence, such as trends with distance from the road and port facilities.	
USGS -14	2. Most often tissue residues reflected whole-organism values that might be lower than target organ residue concentrations.	Medium	Please provide response regarding how the lack of residue data for specific organs may limit the value of the ERA. If warranted, discuss this issue in the uncertainty section of the revised ERA.	Whole-organism tissue concentrations, such as for small mammals, were measured because they best represent the exposure a predator would receive when it consumes the entire prey item. For the purposes of the ecological risk assessment, target organ residue concentrations are not relevant because we did not use tissue threshold concentrations to establish TRVs.	Response is acceptable.
USGS -15	3. The manner in which a resident population is defined could strongly influence average tissue levels. Musk oxen and caribou limited to the site would likely have higher average tissues levels than organisms sampled from a broader area.	High	Please provide response to this USGS concern, including the need to possibly identify and sample resident caribou and musk ox. Discuss this issue in the uncertainty section of the revised RA. Indicate to what extent human health risks may be underestimated.	With regard to human health, although most caribou would not be resident at the site for an extended period of time, the tissue data used in the risk assessment were from caribou that had over-wintered in the area near the mine and road. The results of the caribou metals evaluation (Appendix H) suggest that metals concentrations in caribou that had over- wintered at the site are not elevated relative to background. However, these data ostensibly represent the most exposed portion of the caribou population. Using data from these animals (as was done in the human health risk assessment [HHRA]) is the most protective approach. This issue is further discussed in the uncertainty section of the human health risk assessment. With regard to the ecological risk assessment, when receptors are selected for evaluation in food web exposure models, they serve not only to estimate risk to that particular species, but also as an indicator species, results for which can be used to assess the likelihood of adverse effects to ecologically similar species (i.e., those of a similar trophic level with similar dietary preferences and foraging habits). This approach eliminates the need to assess every species separately. Alaska Department of Environmental Conservation (DEC) guidance recommends this approach by specifying default indicator species for different receptor groups and geographic regions of Alaska (DEC 1999). In this risk assessment, the caribou serves as an appropriate indicator species for muskox, as the diet of the caribou is modeled as consisting of 80 percent nonvascular plants. Furthermore, caribou exposure scenarios evaluated small areas	Response is acceptable.

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				(e.g., port or mine assessment unit), which would be comparable to the lower end of the home range size for muskox. For example, Jingfors (1984) reports a core area, or home range, of 330 square km for a muskox herd inhabiting the Sadlerochit River in northern Alaska. Also, in the Arctic National Wildlife Refuge, radio collared muskoxen used an average core area of 223 square km in the summer and 27 to 70 square km in the winter (Reynolds et al. 2002). These studies indicate that muskox home range is not extremely small, and is comparable in size to the assessment units evaluated in this risk assessment. Thus, based on similar assumptions about dietary composition and home range size, the caribou is an appropriate indicator species for muskox in this ERA, and conclusions regarding risk to caribou are protective of risk to muskox.	
USGS -16	4. Metal concentrations in water, soils, and sediments were largely based on limited transects, thus could be variable to the extent that reference and site levels are difficult to differentiate. As mentioned earlier, the speciation of metals could be quite different from one site to the next.	High	Please indicate how this issue affects selection of COPC and conservative evaluation of site risks. Shortcomings in the study design should be clearly described in the revised RA.	Regarding extent of sampling, please see response to USGS-17. Regarding variability, please see response to USGS-13. Regarding speciation and conservatism associated with that issue, please see response to comment USGS-8.	Response is acceptable.
USGS -17	5. The sampling of biota and substrates within the CAKR was limited, and information generated by NPS studies was not considered in this RA by *Exponent*, thus estimates on the status of metals contamination to habitat and biota of CAKR are based on very limited data.	High	In the revised RA, please indicate to what extent limited sampling within CAKR may affect the strength of the risk estimates for receptors within CAKR. Please evaluate all available data.	National Park Service (NPS) studies were in fact considered in the risk assessment. Additional figures and discussion of the NPS/Hasselbach data have been added in Section 1 describing nature and extent of fugitive dust deposition. Revisions to Section 1.1 (Site Overview) are included below: *Moss studies performed in 2000 and 2001 by the National Park Service (NPS) (Ford and Hasselbach 2001, Hasselbach 2003b, pers. comm., Hasselbach et al. 2005) found elevated concentrations of metals in tundra along the DMTS road and near the port, apparently resulting from fugitive dust from these facilities. A fugitive dust study completed by Teck Cominco in 2001 (Exponent 2002a) provided an initial characterization of the nature and extent of fugitive dust releases from the DMTS corridor and provided baseline data from which to monitor the performance of new transport and handling equipment and dust management practices. A fugitive dust background document was published in spring 2002, providing an overview of local observations and concerns, local and regional background information, Red Dog operations, regulatory history, environmental data, nature and extent of fugitive dust, a preliminary conceptual site model for the risk assessment, and review of regulatory and decision-making frameworks for addressing the fugitive dust issue (DEC et al. 2002).* *Teck Cominco completed additional characterization at the port site in 2002 (Exponent 2003b; Teck Cominco 2003). Sampling programs designed to support the risk assessment were conducted in 2003 and 2004 to obtain data for additional analytes in multiple environments and media. These programs are described in the field sampling plans (Exponent 2003e, 2004a), and in Appendices A and E of this document.*	Response is acceptable.

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				The nature and extent of dust deposition has been evaluated in these prior studies by Exponent and NPS, as listed above. Some key observations are summarized here: • *Moss data collected during various sampling efforts by NPS and Teck Cominco, when presented together (Figure 1-9), effectively illustrate the primary source areas and deposition patterns in the vicinity of the DMTS corridor and mine. The moss concentration patterns illustrate how the prevailing wind patterns originating from the southeast to northeast result in greatest deposition to the north and west of DMTS and mine facility areas.* • *Within the DMTS facility areas, metals concentrations decrease away from facility sources (Figure 1-9), and vary along the length of the road corridor, with the highest concentrations near the port and the mine, as a result of concentrate tracking that has historically occurred with haul trucks exiting the concentrate storage buildings at the mine and port (Figure 1-10).* *Many improvements have been made over the years by Teck Cominco to reduce fugitive dust emissions. Broadly, these include improvement to engineering controls and enclosures around ore crushing, milling, concentrate storage and loading at the mine, as well as concentrate trucking and storage, conveyance, bargeloading, and shiploading facilities at the port. In addition to physical dust control improvements, procedural improvements have been made as well. Further description of these measures, as they pertain to the risk assessment conceptual site model, is provided in Section 2.2.4. Teck Cominco continues to work on additional dust control improvements on an ongoing basis.* Regarding sampling within CAKR: At the time the transect locations were selected, the patterns of dust deposition along the road were reasonably well understood, based on the prior work that had been done. Based on this understanding, terrestrial transect locations were selected to achieve multiple objectives, including sampling a gradient of metals concentrations and targeting dominant plant communities representative of the diverse environments that are subject to dust deposition near the port, in the central portion of the road, and near the mine. However, the comment regarding the limited data available within CAKR is noted, and the possible need for future studies within those areas will be considered during development of the risk management plan.	
	Uncertainties about Food Pathways:				
USGS -18	1. Assumptions made about the uptake of metals from contaminated food pathways are also a source of uncertainty since such models may not accurately reflect uptake by indigenous biota. It is quite likely that there are species-	Medium	In the revised ERA, please clearly describe the approach used to evaluate food-chain uptake of metals in the baseline ERA (i.e., site specific measurement) and how it	The report was revised to clearly indicate that the screening level assessment used a conservative approach due to the limited availability of site-specific data at that time, whereas the baseline assessment is based on a more comprehensive data set, both in	Response is acceptable.

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	specific differences in uptake and assimilation of metals based on the literature.		differs from the approach used in the screening-level ERA.	terms of the types of prey items sampled and the spatial extent over which samples were collected. The following text was added after the first paragraph of Section 6.5.1 (Exposure Characterization) to describe the different approaches used for the screening and baseline food-web models. *The dietary exposures for the baseline assessment are based on a more comprehensive data set than the screening assessment described in Section 3.5.6, in terms of the types of data selected, the prey items sampled, and the spatial extent over which samples were collected. The screening assessment was much more conservative than the baseline assessment. For example, the maximum chemical concentrations reported in food items or environmental media were used in the exposure estimates. The conservative assumptions of the screening represented a worst-case scenario, resulting in protective exposure estimates that were appropriate for a screening-level assessment. The baseline assessment was refined and expanded based on the results of the ecological screening and site-specific observations from the Phase I and Phase II sampling events.* *While both newer and older survey data were incorporated into the screening, data from these older surveys were excluded from the baseline analysis in favor of data from more recent sampling events, which better represent current conditions at the site, and which provide more complete data for the list of CoPCs. In the food web models developed for the baseline ERA, life history information from Arctic Alaska was used to select and derive exposure parameters, such as mean body weights and diet compositions, while in the screening ERA, minimum female body weights were used. Water ingestion was not included in the screening assessment exposure analysis, but it was included in the baseline assessment.* *In the screening, maximum chemical concentrations in tundra soils were used as a measure of potential exposure via incidental soil ingestion, although the maximum soil and moss concentrations were not necessarily collocated for any chemical. Also, for aquatic habitats, the maximum chemical concentrations from any of the three creeks were used to calculate exposure for fish-eating wildlife. In the baseline exposure assessment, the mean CoPC concentrations were used in all terrestrial and aquatic station-based food-web models. For large home-range receptors foraging within assessment units or across the whole site, mean and 95 percent UCL on the mean concentrations were calculated.* In the screening, receptors were assumed to be present on site all year, while in the baseline assessment, intake was calculated on a time-use basis, representing the fraction of the year that a receptor may be resident at the site. Both the screening and baseline exposure assessments assumed 100% gastrointestinal absorption efficiencies. The exposure parameters and food-web	

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				models for the baseline assessment are described in detail below.	
USGS -19	2. Uptake may also be assumed to be spatially random, when in fact there may be preferential factors that attract organisms to contaminated sites. The roadside may provide some attraction for wildlife. Metals salts (including calcium chloride) might be attractive as salt-licks.	Medium	In the revised ERA, please discuss preferential wildlife utilization of the road corridor, how it may affect exposure estimates, and how this may result in non-conservative estimates of risk. Quantify the effect to the extent possible with existing data.	Uncertainties in the risk assessment associated with area use by wildlife are discussed in Section 6.6.5.1.4 (formerly referred to as Section 6.6.3.1.4.). We note that this comment appears to be inconsistent with comment USGS-29, which suggests that animals such as caribou would avoid areas near the road and would not be attracted to them. However, further evaluation of wildlife usage patterns associated with the road (as they pertain to wildlife exposure estimates) may be warranted. For example, it is unknown if altered drainage near the haul road would favor growth of plant species that would attract wildlife. However, the likelihood that wildlife would select the road as productive foraging habitat would be low, given the transportation disturbances related to the road. This was previously stated in the uncertainty section (Section 6.6.5.1.4) appended below, *Also, the exposure models conservatively assumed that all of the DMTS road corridor and port area provided productive habitat for wildlife receptors, even though areas near the road and port facilities, which tended to have higher metals concentrations, are disturbed by transportation activities, which may reduce their attractiveness to wildlife.* Nevertheless, evaluation of wildlife usage patterns associated with the haul road will be considered during development of the risk management plan.	Response is acceptable.
	Sampling Design:				
USGS -20	1. A critical technical issue with the current draft RA is sampling design. NPS resources are inadequately considered in the current sampling design, with very limited sample locations positioned within Park boundaries immediately adjacent or within NANA (Northwest Arctic Native Association) easement within CAKR. This sampling design issue corresponds with our concerns related to reference sites which were poorly characterized relative to potential confounding factors (e.g., to differences in either biotic or abiotic components of habitat) apparent between higher elevation reference and lower elevation NPS lands adjacent (100-1000 meters) to the haul road.	High	Please respond regarding the need for additional sampling on NPS and NANA lands, and the applicability of the existing reference data set to NPS lands. In the revised RA, please indicate how limited sampling within CAKR may affect the strength of the risk estimates for receptors within CAKR.	Regarding sampling within CAKR and the NANA easement: At the time the transect locations were selected, the patterns of dust deposition along the road were reasonably well understood, based on the prior work that had been done. Based on this understanding, terrestrial transect locations were selected to achieve multiple objectives, including sampling a gradient of metals concentrations and targeting dominant plant communities representative of the diverse environments that are subject to dust deposition near the port, in the central portion of the road, and near the mine. Please see also the response to comment USGS-5, regarding data within CAKR used in the assessment, and the representativeness of data from surrounding areas. However, the commenter's point regarding the limited data available within NPS-managed public lands is noted, and the possible need for future studies within those areas will be considered during development of the risk management plan. The reference area is a varied and diverse environment, offering a wide variety of conditions and communities. Stations within the reference area were selected to match the communities sampled at the site as closely as possible. While there will always be some differences between survey sites, we believe the reference sites to be suitable for comparison with CAKR and other site areas. Uncertainties associated with site selection and comparison can	Response is acceptable.

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				be considered during evaluation of possible future work, during development of the risk management plan.	
USGS -21	2. There is also little basis for considering the geochemical similarities or differences in baseline conditions between the single reference location and the relatively large spatial area of NPS areas of concern.	High	In the revised RA, please describe the applicability of the existing reference data set to the "entire" site, and possible need to sample additional reference areas specific to CAKR.	See responses to comments USGS-20 and USGS-22. The latter response describes the selection and use of the reference areas in the risk assessment, including considerations related to geology and mineralization. The text therein reviews uncertainties about the reference area data, and discusses implications of these uncertainties for the use of the reference area data and the findings of the risk assessment.	Response is acceptable.
USGS -22	3. Scale differences were not discussed relative to comparisons between reference sites versus area of concern. For example, *Exponent* did not consider the available published works from, e.g., USGS or NPS (either as NPS reports or in peer-reviewed literature) that might better [define] pre-mining baseline conditions of CAKR. *Exponent* has dismissed differences between reference and areas of concern without convincing arguments that the single reference location captures the range of communities at risk.	High	In the revised RA, please discuss deficiencies in the existing reference data set and ways to rectify it. See also recommendation for USGS-21.	Additional figures and discussion of the NPS/ Hasselbach data have been added in Section 1 describing nature and extent of fugitive dust deposition. Section 1.1 (Site Overview) is appended below, and the revised or added text is highlighted: *The Red Dog Mine is located approximately 50 miles east of the Chukchi Sea, in the western end of the Brooks Range of Northern Alaska (Figure 1-2). Base metal mineralization occurs naturally throughout much of the western Brooks Range (Figures 1-3 and 1-4), and strongly elevated zinc, lead, and silver concentrations (reflecting the mineralization) have been identified in many areas (DEC et al. 2002). The mine is located on land owned by the NANA Regional Corporation (NANA; see land ownership and use map, Figure 1-5). Topography and water features are illustrated in Figure 1-6. The geographical area for the risk assessment is the DMTS corridor extending from the Red Dog Mine to the port, including the road, the port facilities, outlying tundra areas, and the marine environment at the port, as well as the area outside of the ambient air/solid waste permit boundary around the mine[1]. The approximate area of focus in the risk assessment is highlighted in Figure 1-7.* *The Red Dog Mine operations began in 1989. Ore containing lead sulfide and zinc sulfide is mined and milled to produce lead and zinc concentrates in a powder form. These concentrates are hauled year-round from the mine via the DMTS road to concentrate storage buildings (CSBs) at the port, where they are stored for later loading onto ships during the summer months. The storage capacity allows mine operations to proceed year-round. During the shipping season, the concentrates from the storage buildings are loaded into an enclosed conveyor system and transferred to the shiploader, and then into barges (Figure 1-8). The barges have built-in and enclosed conveyors that are used to transfer the concentrates to the holds of deepwater ships.* *Moss studies performed in 2000 and 2001 by the National Park Service (NPS) (Ford and Hasselbach 2001, Hasselbach 2003b, pers. comm., Hasselbach et al. 2005) found elevated*	

[1] The mine area within the permit boundary (shown in Figure 1-5) is not addressed in this assessment.

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				concentrations of metals in tundra along the DMTS road and near the port, apparently resulting from fugitive dust from these facilities. A fugitive dust study completed by Teck Cominco in 2001 (Exponent 2002a) provided an initial characterization of the nature and extent of fugitive dust releases from the DMTS corridor and provided baseline data from which to monitor the performance of new transport and handling equipment and dust management practices. A fugitive dust background document was published in spring 2002, providing an overview of local observations and concerns, local and regional background information, Red Dog operations, regulatory history, environmental data, nature and extent of fugitive dust, a preliminary conceptual site model for the risk assessment, and review of regulatory and decision-making frameworks for addressing the fugitive dust issue (DEC et al. 2002). *Teck Cominco completed additional characterization at the port site in 2002 (Exponent 2003b; Teck Cominco 2003). Sampling programs designed to support the risk assessment were conducted in 2003 and 2004 to obtain data for additional analytes in multiple environments and media. These programs are described in the field sampling plans (Exponent 2003e, 2004a), and in Appendices A and E of this document.* *The nature and extent of dust deposition has been evaluated in these prior studies by Exponent and NPS, as listed above. Some key observations are summarized here:* • *Moss data collected during various sampling efforts by NPS and Teck Cominco, when presented together (Figure 1-9), effectively illustrate the primary source areas and deposition patterns in the vicinity of the DMTS corridor and mine. The moss concentration patterns illustrate how the prevailing wind patterns originating from the southeast to northeast result in greatest deposition to the north and west of DMTS and mine facility areas.* • *Within the DMTS facility areas, metals concentrations decrease away from facility sources (Figure 1-9), and vary along the length of the road corridor, with the highest concentrations near the port and the mine, as a result of concentrate tracking that has historically occurred with haul trucks exiting the concentrate storage buildings at the mine and port (Figure 1-10).* *Many improvements have been made over the years by Teck Cominco to reduce fugitive dust emissions. Broadly, these include improvement to engineering controls and enclosures around ore crushing, milling, concentrate storage and loading at the mine, as well as concentrate trucking and storage, conveyance, bargeloading, and shiploading facilities at the port. In addition to physical dust control improvements, procedural improvements have been made as well. Further description of*	

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				these measures, as they pertain to the risk assessment conceptual site model, is provided in Section 2.2.4. Teck Cominco continues to work on additional dust control improvements on an ongoing basis. The uncertainty assessment in Section 6.6 has been updated with additional discussion regarding the selection of the reference areas, uncertainties associated with the reference area data, and their use in the assessment (including implications for CoPC selection). The new Section 6.6.1 (Uncertainties Related to Reference Area Selection), is included below: ***Uncertainties Related to Reference Area Selection*** *This section describes the selection and use of the reference areas in the risk assessment, reviews uncertainties about the reference area data, and discusses implications of these uncertainties for the use of the reference area data and the findings of the risk assessment.* ***Terrestrial Reference Area*** *Terrestrial reference areas were selected after review of existing studies and data, with a focus on factors such as prevailing wind directions, bedrock geology, topography and physiography (including slope, aspect, and water features such as streams and tundra ponds), and plant and animal communities. Possible reference areas were considered to the east, north, west, and south of the mine and DMTS. The prevailing wind originates from the east, between the northeast and southeast quadrants; thus, the most significant dust deposition has occurred to the north and west of the DMTS road and mine. As a result, areas to the north and west were not preferred areas for establishing the terrestrial reference area. Areas to the east were eliminated because the topography is more mountainous than most of the DMTS area. Thus, the focus was on selecting an area to the south of the mine and DMTS road. However, selecting an area too far south would have put the reference area into the Noatak valley, where the plant community includes trees and would not be as good for comparison with plant communities at the site. Therefore, the terrestrial reference area was targeted for placement somewhere within several miles south of the DMTS. Within that band south of the DMTS, the selected area was to be in a geologic area known to be relatively free of lead/zinc base metal mineralization. The selected area also needed to contain a variety of topographic conditions (elevations, slopes, and aspects), streams and ponds, and plant communities, providing the opportunity to sample environments similar to those along the length of the DMTS road. Based on these criteria, the Evaingiknuk Creek drainage was selected as the best choice. This basin met the most criteria, and had low base metal mineralization compared with other possible*	

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				reference locations that were considered to the south of the DMTS. *Subsequent to the selection of the Evaingiknuk Creek drainage as the terrestrial reference area, sampling was conducted in two phases. The first phase included sampling of moss, which, when included with the overall moss database (including the NPS data, Ford and Hasselbach 2001, Hasselbach 2003b, pers. com., Hasselbach et al. 2005) and plotted together, provided a clearer perspective on overall patterns of deposition in the areas surrounding the DMTS and mine (Figure 1-9). Prior to the first phase of sampling, no moss data were available in that area.* *The mean lead concentration for the three moss samples in the reference area is 8.0 mg/kg. Tundra soil was also sampled in the reference area, and the lead concentration ranged from 2.9 to 23.3 mg/kg, with a mean of 8.9 mg/kg, very similar to the mean moss lead concentration. In the area beyond approximately 16 miles north of the DMTS, where there is no apparent trend in the NPS moss concentration data, the mean lead concentration in moss is 8.5 mg/kg, or 6.4 if one outlier duplicate sample is excluded (Dixon's outlier test was used to confirm that the 38.6 ppm lead result is a statistical outlier at the 0.05 level [$0.02 < P < 0.05$]). The concentrations in the reference area and the area beyond 16 miles north of the DMTS appear to be similar. In the southern extent of Cape Krusenstern National Monument (CAKR), beyond 12 to 13 miles south of the DMTS, the NPS moss lead concentrations average 2.0 mg/kg. It should also be noted that the area surrounding the Red Dog district is more mineralized than the southern part of CAKR. If there were dust depositional influence in the reference area, or the northern extent of the data collection area, it would appear to be very limited.* *The communities in the reference area appear to be healthy, unimpaired communities suitable for use in reference/site comparisons. Even if there were some evidence suggesting low-level deposition in the reference area, the potential for this dust deposition to cause adverse effects to receptors is minimal. The metals concentrations in moss and lichens were very low; copper and zinc concentrations were far below effects levels reported in the literature (e.g., see Tables CK1 and CK2 for moss and lichen comparisons with threshold values). Furthermore, in almost every case, metals concentrations in terrestrial sedge and shrub samples were below phytotoxicity thresholds, even though samples consisted of unwashed tissues (Tables 6-17 and 6-18). Lead and zinc exposures for all wildlife receptors were uniformly low and never exceeded toxicity reference values (TRVs) in the terrestrial reference area. Hazard quotients did exceed 1.0 for some receptors in the reference area, particularly for aluminum and barium, although as discussed in the risk assessment, this appears to be a function of the conservative nature of the TRVs for these metals rather than their concentrations in reference area*	

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				media. For example, aluminum concentrations in reference area moss were similar to or less than concentrations in the southern extent of the CAKR, many miles further away in a prevailing upwind direction from the DMTS. This would suggest a similar level of risk would be predicted from aluminum in south CAKR. However, because south CAKR is well beyond the potential influence of the DMTS, it just illustrates the overly conservative nature of the aluminum TRV. ***Coastal Plain Reference Area*** *In the second phase of sampling, a plant community assessment was conducted, and in order to better match the coastal plain plant community at the port, an additional reference area was selected south of the port in the CAKR (sample station TS-REF-12). Although moss was not collected at this location, tundra soil had a lead concentration of 5.8 mg/kg, slightly lower than the 8.9 mg/kg concentration in the terrestrial reference area.* ***Reference Lagoons*** *The reference lagoons included the Control Lagoon, approximately 2 miles south of the port, and an unnamed lagoon approximately 5 miles south of the port. The Control Lagoon was established as a reference in early port site studies (ENSR 1990), and the unnamed "Reference" lagoon was added during the first phase of the risk assessment sampling efforts (Exponent 2003e). At these distances, any depositional influence would be small, given prevailing wind directions. Mean sediment concentrations (from the 2003 and 2004 sampling events) in the two lagoons at different distances from the site are almost identical, with lead 9.6 and 9.5 mg/kg, zinc 86.6 and 86.9 mg/kg, and cadmium 0.2 and 0.3 mg/kg in the Control and Reference lagoons, respectively.* ***Marine Reference Area*** *The marine reference area is located approximately 3 miles to the south of the port. Sediment samples were collected there during several marine sampling events. Even if there were any depositional influence this far south, the influence would be very slight, and would likely be largely dissipated by dynamic ocean action, including wind, waves, and prevailing northward currents. Regardless of whether there is any detectable influence at the marine reference area, site sediment data from recent sampling events have been below all available screening thresholds, as described in Section 4.3.* ***Effect of Uncertainties*** *There are clearly uncertainties with regard to the potential influence from dust deposition on reference areas. However, the possible effect of these uncertainties on the analyses, such as comparison of site and reference area conditions, appears to be*	

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				limited. Based on the discussion in Section 6.6.1.1, there is very little if any measurable depositional influence from the mine within the terrestrial reference area. Thus, the possible influence of mine dust deposition in the reference area is so small as to be highly unlikely to result in any incremental effects to receptors in that area. Therefore, comparisons of communities (e.g., benthic and plant communities) at the site with those in the reference area are acceptable for the analyses. Further discussion of uncertainty related to the use of reference area comparisons in CoPC selection is included below in Section 6.6.3. ***Summary*** *While all of the reference areas are suitable for the risk assessment, there are clearly some uncertainties with regard to the potential influence from dust deposition. The possible need for additional study to further address these uncertainties will be considered during development of a risk management plan.*	
	Reference Sites				
USGS -23	1. The selection of reference areas could have a significant influence on the two-tiered elimination process for selecting COPCs. For an ecological risk assessment of impacts within CAKR lands the reference areas should reflect the average mineralization for non-mining areas of the CAKR. Heavily mineralized areas having elevated metals concentrations would contribute bias in statistical comparisons with sites of mining operations. Sampling over a broader range of reference sites is clearly justified in that there are obvious changes in habitats that occur over several thousand meters of the haul road.	High	In the revised RA, please describe the applicability of the existing reference data to the CAKR and possible biases in site-to-reference area comparisons. Discuss the extent to which using limited reference data could lead to misidentification of COPCs and underestimation of site risks.	Implications of uncertainties associated with reference area selection and for CoPC selection are discussed in Sections 6.6.1 and 6.6.2. Additional figures and discussion of the NPS/Hasselbach data have been added in Section 1 describing nature and extent of fugitive dust deposition. These revisions are provided above in response to comment USGS-22.	Response is acceptable.
USGS -24	2. Reference areas should not be influenced by dust from the mining operations. Although soils data for the ecological reference sites appear reasonable in comparison with other Alaska soils (Gough and others, 1988), results by Hasselbach et al (2004) suggest that the ecological reference sites could have been affected by the aerial drift of dust from the mine site.	High	In the revised RA, please discuss the adequacy of the chosen reference locations in light of information presented in Hasselbach et al. (2004). If the existing reference data are biased high, describe the magnitude of the effect on site-versus-background risk comparisons. Re-screen COPCs using NPS data to determine and discuss whether any COPCs were dropped inappropriately.	Additional figures and discussion of the NPS/Hasselbach data have been added in Section 1 describing nature and extent of fugitive dust deposition. Implications of uncertainties associated with reference area selection and for CoPC selection are discussed in Sections 6.6. The revised Section 1 and additional Section 6.6 added to the uncertainty comment are provided above in response to comment USGS-22.	Response is acceptable.
USGS -25	3. Data for mosses and lichens may have been more appropriate for differentiating metals concentrations in reference areas and sites adjacent to mine operations. There is considerable information and standardized practices for the use of mosses and lichens for monitoring environmental concentrations of metals that could have been appropriately applied.	Medium	Please provide response regarding lack of use of mosses in identifying true reference areas.	A discussion has been added to Section 6.6.1 describing the selection of the reference areas, and the information used in that process. The revised section is presented in response to comment USGS-22.	Response is acceptable.
	Population vs. Local Effects:				
USGS -26	*1. Exponent* concludes that no population effects are predicted for wildlife and furthermore, recommends no restrictions for lands used by native subsistence hunter/gatherers. These conclusions are made despite clear documentation of significantly increased concentrations of COPCs in regions near the haul road, mine, and port site as a result of fugitive dusts. For example, overall "site" mean soil concentrations of	High	In the revised RA, indicate how high fractional intake can be before use restrictions are in order. Describe how likely such a fractional intake is for the site. For wildlife, unsupported conclusions about lack of risk to populations should be omitted from the revised RA.	Note that the site soil samples listed in Table 3-4 are all within road and port facility areas, and that the vast majority of these soil samples are within the port area close to active facilities, which gives a very conservative high bias to the site mean values that this comment references. Similarly for tundra soil, the vast majority of samples are within the port, giving a conservative high bias to the site mean values this comment cites from Table 3-5.	Response is acceptable.

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	cadmium, lead, and zinc are elevated by factors of 23, 30, and 23, respectively above the corresponding reference site means for the soils (human assessment, *Exponent* Table 3-4) and by factors of 44, 75, and 19, respectively, for the terrestrial tundra ecological assessment (*Exponent* Table 3-5). Moss samples analyzed by NPS indicated much greater enrichment (contamination) factors. Although conservative assumptions were in fact used to derive screening-level hazard quotients, overall subsistence use risks are calculated to be low or negligible based upon the low fractional intake from "the site" (0.09) estimated for the affected areas. This broad geographic assessment approach would be more defensible if the contaminated area was poorly defined or randomly distributed within a larger geographic area. Combining a defined geographically affected area (≤1,000 m within ore concentrate transportation vectors) with a much larger and presumptively unaffected area may discount overall risk, but would ignore risks to localized subsistence activities.			Figure 3-2 illustrates the locations of the soil and tundra soil samples. For the human health scenarios, the impact of different fractional intake (FI) assumptions on risk estimates was discussed in the uncertainty assessment of the HHRA. This discussion has been revised in Section 5.4.3.7 (Fractional Intake) of the updated HHRA to account for modifications made during the comment response process, and is included below. For example, in the child subsistence use scenario, a cumulative hazard index of 1.0 is estimated only when the assumed fractional intake is 0.36 (i.e., 36 percent of all soil, water, and food consumption is from the site). If a fractional intake of 1.0 is assumed (i.e., that 100 percent of all soil, water, and food consumption was from the site), the resulting cumulative hazard index is 2.9. While this hazard index exceeds the target of 1.0, it is still within the degree of uncertainty inherent in the reference doses (RfDs) used to calculate risks. In addition, risks from individual CoPCs are not typically considered cumulative and summed unless the target organ and mechanism of action on which the RfD is based are the same. Only two CoPCs (i.e., barium and cadmium) have RfDs based on effects in the same target organ (the kidney). In reality, the fractional intake from the site would never be 1.0 for a child, and the FI of 0.09 used in the risk assessment likely significantly overestimates an actual child's contact with the site. For both the adult subsistence use and the combined worker/subsistence use scenarios, a cumulative hazard index of 1.0 was estimated only when the assumed fractional intake was 0.95 (i.e., 95 percent of all soil, water and food consumption was from the site). If a fractional intake of 1.0 is assumed, the resulting cumulative hazard index is 1.1. Again, this is within the degree of uncertainty inherent in RfD derivation, and no individual CoPC exposure would result in a cumulative hazard index exceeding 1.0, even with a fractional intake of 1.0. Although an adult may come into contact with the site to a greater degree than a child, an actual adult would still never attain 95 percent of their soil, water, and food from the site. Furthermore, it should be noted that subsistence harvesting is prohibited at the site (both port and road areas). The revised text from Section 5.4.3.7 (Fractional Intake Uncertainty) is included below: *For the child subsistence use scenario, a cumulative hazard index of 1.0 is estimated only when the assumed fractional intake is 0.36 (i.e., 36 percent of all soil, water, and food consumption was from the site). If a fractional intake of 1.0 is assumed (i.e., that 100 percent of all soil, water, and food consumption was from the site), the resulting cumulative hazard index is 2.9. While this hazard index exceeds the target of 1.0, it is still within the degree of uncertainty inherent in the RfDs used to calculate risks. In addition, risks from individual CoPCs are not typically considered cumulative and summed unless the target organ and mechanism of action on which the RfD is based are the same.*	

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				Only two CoPCs (i.e., barium and cadmium) have RfDs based on effects in the same target organ (the kidney). In reality, the fractional intake from the site would never be 1.0 for a child, and the FI of 0.09 used in the risk assessment likely significantly overestimates an actual child's contact with the site. *For both the adult subsistence use and the combined worker subsistence use scenarios, a cumulative hazard index of 1.0 was estimated only when the assumed fractional intake was 0.95 (i.e., 95 percent of all soil, water and food consumption was from the site). If a fractional intake of 1.0 is assumed, the resulting cumulative hazard index is 1.1. Again, this is within the degree of uncertainty inherent in RfD derivation, and no individual CoPC exposure would result in a cumulative hazard index exceeding 1.0, even with a fractional intake of 1.0. Although an adult may come into contact with the site to a greater degree than a child, an actual adult would still never attain 95 percent of their soil, water, and food from the site. Furthermore, site restrictions do not allow subsistence harvesting on the site at all.* With regard to risks to wildlife populations, in response to this and other comments, the document has been revised to modify conclusions that appear to downplay possible population-level effects. Additionally, the Uncertainty Assessment (Section 6.6.5.6) has been expanded with a discussion (provided below) of challenges associated with determining the spatial scales at which populations should be considered with regard to risk evaluations conducted as part of this ERA. The two paragraphs below were added to the end of Section 6.6.5.6 (Population Level Uncertainty): *An additional uncertainty related to estimating the potential for population-level effects relates to the appropriate definition of what constitutes a population for the receptors being evaluated. For example, as noted above, caribou present at the site, either as migrants or winter residents, are part of a herd (the Western Arctic Caribou Herd) that moves over vast areas of western Alaska. As discussed above, it is inappropriate to extrapolate results of individual-based food web models to conclude population-level effects without putting those results into context with regard to the proportion of the entire WACH population that is potentially exposed to CoPCs at the site. Similarly, although moose do not migrate like caribou, their home ranges can be large, up to 5 to 10 km^2 (Wilson and Ruff 1999), and they can make seasonal movements up to almost 100 km during calving, rutting, or wintering (DFG 2003e). Therefore, creek or lagoon specific assessments, as were performed for moose, may be conservative with respect to risks to any individual moose, given their home range size in relation to the areas of lagoons and streams from which samples were collected, and even more conservative with respect to the larger moose population that frequents habitats within and beyond the DMTS assessment area.*	

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				Food-web model results for small-home-range receptors, such as shrews and voles, indicate the potential for adverse effects primarily within localized areas (e.g., within 100 m of the road, or around the mine boundary). These adverse effects to individuals, if occurring, could produce detectable higher-level responses, such as decreased population abundance or increased mortality, within these localized areas. However, the individuals in these localized areas are components of larger meta-populations. For example, it is very likely that voles move and disperse near as well as away from the road. Therefore, effects to individuals near the road would probably only translate into population level effects over larger areas (e.g., square kilometers of tundra) if habitats near the road represent a population "sink" where local environmental factors, including CoPCs, do not permit reproduction to occur at the replacement rate, and immigration of migrants from other sup-populations results in an overall decrease in abundance at the meta-population level. No population data are available confirm or deny the existence of such a sink near the road or mine. Therefore, there is considerable uncertainty that putative effects to individual small mammals living in habitats near these features would produce detectable population-level changes over broader spatial scales (e.g., within a kilometer from the road, within Cape Krustenstern National Monument, etc.). Broad-scale population surveys would be required to determine whether impacts to populations are occurring over these larger spatial scales.	
USGS -27	2. Similarly, *Exponent* concludes that substantial risks are likely to individual voles, ptarmigan, and other biota in the vicinity of the haul road and port site, but population effects are expected to be low, so no action is needed. This conclusion may not be acceptable to NPS or to subsistence food gathering near the road. Therefore, a more focused risk assessment should be conducted specifically to determine if any action is needed for the affected area (e.g., hazard communication, barriers, more effective fugitive dust reduction measures, or remediation).	High	Omit unsupported conclusions about no population level effects to voles, ptarmigan, and other receptors from the revised ERA. Acknowledge that actions should be taken to further reduce emissions of fugitive dust during transport and storage of the ore concentrates.	Please see the response to comment USGS-26 regarding conclusions about risk to wildlife populations.	Response is acceptable.
USGS -28	3. The average site concentration of each COPC was used in ecological risk calculations despite wide ranges of concentrations in each environmental matrix sampled or considered during this RA. However, the average value is not necessarily the best statistical estimator of the central tendency of a population. The median would have been a better statistic for this purpose. Moreover, it would seem that values more representative of the worse-case concentrations, for example the upper 90th percentile concentration, could have also been applied for characterizing risks to the most susceptible receptors.	Medium	Please provide response regarding need to present additional risk estimates based on the median and/or 90^{th} percentile concentration.	The ERA used both mean and 95% UCL on the mean values for the risk estimates. In cases where the 95% UCL on the mean could not be calculated because of a small data set, then the maximum value was used instead. Thus, calculations using the median are not needed. Calculations using the 90^{th} percentile concentrations would not be appropriate for the baseline assessment, as the purpose of the assessment is to generate realistic estimates of risk for receptor populations. Evaluation of risk to the most susceptible receptors was performed in the screening assessment when maximum CoPC concentrations and most-conservative exposure assumptions were used in exposure evaluations.	Response is acceptable.
	Effects of Road Dust versus Ore Concentrate:				
USGS -29	*Exponent's* interpretation of dust and haul road interrelationships are generally poorly characterized, and their conclusions are poorly supported by citation to works readily available (but require some reading and placing those works into the context of the haul road	High	Please consult the references cited by the USGS and add to the ERA a description of possible adverse impacts the haul road may have on movement of large mammals, such as caribou and moose.	Comments noted. These issues are not related to fugitive dust, which is the focus of the DMTS fugitive dust risk assessment. They pertain more to an evaluation typically associated with an environmental impact statement, which was conducted for the	Response is acceptable.

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	and how it effects or does not effect adjacent lands). There is considerable literature on the effects of roads in Alaska and in Arctic latitudes. Much of road research in Alaska deals with impacts on caribou and other large mammals, e.g., caribou density is highly affected by the presence of roads regardless of the road's relationship to mining (Nelleman and Cameron 1998) and may serve as barriers to caribou movement (Whitten and Cameron 1983). To *Exponent's* advantage, contradictory studies have also be published, e.g., Cronin et al. 1998; Yost and Wright 2001; Burson et al. 2000) suggesting that development and roads appeared unrelated to caribou distribution or behavior. Although there is no unanimous conclusion, the majority of the research suggests that roads have a negative impact on caribou, especially female caribou and overall caribou movements. Any negative effect on female movement is particularly important because it potentially reduces the herd's reproductive capability.			DMTS in the early 1980s (Dames and Moore 1983a,b). As a general comment, however, it should be noted that if roads have a negative effect on caribou (i.e., caribou avoid areas adjacent to the road), then the results of the risk assessment for this receptor would be conservative, as CoPC data in food and media near the road (10-100 m) were used in developing exposure estimates.	
USGS -30	While caribou have received the bulk of research efforts when roads are being considered as potential conditions adversely affect terrestrial wildlife, other large mammals have been the focus of field research. For example in interior Alaska, moose distribution was found to be less than expected in areas close to roads and rights-of-way in parks (Yost and Wright 2001; Burson et al. 2000). In contrast, Dall sheep, have not been found to be as impacted within NPS lands where roads have been constructed (Dalle-Molle and Van Horn 1991; Burson et al. 2000). Research on bears and roads in Alaska is limited, although a wide range of bear studies in other areas found an increased mortality associated with roads, and an avoidance of roads with human activity (e.g. Gibeau et al. 2002; Benn and Herrero 2002). Habituation, however, may influence any roads impacts, e.g., in Denali National Park grizzly bears occurred near roads more often than in previous years (Burson et al. 2000). Wolves south-central Alaska frequented roads with little human presence, but avoided areas that were used by humans (Thurber et al. 1994). Lynx displayed little avoidance of roads in the same region, but by using roads lynx were threatened by increased human-caused mortality (Bailey and Winthrop 1999). Similarly, caribou, grizzly bears, and raptors use roadsides for foraging and hunting, and this increased habitat use near roads has led to increased vehicle-caused mortality, lack of a sufficient food source, and related problems (Walker and Everett 1987).	Medium	Please consult the references cited by the USGS and add to the ERA a discussion of possible adverse impacts the haul road may have on movement of large mammals. Consider the need to identify the haul road itself as a stressor.	Please see response to comment USGS-29.	Response is acceptable.
USGS -31	Based on first-hand observations, fugitive dusts from the haul road remain an issue for CAKR. Traffic on the haul road can release variously large amounts of dust, depending in part on environmental conditions (e.g., windy days *v.* calm days) and institutional controls (e.g., palliative dust control as institutional measures taken with application of $CaCl_2$). Within a landscape perspective, fugitive dust appears to be local, yet the impact can be wide-ranging, affecting vegetation, soils, ground ice, and wildlife (Walker and Everett 1987). Many of the impacts of dust in relation to wildlife occur because of increased snow melt adjacent to roads (Foreman et al. 2003, Auerbach et al. 1997). Early snow melt leads to an increase in the concentration of waterfowl, ptarmigan, and	High	Please consult the references cited by the USGS and describe possible adverse impacts due to early snow melt in the revised ERA. Does early snowmelt along the haul road concentrate wildlife in areas were COPC levels are greatest? Do existing wildlife risk estimates account for this? If not, this shortcoming should be clearly described in the uncertainty section of the ERA.	Section 6.2 of the ERA, particularly Section 6.2.3, discusses the possible effects to vegetation from the presence of the road. Some supplemental text has been added to the end of the sixth paragraph in Section 6.2.3.1, and is included below: *Other changes that may occur as a result of the presence of the road include physical effects on hydrology, snow accumulation downwind of the road prism, early melting of snow near the road as a result of increased albedo from dust on the snow, and a deeper thaw of permafrost in these areas. These physical changes contribute to plant community changes along any road,*	Response is acceptable.

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	their predators near roads. Some bird species return early from migration because of early snow melt. Brabets (2004) has specifically reported on snow cover and dust interactions that directly or indirectly influence metal constituents common to ore concentrates transfer to Port Site via haul road that transects CAKR.			*independent of any potential effects from metals in the deposited dust.* Also, uncertainties in the risk assessment associated with area use by wildlife are discussed in Section 6.6.5.1.3 (Time Use) and Section 6.6.5.1.4 (formerly referred to as Section 6.6.3.1.4), and included below. At the end of Section 6.6.5.1.4, the following sentence was added: *However, there is some uncertainty as to the possibility of wildlife usage in near-road areas that could occur as a result of early snowmelt (Auerbach et al. 1997).* The following paragraph was added to the end of Section 6.6.5.1.3 to address concerns that wildlife species may be drawn to the haul road by early snowmelt: *The potential for elevated concentrations to occur during the period of snowmelt has been preliminarily assessed in a USGS study by Brabets (2004). The study found no exceedances of drinking water or aquatic life standards in stream water or snow samples. Therefore, wildlife that utilize the DMTS during periods of snowmelt would not likely be acutely affected through dietary exposure. Nevertheless, the possible need for future studies will be evaluated during development of the risk management plan, as described in Section 7.3.* In addition to the text that has been added to the document, further evaluation of wildlife usage patterns associated with the road (as they pertain to wildlife exposure estimates) may be warranted, and will be considered during development of the risk management plan.	
USGS -32	From the perspective of dust as a physical stressor, Auerbach, et al (1997) intensively studied tundra adjacent to the gravel Dalton Highway in northern Alaska with a particular focus on effects of 15 years of chronic road and road dust disturbance. Mildly acidic (soil pH 5.0) and an acidic sites (soil pH < 5.0) differed with respect to susceptibility and sensitivity to road dust. Effects on vegetation were more pronounced in acidic tundra, which are evidently the baseline condition of tundra soils in CAKR. From the work of Auerbach, et al (1997), in these acidic soils initial substrate pH appears to control the degree of response to disturbance by road and calcareous road dust. Soils next to the road presented elevated pH readings and had lower nutrient levels, altered organic horizon depth, higher bulk density, and lower moisture. Vegetation biomass of most taxa was reduced near the road, and species richness in acidic tundra next to the road was less than half of that at 100 m away from the road. In acidic tundra soils, vegetation community composition was altered. Sphagnum mosses were dominant in acidic low arctic tussock tundra and virtually eliminated near the	High	Please ensure that the revised ERA adequately discusses all possible adverse impacts resulting from road use and dust emissions, particularly those described in this comment.	Please see response to comment USGS-31. In addition, discussion of road effects on vegetation is described in Sections 6.2.3 and 6.7.1 of the risk assessment.	Response is acceptable.

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	road at the acidic tundra site. *Salix lanata* was more abundant next to the road in nonacidic soils. Effects on snowpack were also noted, including increased drifting in the lee of the road and earlier meltout near the road due to dust-induced change in albedo. Thaw of permafrost was deeper on both sides of the road, and potentially could affect road structure detrimentally. Differential effects of road construction and use, including the long-term effects of hydrological alterations and dust mobilization on local corridors, are key information for planning development in areas of arctic tundra.				
USGS -33	*Exponent's* position that effects of road dust and metals associated as dust constituents (i.e., physical/chemical stressor effects associated with any road's dust) can not be distinguished from metal toxicity independent of physical stressor, is a technical point that may well be intractable. An analogy would be the interaction effects in a simple 2-way ANOVA wherein conclusions regarding the relationships of independent variables are intractably confounded by significant interactions between the two. Simply stated, we may never be able to tease out 'metal effects' from 'dust effects', since the two may be intractably linked and their effects are an expression of both chemical and physical attributes of the 'joint stressor'.	Low	In the revised RA, please ensure that adverse impacts, whether due to chemical or physical factors, are still identified as adverse impacts.	Comment noted, language revised. The revised ecological risk assessment conclusions are included in the risk assessment, and the revised text from Section 8 (Conclusions) is provided below. First, the introductory paragraph was revised as follows: *The results of the risk assessment provide a snapshot of risk under current conditions that will help risk managers to determine what additional actions may be necessary to reduce those risks now and in the future. The following subsections summarize the findings of the human health and ecological risk assessments.* In addition, changes made to Section 8.2.1 (Terrestrial Habitats) and Section 8.2.4 (Coastal Lagoons) have been provided in comment USGS-5.	Response is acceptable.
	III. Summary and Recommendations				
USGS -34	We conclude that contamination from aspects of the mining operation approaches thresholds for injury for certain biota along the DMTS. We anticipate that such injury to wildlife is likely limited to areas within 100 m of the road, but injury beyond distances of 1,000 m cannot be ruled out. For example, the RA indicates that lichens are impacted at 2,000 m and beyond. If future COPC inputs to the site are greatly reduced and documented, we do not feel that mitigative actions are necessary within this area, because the physical disruption of such actions are likely to be more injurious than existing contamination. Historical documents and land-lease agreements explicitly state the responsibility of Teck Cominco Alaska to minimize environmental impacts from Red Dog mine operations. Consequently, the development of a Risk Management Plan specific to this operation is needed. Considerable improvements in reducing fugitive dusts have been made, particularly at the port site, but there is no evidence or documentation that allows a quantitative assessment of these changes. Because it is not feasible to remove fugitive ore concentrate residues from haul trucks during the bulk of the year, a more efficient, less contaminating means for transferring concentrates or other methods of decontamination should be considered. Ecological risks are likely to increase from cumulative effects of COPCs if even low-level escapement of ore concentrates is allowed to continue.	High	The revised ERA should indicate that thresholds for adverse impacts have been exceeded for several receptor groups at the site, and that actions are necessary to further reduce emissions of fugitive dust during transport and storage of the ore concentrates.	Comment noted. Language regarding exceedance of thresholds has been revised, and revisions are included below: As the comment notes, considerable improvements have been made in reducing fugitive dust emissions. Detailed discussion of monitoring efforts is beyond the scope of the risk assessment. Possible actions to further reduce emissions during transport and storage of concentrates, to assess the effectiveness of control measures, and to address risks identified in the risk assessment will be considered and outlined during development of the risk management plan. In response to this comment, the following revisions have been made to the document. The sixth paragraph of Section 6.7.1 has been modified as follows: *The food web model results for terrestrial herbivorous birds (i.e., ptarmigan) suggest that adverse effects (mortality or reproductive effects) from barium and lead exposures may occur in individuals foraging near the mine, and that adverse effects from lead are also possible in individuals foraging near the port, particularly the most highly exposed individuals. These effects, if occurring, could result in population-level effects in areas near the port or mine. However, as stated above, the barium TRVs may overestimate toxicity of the relatively low solubility, low bioavailability forms of barium found on the site (Shock et al.*	Response is acceptable.

No.	Comment	Priority	Recommendation	Response	DEC Remarks
				2007). Along the length of the road, the likelihood of adverse effects to herbivorous birds foraging in these areas is low, as 95 percent UCL on the mean exposures did not exceed NOAEL or LOAEL TRVs, except for exposure to barium, which exceeded the NOAEL TRV (hazard quotient of 1.7). Therefore, although risks cannot be considered negligible to ptarmigan inhabiting areas along the length of the road, it is unlikely that effects, if any, would result in a population-level effect in this area. The last paragraph of Section 6.7.1 has also been modified: *In summary, the potential for adverse effects to wildlife is most pronounced in the first 100 m adjacent to the road or facilities (Table JS5b) and effects in general are not expected to occur at any substantial distance from the road, port facilities or mine ambient air/solid waste boundary. However, lichen cover values at 1,000-m and 2,000-m stations were significantly lower than reference cover values, suggesting that lichen effects may still occur at these distances from the DMTS road corridor. Furthermore, the contribution of metals in producing some of these effects, particularly on plant communities near the DMTS road, is unclear. Overall, results of the ERA suggest that adverse effects to wildlife receptors are largely restricted to localized areas adjacent to the DMTS road, the port facility, and the mine ambient air/solid waste boundary; however, effects on tundra vegetation apparently extend farther, with effects on lichens observed at 1,000 to 2,000 m away from these dust sources, and perhaps beyond, as summarized in Table JS7. Further study would be required to define the full nature and extent of lichen effects beyond 1,000 to 2,000 m and to distinguish the relative contributions of causative agents, such as metals and road dust or other factors on lichen toxicity.* Section 6.7.2 has been modified as follows: *In general, adverse ecological effects are not predicted in streams that cross the DMTS road, based on multiple lines of evidence. First, the evaluation of benthic macroinvertebrate drift assemblages indicated that the overall characteristics of the communities found in the three site stream stations were similar to reference streams. Second, fish monitoring studies have found relatively low metals concentrations in fish from Aufeis Creek and Omikviorok River compared to streams near the mine, and no consistent evidence of a road effect on fish metals concentrations in these streams (Ott and Morris 2004). In Anxiety Ridge Creek, where cadmium and lead concentrations in juvenile Dolly Varden were significantly higher in downstream fish than upstream fish, maximum concentrations of cadmium and lead also exceeded the lowest literature thresholds for effects to survival, growth, or reproduction, but concentrations were also within the range of no-effects thresholds (Table CS1). Therefore adverse effects to fish cannot be conclusively predicted, as the sensitivity of Dolly Varden relative to the test species is not*	

No.	Comment	Priority	Recommendation	Response	DEC Remarks
				known. Furthermore, maximum whole body fish tissue concentrations reported from a nearby naturally mineralized creek located north of the Red Dog Mine were higher or similar to concentrations reported for Anxiety Ridge Creek fish. Third, metals concentrations in plants were within the range of reference concentrations (with the exception of aluminum and zinc in some willow leaf samples, and aluminum and chromium in sedges from the Omikviorok River) and in general, were not elevated in comparison to literature phytotoxicity thresholds. Fourth, food web models indicated that exposure to CoPCs is unlikely to result in adverse effects to avian and mammalian herbivores (e.g., green-winged teal, muskrat, and moose) or avian invertivores (e.g., common snipe) foraging in the streams, as LOAEL-based hazard quotients were less than or equal to 1.0, or in the case of aluminum ranged from 1.8 to 8.3 for muskrat, but were comparable to reference area hazard quotients. Collectively, these findings indicate that no ecologically significant effects are likely in streams, with the possible exception of potential effects to fish in Anxiety Ridge Creek. *In general, adverse effects are not predicted in tundra ponds located greater than 100 m from the DMTS road and port facilities, with the exception of potential vegetation effects identified based on comparison to literature screening values at ponds situated in low-lying areas to the southwest of the mine's ambient air/solid waste permit boundary. For ponds TP1-1000, TP3, and TP4, CoPC concentrations in sediment were less than the maximum no-effects concentrations for sediments from coastal lagoons that were evaluated in toxicity tests using freshwater test organisms. Vegetation around the ponds appeared to be healthy, and metals concentrations were within the range of reference concentrations (with a few exceptions for cobalt, lead, and zinc), and/or below phytotoxicity thresholds.* *Incremental exposure to lead and zinc at pond TP4 (located along the road near the mine) resulted in minor exceedances of phytotoxicity thresholds in sedge tissue (Table 6-23). However, plant samples were not washed or rinsed prior to analysis. If they had been washed, concentrations may have been below effects thresholds. Also, the vegetation appeared healthy in observations made during field sampling. Given these considerations, adverse effects to vegetation are not expected in tundra pond TP4.* *Tundra ponds observed at the site and reference area were hydrologically disconnected from surface water inputs from streams and are unlikely to support permanent fish populations. Therefore, pathways to fish and piscivorous wildlife are believed to be incomplete, and no adverse effects are expected for these receptors. Food-web models indicate a very low likelihood of adverse effects to survival, growth, or reproduction of herbivorous wildlife potentially foraging at these ponds.*	

No.	Comment	Priority	Recommendation	Response	DEC Remarks
				The possibility of adverse effects to invertebrates and plants could not be conclusively discounted at Station TP1-0100, located near the concentrate conveyor and other port facilities (Photograph 4). As described above in Section 6.3.2, the likelihood of adverse effects to macroinvertebrates in TP1-0100 could not be evaluated, and phytotoxicity threshold comparisons for sedges showed a potential for vegetation effects from lead and zinc exposures. Aerial transport and surface flow are probably the main mechanisms by which metals in fugitive dust become deposited in this habitat, as is likely for the surrounding tundra. Ponds near the port facilities, such as TP1-0100, are not true ponds, but rather flooded depressions in the tundra, and may not be permanent as they are dependent on precipitation and surface runoff to maintain volume. The ephemeral nature of the port area ponds suggests that they would be less likely to support the diversity of ecological receptors that the larger, more permanent ponds that occur in the tundra along the DMTS road would. Therefore, any adverse effects in these ponds have less ecological significance than if similar effects were to occur in ponds scattered across the tundra.	

Notes: Please note that RA text quoted herein may differ from that in other comment response documents, and in comparison with the final RA document, as a result of successive revisions made during the comment resolution process.

USGS comments were prepared by W. Brumbaugh, G. Linder, E. Little, T. May, and M. Mora, Columbia Environmental Research Center, 4200 New Haven Road, Columbia, Missouri for Peter Neitlich, National Park Service, Western Arctic National Parklands, Winthrop, Washington.

See original USGS comment letter for complete citations of cited literature.

ANOVA - analysis of variance
CAKR - Cape Krusenstern National Monument
CoPC - chemical of potential concern
DEC - Department of Environmental Conservation (Alaska) DMTS = DeLong Mountain Regional Transportation System
ERA - ecological risk assessment
NANA - Northwest Arctic Native Association
NPS - National Park Service
RA - risk assessment
USGS - U.S. Geological Survey

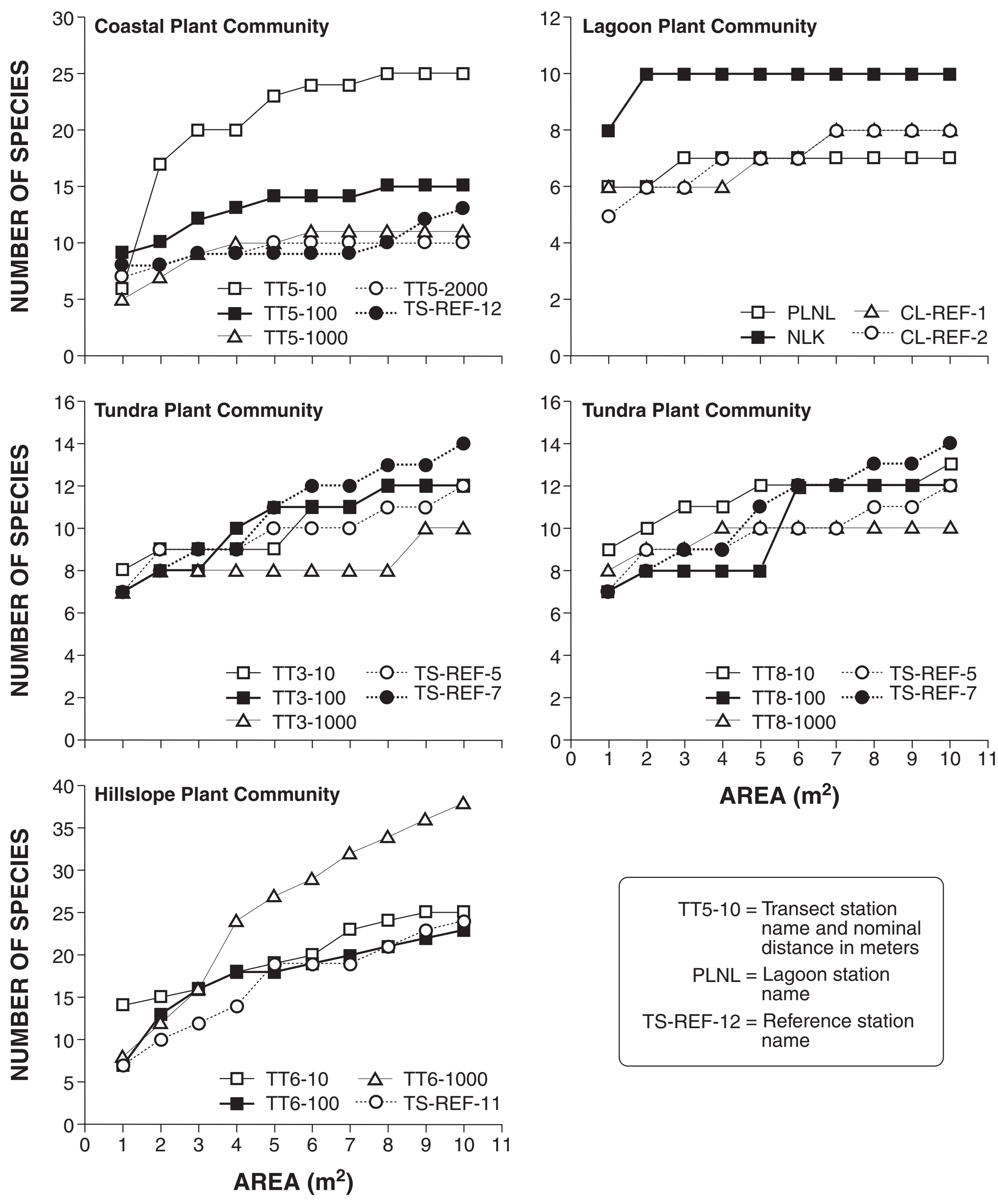

Figure ME1. Species area curves for plant community surveys

8601997.001 5400 04/19/06 WA

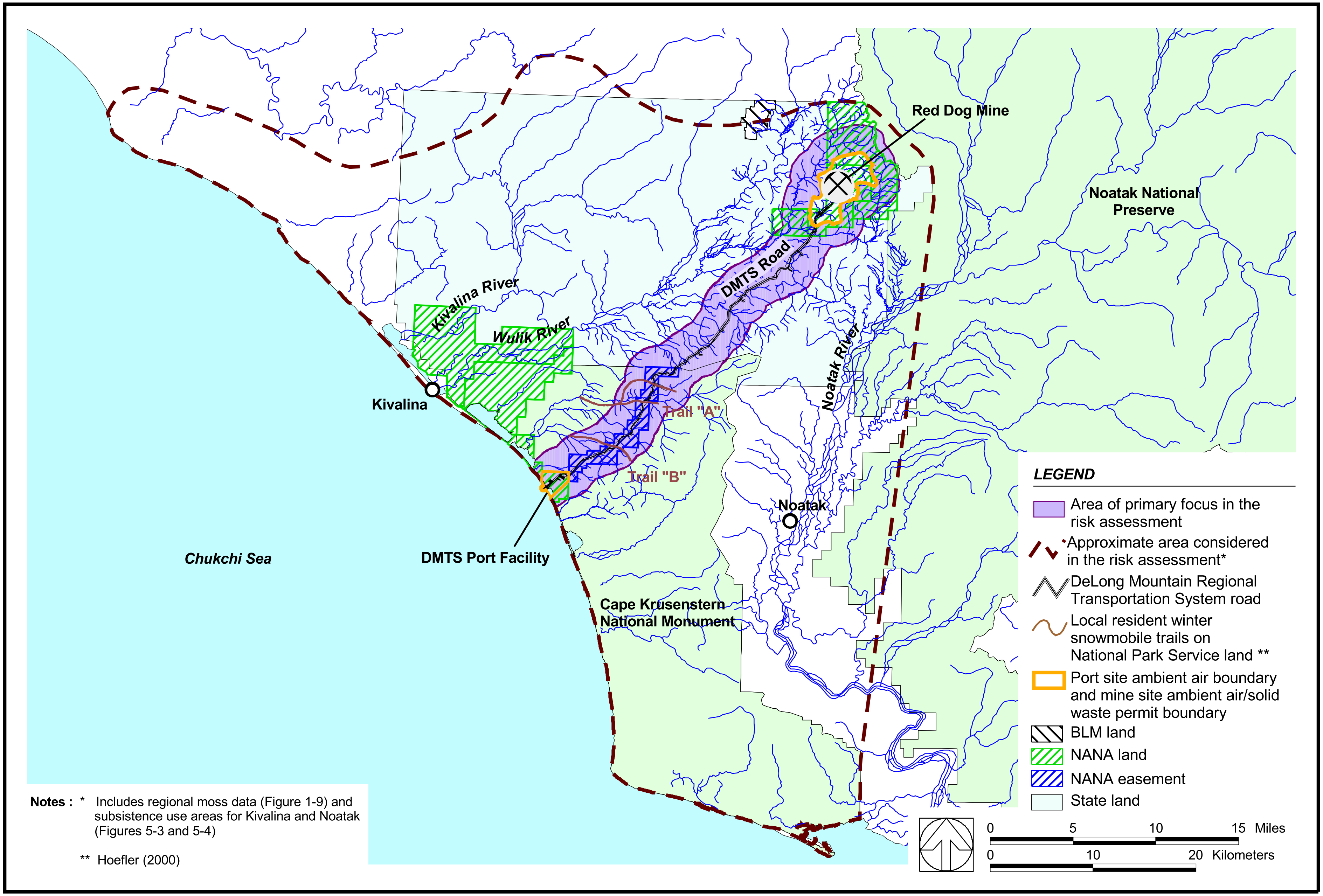

Figure 1-7. Areas evaluated in the risk assessment

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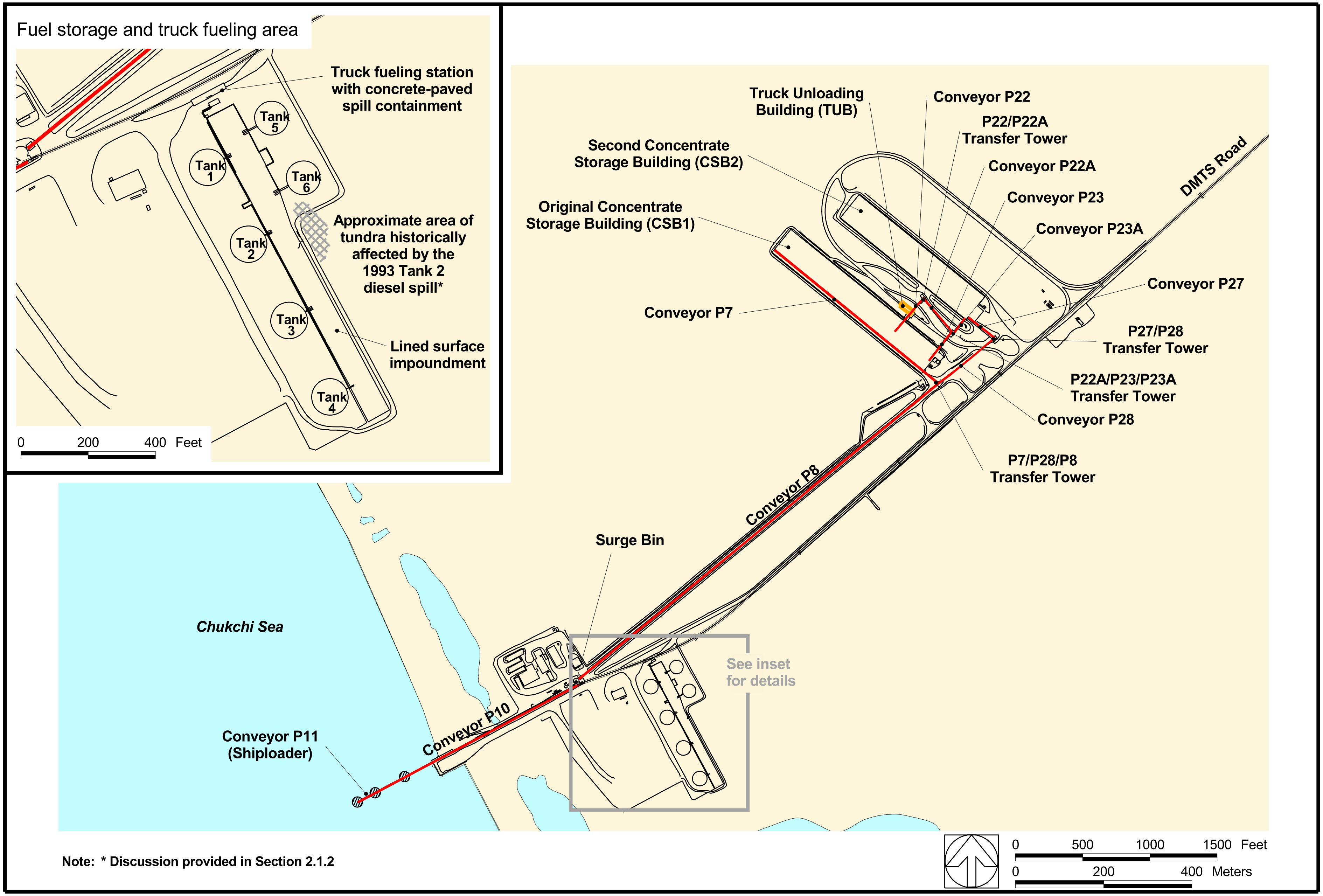
8601997.007 5400 | Jun 24, 2007 | Fig 1-7 evaluation view | Fig 1-7 RA evaluation layout | j:\red_dog\projects\post_fsp_2003_base_figures.apr



Note: * Discussion provided in Section 2.1.2

Figure 1-8. Port site storage and conveyance features map

Exponent®

8601997.001 3400/3500 | Nov 12, 2004 | Fig 1-8 tank detail view | Fig 1-8 Port detail layout | j:\red_dog\projects\port_conveyance.apr

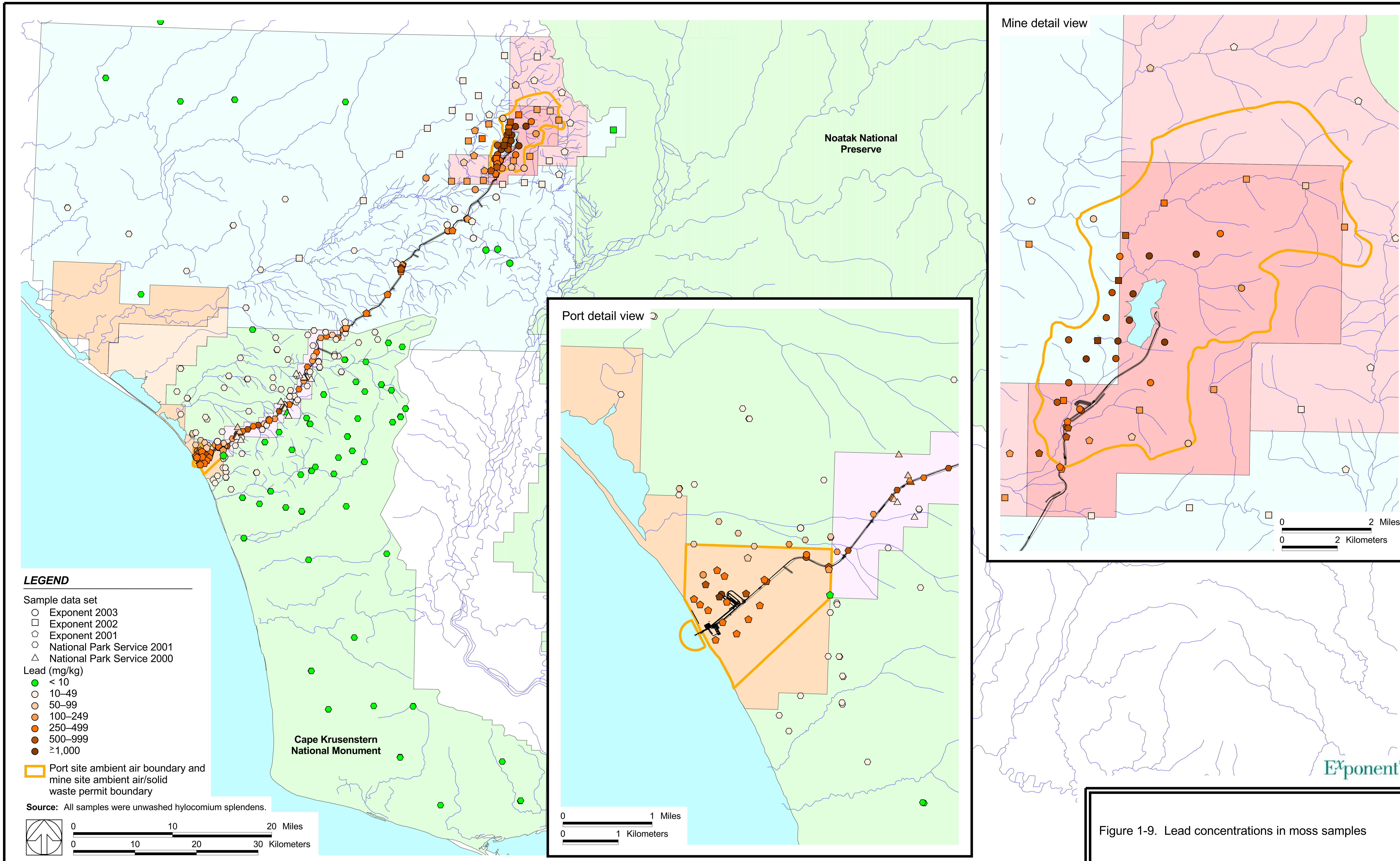


Figure 1-9. Lead concentrations in moss samples

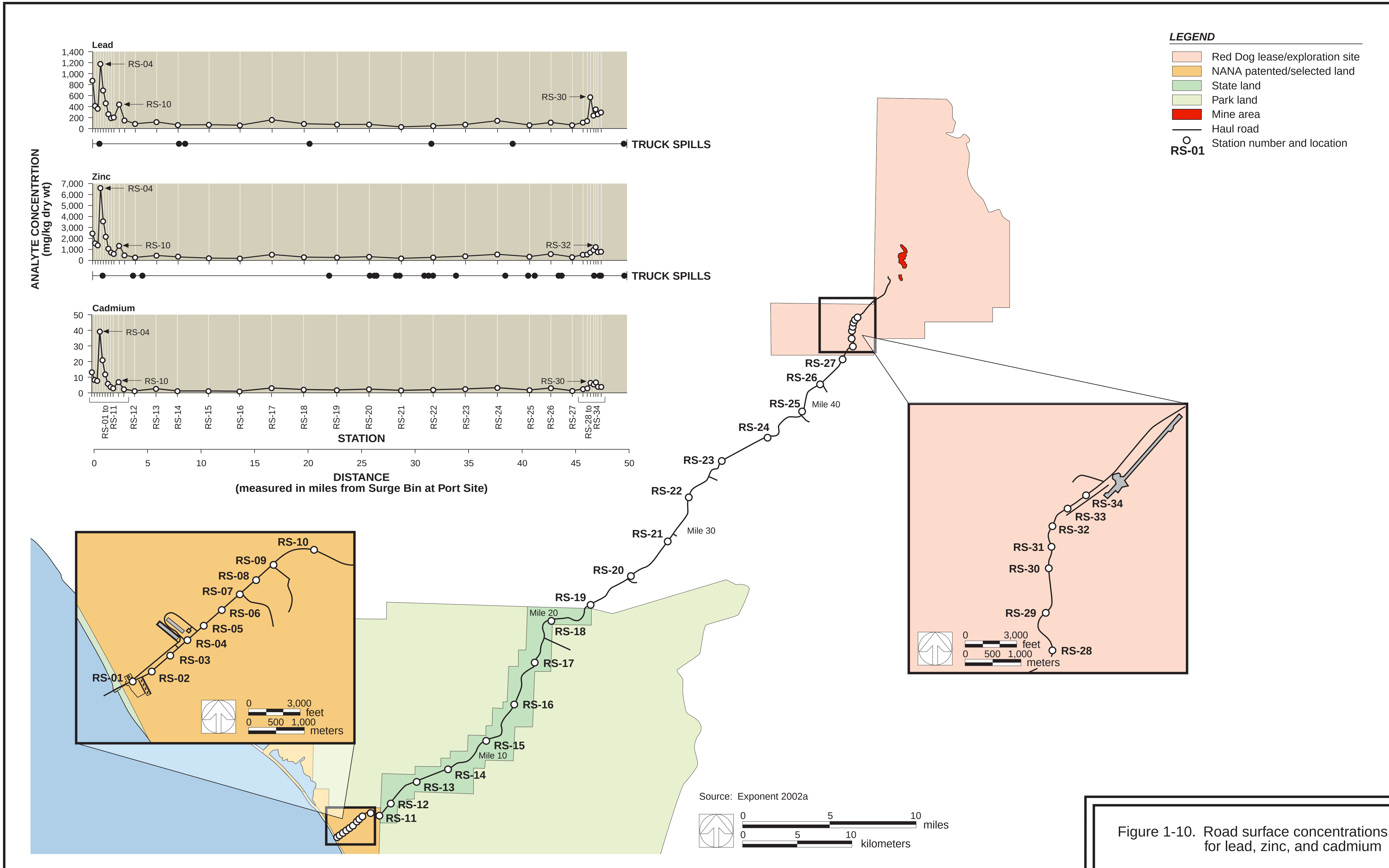


Figure 1-10. Road surface concentrations for lead, zinc, and cadmium

8601997.001 4400 01/24/06 WA

Table CK1. Comparison of tissue threshold concentrations in moss samples (*Hylocomium splendens*)

	Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc	Tissue Threshold Concentrations[a]
					mg/kg	A = 25 - 60	μg/g	A = 150 - 290
					dry	B = 35 - 90	dry	B = 190 - 350
						C = 70 - 110		C = 300 - 400
Site								
	001P-M01	ECO-R	001P-M-01	2001			1530	C
	002P-M01	ECO-R	002P-M-01	2001			1970	C
	003P-M01	ECO-R	003P-M-01	2001			2060	C
	004P-M01	ECO-R	004P-M-01	2001			1420	C
	005P-M01	ECO-R	005P-M-01	2001			2090	C
	006P-M01	ECO-R	006P-M-01	2001			1970	C
	007P-M01	ECO-R	007P-M-01	2001			1280	C
	008P-M01	ECO-R	008P-M-01	2001			1330	C
	009D-M01	ECO-R	009D-M-01	2001			3440	C
	009P-M01	ECO-R	009P-M-01	2001			3210	C
	010P-M01	ECO-R	010P-M-01	2001			2490	C
	011P-M01	ECO-R	011P-M-01	2001			1110	C
	013P-M01	ECO-R	013P-M-01	2001			1450	C
	015P-M01	ECO-R	015P-M-01	2001			424	C
	016P-M01	ECO-R	016P-M-01	2001			1160	C
	017P-M01	ECO-R	017P-M-01	2001			191	B
	018D-M01	ECO-R	018D-M-01	2001			261	B
	018P-M01	ECO-R	018P-M-01	2001			264	B
	019P-M01	ECO-R	019P-M-01	2001			518	C
	020P-M01	ECO-R	020P-M-01	2001			901	C
	021P-M01	ECO-R	021P-M-01	2001			1250	C
	022P-M01	ECO-R	022P-M-01	2001			602	C
	023P-M01	ECO-R	023P-M-01	2001			981	C
	024P-M01	ECO-R	024P-M-01	2001			1140	C
	025P-M01	ECO-R	025P-M-01	2001			862	C
	026D-M01	ECO-R	026D-M-01	2001			420	C
	026P-M01	ECO-R	026P-M-01	2001			290	B
	028P-M01	ECO-R	028P-M-01	2001			922	C
	029P-M01	ECO-R	029P-M-01	2001			119	
	030P-M01	ECO-R	030P-M-01	2001			209	B
	030R-M01	ECO-R	030R-M-01	2001			124	
	031P-M01	ECO-R	031P-M-01	2001			301	C
	031R-M01	ECO-R	031R-M-01	2001			348	C
	032P-M01	ECO-R	032P-M-01	2001			207	B
	032R-M01	ECO-R	032R-M-01	2001			169	A
	033P-M01	ECO-R	033P-M-01	2001			117	
	034D-M01	ECO-R	034D-M-01	2001			93.6	
	034P-M01	ECO-R	034P-M-01	2001			109	
	034R-M01	ECO-R	034R-M-01	2001			97.3	
	035P-M01	ECO-R	035P-M-01	2001			92.5	
	036P-M01	ECO-R	036P-M-01	2001			559	C
	036R-M01	ECO-R	036R-M-01	2001			436	C
	037P-M01	ECO-R	037P-M-01	2001			179	A
	038P-M01	ECO-R	038P-M-01	2001			116	
	038R-M01	ECO-R	038R-M-01	2001			153	A
	039P-M01	ECO-R	039P-M-01	2001			187	A
	040P-M01	ECO-R	040P-M-01	2001			72.3	
	040R-M01	ECO-R	040R-M-01	2001			71.9	

Table CK1. (cont.)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc	Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	μg/g	A = 150 - 290
				dry	B = 35 - 90	dry	B = 190 - 350
					C = 70 - 110		C = 300 - 400
041P-M01	ECO-R	041P-M-01	2001			309	C
042D-M01	ECO-R	042D-M-01	2001			84.2	
042P-M01	ECO-R	042P-M-01	2001			83	
042R-M01	ECO-R	042R-M-01	2001			82.9	
044P-M01	ECO-R	044P-M-01	2001			230	B
044R-M01	ECO-R	044R-M-01	2001			184	A
045P-M01	ECO-R	045P-M-01	2001			74.4	
046P-M01	ECO-R	046P-M-01	2001			223	B
048P-M01	ECO-R	048P-M-01	2001			129	
048R-M01	ECO-R	048R-M-01	2001			148	
050P-M01	ECO-P	050P-M-01	2001			377	C
051A-M01	ECO-P	051A-M-01	2001			358	C
052P-M01	ECO-P	052P-M-01	2001			637	C
053D-M01	ECO-P	053D-M-01	2001			197	B
053P-M01	ECO-P	053P-M-01	2001			193	B
059D-M01	ECO-P	059D-M-01	2001			300	B
059P-M01	ECO-P	059P-M-01	2001			384	C
060P-M01	ECO-P	060P-M-01	2001			340	C
102P-M01	ECO-R	102P-M-01	2001			141	
103P-M01	ECO-R	103P-M-01	2001			85.6	
116P-M01	ECO-R	116P-M-01	2001			87.8	
117P-M01	ECO-R	117P-M-01	2001			101	
117R-M01	ECO-R	117R-M-01	2001			119	
161P-M01	ECO-P	161P-M-01	2001			128	
161R-M01	ECO-P	161R-M-01	2001			156	A
201P-M01	ECO-R	201P-M-01	2001			132	
HR01-01A	ECO-P	HR-01-01-M	2001			4180	C
HR01-02M	ECO-P	HR-01-02-M	2001			2040	C
HR01-03M	ECO-P	HR-01-03-M	2001			273	B
HR02-01M	ECO-P	HR-02-01-M	2001			3140	C
HR02-02M	ECO-P	HR-02-02-M	2001			949	C
HR02-03M	ECO-P	HR-02-03-M	2001			59.2	
HR03-01M	ECO-R	HR-03-01-M	2001			1160	C
HR03-02M	ECO-R	HR-03-02-M	2001			435	C
HR03-03M	ECO-R	HR-03-03-M	2001			164	A
HR04-01B	ECO-R	HR-04-01-M	2001			1240	C
HR04-02M	ECO-R	HR-04-02-M	2001			889	C
HR04-03M	ECO-R	HR-04-03-M	2001			167	A
HR05-01M	ECO-R	HR-05-01-M	2001			1360	C
HR05-02M	ECO-R	HR-05-02-M	2001			460	C
HR05-03M	ECO-R	HR-05-03-M	2001			118	
HR06-01M	ECO-M	HR-06-01-M	2001			1440	C
HR06-02M	ECO-M	HR-06-02-M	2001			1200	C
HR06-03M	ECO-M	HR-06-03-M	2001			1450	C
HR06-04M	ECO-M	HR-06-04-M	2001			433	C
HS1N0003	ECO-R	HS-1N-0003-M	2000			1570	C
HS1N0050	ECO-R	HS-1N-0050-M	2000			1020	C
HS1N0100	ECO-R	HS-1N-0100-M	2000			554	C
HS1N0250	ECO-R	HS-1N-0250-M	2000			281	B

Table CK1. (cont.)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc		Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	μg/g		A = 150 - 290
				dry	B = 35 - 90	dry		B = 190 - 350
					C = 70 - 110			C = 300 - 400
HS1N1000	ECO-R	HS-1N-1000-M	2000			153		
HS1S0003	ECO-R	HS-1S-0003-M	2000			1500		C
HS1S0050	ECO-R	HS-1S-0050-M	2000			352		C
HS1S0100	ECO-R	HS-1S-0100-M	2000			207		B
HS1S0250	ECO-R	HS-1S-0250-M	2000			148		
HS1S1000	ECO-R	HS-1S-1000-M	2000			111		
HS1S1600	ECO-R	HS-1S-1600-M	2000			96.1		
HS2N0003	ECO-R	HS-2N-0003-M	2000			2750		C
HS2N0050	ECO-R	HS-2N-0050-M	2000			1880		C
HS2N0100	ECO-R	HS-2N-0100-M	2000			1040		C
HS2N0250	ECO-R	HS-2N-0250-M	2000			516		C
HS2N1000	ECO-R	HS-2N-1000-M	2000			237		B
HS2S0003	ECO-R	HS-2S-0003-M	2000			1200		C
HS2S0050	ECO-R	HS-2S-0050-M	2000			321		C
HS2S0100	ECO-R	HS-2S-0100-M	2000			255		B
HS2S0250	ECO-R	HS-2S-0250-M	2000			138		
HS2S1000	ECO-R	HS-2S-1000-M	2000			118		
HS3N0003	ECO-R	HS-3N-0003-M	2000			1180		C
HS3N0050	ECO-R	HS-3N-0050-M	2000			856		C
HS3N0100	ECO-R	HS-3N-0100-M	2000			695		C
HS3N0250	ECO-R	HS-3N-0250-M	2000			259		B
HS3N1000	ECO-R	HS-3N-1000-M	2000			158		A
HS3N1600	ECO-R	HS-3N-1600-M	2000			169		A
HS3S0003	ECO-R	HS-3S-0003-M	2000			2860		C
HS3S0050	ECO-R	HS-3S-0050-M	2000			751		C
HS3S0100	ECO-R	HS-3S-0100-M	2000			453		C
HS3S0250	ECO-R	HS-3S-0250-M	2000			222		B
HS3S1000	ECO-R	HS-3S-1000-M	2000			112		
MI-02M	ECO-M	MI-02-M	2001			589		C
MI-104	ECO-R	MS0024	2003			74.5		
MI-107	ECO-R	MS0020	2003			137		
MI-108	ECO-R	MS0023	2003			386		C
MI-25-M	ECO-R	MI-25-M	2002			440		C
MI-26-M	ECO-R	MI-26-M	2002			166		A
MI-42-M	ECO-M	MI-42-M	2002			611		C
MI-45-M	ECO-M	MI-45-M	2002			748		C
PO-01M	ECO-P	PO-01-M	2001			1370	*J*	C
PO-02M	ECO-P	PO-02-M	2001			2540	*J*	C
PO-04M	ECO-P	PO-04-M	2001			2090	*J*	C
PO-05M	ECO-P	PO-05-M	2001			6480	*J*	C
PO-06M	ECO-P	PO-06-M	2001			3950	*J*	C
PO-07M	ECO-P	PO-07-M	2001			1580	*J*	C
PO-09M	ECO-P	PO-09-M	2001			1560	*J*	C
PO-10M	ECO-P	PO-10-M	2001			1930	*J*	C
PO-11M	ECO-P	PO-11-M	2001			1260	*J*	C
PO-13M	ECO-P	PO-13-M	2001			1580	*J*	C
PO-15M	ECO-P	PO-15-M	2001			1500	*J*	C
PO-16M	ECO-P	PO-16-M	2001			1520	*J*	C
PO-17M	ECO-P	PO-17-M	2001			1550	*J*	C

Table CK1. (cont.)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc		Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	μg/g		A = 150 - 290
				dry	B = 35 - 90	dry		B = 190 - 350
					C = 70 - 110			C = 300 - 400
PO-18M	ECO-P	PO-18-M	2001			1480	*J*	C
TT1-0100	ECO-P	MS0005	2003	24.2		8120		C
TT1-1000	ECO-P	MS0008	2003	4.56		869		C
TT2-0010	ECO-P	MS0004	2003	21.6		2910		C
TT2-0100	ECO-P	MS0003	2003	13.1		1340		C
TT2-1000	ECO-P	MS0006	2003	3.85		251		B
TT3-0010	ECO-R	MS0002	2003	16.8		1110		C
TT3-0100	ECO-R	MS0001	2003	9.73		595		C
TT3-1000	ECO-R	MS0015	2003	3.49		135		
Reference								
TS-REF-7	ECOREF	MS0011	2003	3.73		47.9		
TS-REF-8	ECOREF	MS0010	2003	4.35		64		
TS-REF10	ECOREF	MS0009	2003	3.29		55		

Note: [a] Tissue threshold concentration ranges defined as follows based on effects thresholds reported for multiple species in Folkeson and Andersson-Bringmark (1988).

A - exceeds minimum threshold for first signs of reduction in cover
B - exceeds minimum threshold for obvious reductions in cover
C - exceeds minimum apparent survival thresholds (some dead individuals observed)

Both site and literature reference samples were unwashed.

J - estimated value

Data Sources: Exponent (2002a)
Ford and Hasselbach (2001)
Exponent (2003c) and Appendix A of this document
Further detail is provided in Appendix Table C-21

Table CK2. Comparison of tissue threshold concentrations in lichen samples

	Station	Sample ID	Event	Taxon	Zinc		Tissue Threshold Concentrations[a]
					μg/g dry		A = 480 - 1,300 B = 550 - 1,800 C = 600 - 2,200
Site							
	HR01-02L	HR-01-02-L	2001	*Peltigera*	1610		C
	HR02-02L	HR-02-02-L	2001	*Peltigera*	545	*J*	A
	HR02-03L	HR-02-03-L	2001	*Peltigera*	82.2	*J*	
	HR03-03L	HR-03-03-L	2001	*Peltigera*	115	*J*	
	HR05-03L	HR-05-03-L	2001	*Peltigera*	85.2	*J*	
	HR07-01B	HR-07-01-L	2001	*Peltigera*	1720	*J*	C
	HR07-02L	HR-07-02-L	2001	*Peltigera*	1040	*J*	C
	HR07-03L	HR-07-03-L	2001	*Peltigera*	185	*J*	
	HR07-04L	HR-07-04-L	2001	*Peltigera*	121	*J*	
	PO-04L	PO-04-L	2001	*Peltigera*	1010	*J*	C
	PO-11L	PO-11-L	2001	*Peltigera*	1020	*J*	C
	PO-17L	PO-17-L	2001	*Peltigera*	1050	*J*	C
	TT2-0010	LI0018	2004	*Peltigera*	780		C
	TT2-0100	LI0008	2004	*Peltigera*	292		
	TT2-1000	LI0007	2004	*Peltigera*	137		
	TT3-0010	LI0010	2004	*Peltigera*	209		
	TT3-0100	LI0037	2004	*Peltigera*	119	*J*	
	TT3-1000	LI0016	2004	*Cladina*	81.9		
	TT3-1000	LI0017	2004	*Peltigera*	94.4		
	TT5-0010	LI0038	2004	*Peltigera*	594		B
	TT5-0100	LI0006	2004	*Peltigera*	572		B
	TT5-1000	LI0002	2004	*Peltigera*	531		A
	TT5-2000	LI0019	2004	*Cladina*	278		
	TT6-0010	LI0034-D	2004	*Peltigera*	351	*J*	
	TT6-0010	LI0036	2004	*Cladina*	317	*J*	
	TT6-0100	LI0022	2004	*Cladina*	420	*J*	
	TT6-0100	LI0023	2004	*Peltigera*	392	*J*	
	TT6-1000	LI0020	2004	*Peltigera*	335	*J*	
	TT6-1000	LI0021	2004	*Cladina*	386	*J*	
	TT6-2000	LI0026	2004	*Peltigera*	163	*J*	
	TT6-2000	LI0027	2004	*Cladina*	141	*J*	
	TT7-0010	LI0025	2004	*Cladina*	2740	*J*	C
	TT7-1000	LI0024	2004	*Cladina*	996	*J*	C
	TT7-2000	LI0039	2004	*Cladina*	1260		C
	TT8-0010	LI0015	2004	*Peltigera*	627		C
	TT8-0100	LI0014	2004	*Peltigera*	397		
	TT8-1000	LI0011	2004	*Cladina*	70		
	TT8-1000	LI0012-D	2004	*Peltigera*	149		
Reference							
	TS-REF-5	LI0028	2004	*Cladina*	45.2		
	TS-REF-5	LI0029	2004	*Peltigera*	48.5		
	TS-REF-7	LI0030	2004	*Cladina*	26.9		
	TS-REF-7	LI0031	2004	*Peltigera*	39.2		
	TS-REF11	LI0032	2004	*Cladina*	19.4	*J*	
	TS-REF11	LI0033	2004	*Peltigera*	29.7	*J*	

Notes on following page

Table CK2. (cont.)

Note: [a] Tissue threshold concentration ranges defined as follows based on effects thresholds reported for multiple species in Folkeson and Andersson-Bringmark (1988).

A - exceeds minimum threshold for first signs of reduction in cover

B - exceeds minimum threshold for obvious reductions in cover

C - exceeds minimum apparent survival thresholds (some dead individuals observed)

Both site and literature reference samples were unwashed.

J - estimated value

Data Sources: Exponent (2004a) and Appendix E of this document.
Data are presented in Appendix Table G-19.

Table JS5b. Locations and receptors for which only LOAEL hazard quotients exceed 1.0

Assessment Unit Location	Aluminum	Antimony	Arsenic (arsenate)	Arsenic (arsenite)	Barium	Cadmium	Chromium	Cobalt	Lead	Mercury	Molybdenum	Selenium	Thallium	Vanadium	Zinc
DMTS Road and Port Operations															
Site Stations															
Whole Site	Caribou				Caribou										
Port Site	Caribou, fox								Ptarmigan						
Near Mine	Caribou				Ptarmigan, caribou				Ptarmigan						
Road Site	Caribou									Fox, owl					
Reference Stations															
Reference Site	Caribou														
Lagoon Environment															
Site Stations															
Control Lagoon															
North Lagoon															
Port Lagoon North															
Reference Stations															
Reference Lagoon															
Tundra Pond Environment															
Site Stations															
TP1-0100															
TP1-1000															
TP3															
TP4					Muskrat										
Reference Stations															
TP-REF-2															
TP-REF-3	Muskrat														
TP-REF-5	Muskrat														
Stream Environment															
Site Stations															
ARC-R	Muskrat														
OR-R	Muskrat														
AC-R															
Reference Stations															
ST-REF-3	Muskrat														
ST-REF-5	Muskrat														
ST-REF-6	Muskrat														

Table JS5b. (cont.)

Assessment Unit Location	Aluminum	Antimony	Arsenic (arsenate)	Arsenic (arsenite)	Barium	Cadmium	Chromium	Cobalt	Lead	Mercury	Molybdenum	Selenium	Thallium	Vanadium	Zinc
Terrestrial Environment															
Site Stations															
TT2-0010	Vole, shrew				Vole, shrew										
TT2-0100	Vole, shrew														
TT2-1000															
TT3-0010	Vole, shrew				Vole, shrew										
TT3-0100	Vole, shrew				Vole, shrew										
TT3-1000															
TT5-0010	Vole, shrew				Vole, shrew										
TT5-0100	Vole, shrew				Vole, shrew										
TT5-1000															
TT5-2000															
TT6-0010	Vole, shrew				Vole, shrew										
TT6-0100	Vole, shrew				Vole, shrew										
TT6-1000	Vole				Shrew										
TT6-2000															
TT7-0010	Vole				Vole										
TT7-1000	Vole				Vole										
TT7-2000					Vole										
TT8-0010	Vole				Vole										
TT8-0100	Vole				Vole										
TT8-1000															
Reference Stations															
TS-REF-5 Site	Vole, shrew														
TS-REF-7 Site															
TS-REF-11 Site															

Source: Appendix K tables of this report.

Note:
- -0010, -0100, -1000 - approximate distance of station from DMTS Road or facilities in meters
- AC-R - Aufeis Creek station, just downstream of the DMTS road crossing
- ARC-R - Anxiety Ridge Creek station, just downstream of the DMTS road crossing
- DMTS - DeLong Mountain Regional Transportation System
- LOAEL - lowest-observed-adverse-effect level
- OR-R - Omikviorok River station, just downstream of the DMTS road crossing
- REF - reference stations
- ST - stream station
- TP - tundra pond station
- TS - tundra soil station
- TT - terrestrial transect station

Table JS7. Summary of potential ecological effects

Terrestrial Habitats	Potential for Effects		
Receptor	Near Port	Near Mine[a]	DMTS Road
Caribou	--	--	--
Moose	--	--	--
Lapland longspur	--	--	--
Snowy owl	--	--	--
Arctic fox	--	--	--
Ptarmigan	yes[b]	yes[b]	--
Tundra vole	--	--	--
Tundra shrew	--	--	--
Vegetation	yes[c]	yes[a,d]	yes[c]

Freshwater Habitats	Potential for Effects			
Receptor	Aufeis Creek	Omikiviorok Creek	Anxiety Ridge Creek	Tundra Ponds
Benthic macroinvertebrates	--	--	--	[e]
Fish	--	--	--	--[f]
Green-winged teal	--	--	--	--
Muskrat	--	--	--	--
Moose	--	--	--	--
Common snipe	--	--	--	--
Vegetation	[e]	[e]	[e]	--[g]

Coastal Lagoon Habitats	Potential for Effects
Receptor	Lagoons[h]
Benthic macroinvertebrates	--
Fish	--[i]
Brant	--
Muskrat	--
Moose	--
Black-bellied plover	--
Vegetation	--

Note:

-- Indicates very low or no likelihood of adverse effects

[a] The areas evaluated near the mine were outside the mine boundary. The area within the mine boundary was beyond the scope of this assessment.

[b] Potential for adverse effects from lead.

[c] Vegetation survey parameters were statistically compared to reference area data (Tables 6-3 and JS-1). No individual metals were isolated as primary causative factors, multiple causative factors likely.

[d] The hillslope community vegetation did not show significant difference from the reference site (Tables 6-3 and JS-1). However, just outside the mine's ambient air/solid waste permit boundary, some shrubs appeared to be in poor condition.

[e] Not evaluated

[f] No fish present in tundra ponds.

[g] Exception: Effects possible from lead and zinc in ephemeral tundra ponds located within 100 m of port facilities, based on exceedances of literature-derived effects thresholds. However, tundra pond vegetation appeared healthy during field sampling.

[h] Lagoons located within the port site boundary.

[i] No fish were present in port site lagoons, as they have no open water connections to the Chukchi Sea.

Table CS1. Comparison of juvenile Dolly Varden tissue concentrations with effects thresholds

	Source[a]	Date Collected	N	Total Cadmium Min.	Total Cadmium Max.	Total Lead Min.	Total Lead Max.	Total Selenium Min.	Total Selenium Max.	Total Zinc Min.	Total Zinc Max.
Anxiety Ridge Creek (all)	ADFG	1993–2002	61	0.017	0.308	0.001	0.612	0.010	2.01	11.48	36.12
ARC at Haul Road	ADFG	1993–2000	31	0.022	0.090	0.041	0.612	0.529	1.37	--	--
ARC Upstream	ADFG	2002	15	0.017	0.224	0.001	0.101	0.010	2.01	11.48	36.12
ARC Downstream	ADFG	2002	15	0.039	0.308	0.031	0.138	0.895	2.01	21.97	32.56
Literature values[b] for tissue residue and effect (ppm)											
No effects (range)[c]				0.036–5.0		0.34–5.1		0.12–19		4.5–480	
No effects (range)[d]				0.04–2		0.34–5.1		0.2–0.8		4.5–60	
Effects (range)[c]				0.12–8.0		0.4–4.0		0.66–4.6		40–60	
Effects (range)[d]				0.12–4.0		0.4–4.0		0.66–2.08		--	

Note: Concentrations are reported in ppm wet wt (converted from dry wt).
Based on studies with ecologically relevant endpoints (survival, growth, or reproduction).
If multiple effects thresholds were provided in a single study, the highest no effects threshold value was used.
If multiple effects thresholds were provided in a single study, the lowest effects threshold value was used.
ADFG - Alaska Department of Fish and Game
ARC - Anxiety Ridge Creek
-- - Not available

[a] Ott, A.G., and W.A. Morris. 2004. Juvenile Dolly Varden whole body metals analyses, Red Dog Mine (2002). Technical Report No. 04-01. Alaska Department of Natural Resources, Office of Habitat Management and Permitting.

[b] Jarvinen, A.W., and G.T. Ankley. 1999. Linkage of effects to tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. SETAC Technical Publication Series. Society of Environmental Toxicology and Chemistry, Pensacola, FL.

[c] Ranges of whole body tissue concentrations for all freshwater fish species (Atlantic salmon, bluegill, brook trout, Chinook salmon, dace, fathead minnow, flagfish, guppy, largemouth bass, perch, rainbow trout, stickleback) exposed to chemicals in water or their diet for at least 30 days.

[d] Ranges of whole body tissue concentrations for only freshwater salmonids (Altantic salmon, brook trout, Chinook salmon, rainbow trout) exposed to chemicals in water or their diet for at least 30 days.