DRAFT

Fugitive Dust Risk Management Plan

Red Dog Operations, Alaska

August 2008

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Acronyms and Abbreviations

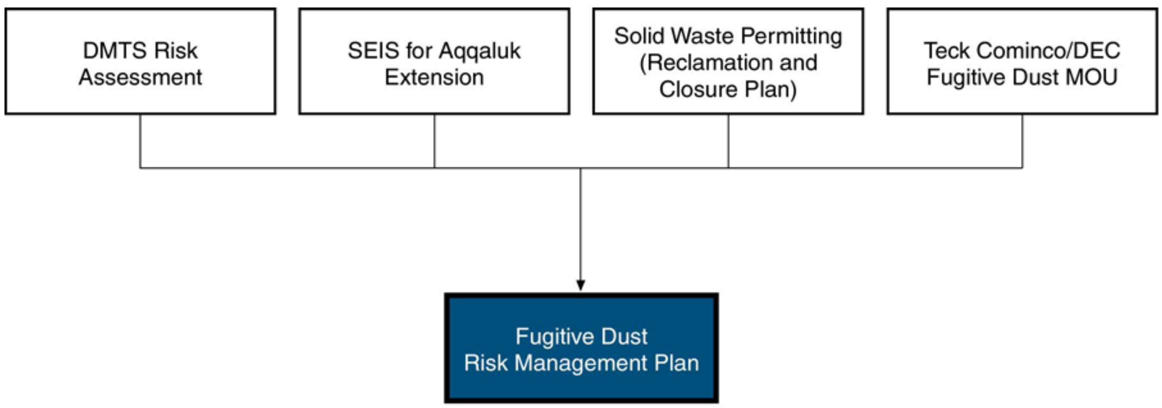
ADEC	Alaska Department of Environmental Conservation
AIDEA	Alaska Industrial Development and Export Authority
CSB	concentrate storage building
DEC-CSP	Alaska Department of Environmental Conservation - Contaminated Sites Program
DFG	Alaska Department of Fish and Game
DMTS	DeLong Mountain Regional Transportation System
DNR	Alaska Department of Natural Resources
EHSMS	Environmental, Health and Safety Management Standards
EPA	U.S. Environmental Protection Agency
IGAP	Indian Environmental General Assistance Program
IRA	Indian Reorganization Act
MOU	memorandum of understanding
NANA	NANA Regional Corporation
NGO	non-governmental organization
NPS	National Park Service
SEIS	Supplemental Environmental Impact Statement
Teck Cominco	Teck Cominco Alaska Incorporated

1 Introduction

Elevated metals concentrations have been identified in tundra in areas surrounding the DeLong Mountain Regional Transportation System (DMTS), primarily as a result of deposition of fugitive dust originating from the DMTS corridor, which is used to transport zinc and lead ore concentrates from the Red Dog Mine, operated by Teck Cominco Alaska Incorporated (Teck Cominco (Figure 1). As a result, the DMTS fugitive dust risk assessment (Exponent 2007a) was conducted to estimate possible risks to human and ecological receptors posed by exposure to metals in soil, water, sediments, and biota in areas surrounding the DMTS, and in areas surrounding the Red Dog Mine ambient air/solid waste permit boundary. In addition, as part of the reclamation and closure planning process, an ecological risk evaluation was conducted to evaluate potential risks to ecological receptors in areas within the mine boundary (Exponent 2007c). These studies are part of the overall process in which areas of fugitive dust deposition surrounding the DMTS are being evaluated. The results of these studies provided a snapshot of risk under current conditions that will help risk managers determine what additional actions may be necessary to reduce those risks now and in the future, considering the decision-making framework established in DEC et al (2002), and shown in Figure 2.

This document presents a risk management plan that develops fundamental risk management objectives and identifies and evaluates risk management options to achieve the overall goal of minimizing risk to human health and the environment surrounding the mine, road, and port, over the life of the mine and post-closure operation. The plan describes a process for developing implementation plans to achieve the fundamental objectives presented herein.

The risk management plan builds upon ongoing efforts by Teck Cominco to reduce dust emissions and minimize effects to the environment. This plan addresses dust-related issues identified by the DMTS risk assessment, the mine-area ecological risk evaluation conducted as part of the closure and reclamation planning process, the Memorandum of Understanding (MOU) between the Alaska Department of Environmental Conservation (ADEC) and Teck Cominco, and the Supplemental Environmental Impact Statement (SEIS) for the Aqqaluk Pit Extension. Thus, this plan seeks to combine multiple parallel fugitive dust-related efforts into one cohesive effort, as illustrated below and in Figure 3. Further discussion of these contributing programs and efforts is provided in the context discussion in Section 2. This plan also incorporates initial stakeholder input that was obtained at a 3-day risk management workshop held in Kotzebue, Alaska, in March 2008, hereafter referred to as "the workshop" (Teck Cominco 2008). The methods by which this input was incorporated into the plan are described in Section 4.



DEC – Alaska Department of Environmental Conservation
DMTS – DeLong Mountain Regional Transportation System
MOU – memorandum of understanding
SEIS – supplemental environmental impact statement
Teck Cominco – Teck Cominco Alaska Incorporated

The remainder of the document is organized into the following sections:

- *Section 2 – Identification of the Decision Context* – describes the legal, social, cultural, and environmental context in which the risk management plan is being developed.
- *Section 3 – Development of Risk Management Objectives* – describes the fundamental objectives that were developed to address the overall goal of minimizing risk to human health and the environment.
- *Section 4 – Evaluation of Actions to Achieve Risk Management Objectives* – describes the categories of actions and specific actions developed to address the fundamental objectives, and the process by which those actions were identified and prioritized.

- *Section 5 – Implementation of Actions* – describes the overall framework for developing specific implementation plans to achieve the fundamental risk management objectives
- *Section 6 – Review and Reporting* – describes an approach to evaluating and reporting study findings, and evaluating the effectiveness of the plans in achieving the fundamental risk management objectives.

2 Identification of the Decision Context

A risk management plan is developed under a particular set of circumstances unique to the site that drive the process of defining the objectives and actions ultimately recommended by the plan. Defining this set of circumstances, or decision context, is the first step of the risk management process. The following sections describe the risk management decisions under consideration, the stakeholder parties that have been and/or will be involved, and provide a description of the legal, social, cultural, and environmental context within which decisions will be made.

2.1 What are we trying to decide?

The overall goal of the fugitive dust risk management plan is to minimize risk to human health and the environment in the area surrounding Red Dog Mine and the DMTS road and port, over the life of the mine and post-closure operations. Thus, the focus of the risk management plan is to define a set of fundamental objectives and decide on an associated set of actions designed to attain that overall goal.

2.2 Who needs to be involved?

A wide-ranging set of scientists, regulators, community members, and other stakeholders has been involved in the design, conduct, and review of studies and evaluations conducted at the site, including the DMTS risk assessment and related studies. Many of these stakeholders have also been engaged in development of the risk management plan through participation in the risk management workshop (Teck Cominco 2008) and through their input in other forums. The following is a list of stakeholder groups that have participated, or will likely participate, in the assessment and management process.

Risk Managers—The risk assessment was conducted under the “site cleanup rules” in the Alaska Administrative Code, sections 18 AAC 75.325 through 75.390, and was overseen by the

Alaska Department of Environmental Conservation Contaminated Sites Program (DEC-CSP). DEC-CSP is also the primary risk manager for the site.

Landowners/Land Managers/Operators—Red Dog Mine is located on NANA Regional Corporation (NANA) land, and is operated by Teck Cominco. NANA also owns the land in the port area, and leases it to the Alaska Industrial Development and Export Authority (AIDEA). AIDEA owns and operates the DMTS. The DMTS road runs through lands owned by the State of Alaska (maintained by Teck Cominco), NANA, and the federally owned Cape Krusenstern National Monument, which is administered by the National Park Service (NPS). The Alaska Department of Natural Resources (DNR) is the lead agency for the solid waste permitting and closure and reclamation planning efforts for the mine area. These efforts have a dust-related component to them, particularly related to ecological monitoring needs.

Other Agencies—Other federal and state agencies that have had involvement with the site and/or surrounding areas have also been involved in the evaluation and risk management process for the DMTS and Red Dog Mine. These agencies include the U.S. Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Registry, the Alaska Division of Public Health, and the Alaska Department of Fish and Game(DFG).

Risk Assessors—Exponent conducted the DMTS risk assessment and other associated studies, and is developing the risk management plan with the input of all stakeholders.

Local Representatives and Agencies—Red Dog is located within the Northwest Arctic Borough. Representatives of the Borough have participated as stakeholders. Maniilaq, the regional health authority, has also been a participant. The Kivalina and Noatak villages are the closest communities to the Red Dog Mine. Large areas around these villages, including areas near the DMTS, are extremely important for their subsistence economies. When Teck Cominco signed its agreement with NANA to develop the mine, the Subsistence Advisory Committee was formed. Its purpose is to ensure that all mining activities are consistent with the subsistence needs of the people. Initially, the Subsistence Committee participated in the selection of a DMTS road location that would minimize effects on caribou migration paths, fish spawning areas, and waterfowl nesting sites. The committee meets a minimum of four times per year to review mining activities and their potential effects on subsistence lifestyles. Members of the communities of Kivalina and Noatak have been involved in the risk assessment and management process, either as official representatives (e.g., Subsistence Committee members, city and Indian Reorganization Act (IRA) council members, Indian Environmental General Assistance Program (IGAP) representatives) or as individuals.

Non-Governmental Organizations (NGOs)—A number of NGOs have provided input on activities at the site through different venues (e.g., comments on the DMTS Risk Assessment, independent studies, participation in the risk management workshop). These organizations include the Center for Science in Public Participation, Alaska Community Action on Toxics, Alaskans for Responsible Mining, Trustees for Alaska, Northern Alaska Environmental Center, National Parks Conservation Association, Alaska Center for the Environment, Alaska Conservation Voters, Alaska Conservation Alliance, and Alaska Conservation Foundation.

2.3 What is the context?

This section describes the context within which the risk management planning will be done and decisions will be made. The context of the risk management plan includes the values held by those people that will be affected by decisions that will be made as part of the risk management plan, in addition to the established legal, regulatory, and institutional requirements, and the space and time in which the decision may be made. The location of the mine, road and port activities, and the resulting depositional patterns of fugitive dust place the risk management plan in a site-specific geographical context. In addition, past site-specific studies have shaped the context of the concerns and issues that the risk management planning process is intended to address. All stakeholders that participate in the risk management process bring a unique perspective and set of values, responsibilities, and requirements to the planning process. The areas of context involved with this risk management planning effort are discussed below.

2.3.1 Geographic Context

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. Base metal mineralization occurs naturally throughout much of the western Brooks Range, and strongly elevated zinc, lead, and silver concentrations (reflecting the mineralization) have been identified in many areas (Exponent 2007a). The mine is located on land owned by NANA (Figure 1).

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. The barges have built-in and enclosed conveyors that are used to transfer the concentrates to the holds of deepwater ships.

The geographic area that the risk management plan addresses includes 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, the area outside of the ambient air/solid waste permit boundary around the mine, as well as the area within mine boundary, which includes significant habitat areas (Figure 1).

2.3.2 Temporal Context

The temporal context for the risk management plan will be over the entire life of the mine, including post-closure operations. Although a number of studies have been completed for the area, such as the DMTS risk assessment, these studies represent past and present conditions. However, conditions may change over time. Therefore, the risk management plan will define a set of actions to be taken, and will provide the means to monitor changes in conditions and trigger additional actions beyond those, if needed, to control and minimize potential for risks.

2.3.3 Prior Site-Specific Studies

Several studies provide context and direction for development of the risk management plan. The focus and conclusions of these studies are summarized below.

2.3.3.1 Moss Studies

Moss studies performed in 2000 and 2001 by the NPS in Cape Krusenstern National Monument (Ford and Hasselbach 2001, Hasselbach 2003, 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. The NPS transect sampling showed that metals concentrations decreased rapidly with distance from the road. However, concentrations were still somewhat elevated at transect endpoints 1,000 and 1,600 m from the road. 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. As part of that study, moss, lichen, willow, and salmonberry samples were collected on transects positioned along the DMTS road from the port facility to the mine. Metals concentrations in moss were higher in transects near either end of the road, and were lower in transects located in the middle section of road and were consistent with NPS study results. Exponent's sample results confirmed the NPS finding that concentrations typically decreased with distance away from the road. Lead, zinc, and cadmium concentrations in moss samples were highest near operational features such as the CSBs and the loop road, where trucks pull into the CSBs.

2.3.3.2 Risk Assessment

A human health and ecological risk assessment (Exponent 2007a) was conducted to estimate possible risks to human and ecological receptors posed by exposure to metals in soil, water, sediments, and biota in areas surrounding the DMTS, and in areas surrounding the Red Dog Mine ambient air/solid waste permit boundary associated with fugitive dust emissions along the DMTS.

The human health risk assessment evaluated potential exposure to DMTS-related metals through incidental soil ingestion, water ingestion, and subsistence food consumption under three scenarios: 1) child subsistence use, 2) adult subsistence use, and 3) combined worker/ subsistence use. Overall, estimated risks were well within acceptable public health limits. The results of the risk assessment, along with the results from the subsistence foods evaluations suggest that risks associated with continued harvesting of subsistence foods from the site, including in unrestricted areas near the DMTS, are not significantly elevated.

The ecological risk assessment evaluated potential risks to ecological receptors inhabiting terrestrial, freshwater stream and pond, coastal lagoon, and marine environments from exposure to DMTS-related metals. The potential for harmful effects to occur in the environments surrounding the road, port, and mine was considered to be low in most cases. No harmful effects were observed or predicted in the marine, coastal lagoon, freshwater stream, and tundra pond environments, although the potential for effects to invertebrates and plants could not be ruled out for some small, shallow ponds found close to facilities within the port site. However, no effects were observed in these port site ponds during field sampling. In the tundra environment, changes in plant community composition (for example, decreased lichen cover) were observed near the road, port, and mine, although it is not clear to what extent those effects may be a result of metals from fugitive dust or other chemical and physical effects typical of dust from gravel roads in Alaska (for example, effects associated with salting of roads). The likelihood of risk to populations of animals was considered low, with the exception that risks related to lead were predicted for ptarmigan living closest to the port and mine, which may affect ptarmigan populations in those localized areas.

In part, the risk management plan is being developed to address issues identified by the risk assessment (Exponent 2007a). Although human health risks were not found to be elevated, the potential for conditions to change over time is also addressed in the development of this risk management plan. Ecological risks that were observed or predicted by the risk assessment (Exponent 2007a) are intended to be proactively addressed in the development of this risk management plan.

The conclusions of the risk assessment led to the development of an overall goal for the risk management plan. The overall goal is to minimize risk to human health and the environment surrounding the DMTS and Red Dog Mine over the life of the mine and post-closure operations. In support of the overall goal, several preliminary objectives and potential actions were outlined in the risk assessment as a starting point for the risk management plan. These preliminary objectives included the following:

- Preliminary Objective 1: Reduce fugitive dust concentrations in nonvascular plants[1] along the DMTS road and near the port and mine to decrease risk to these plants (particularly mosses and lichens), and to minimize exposure to wildlife that may consume these plants. (Reduce dust exposure to plants and animals that are potentially at risk)
  - Action 1: Moss and/or lichen tissue concentrations will be monitored to track the rate of change.
  - Action 2: Moss and lichen community composition (e.g., diversity, abundance, cover, etc.) will be monitored at various distances from the DMTS road to track changes in moss and lichen condition in response to changes in fugitive dust deposition.
- Preliminary Objective 2: Reduce fugitive dust concentrations in shrubs and herbaceous plants to minimize exposure to herbivorous birds (and other wildlife) that may consume these food items in areas near the port and mine.
  - Action: Tissue concentrations in shrubs and/or herbaceous plants will be monitored to track the rate of change.

The risk management plan is not limited to these preliminary objectives and potential actions. However, they are included as part of the context for this plan, and will be developed further as part of the risk management plan, and subsequent detailed monitoring plans.

[1] Technically, mosses and lichens are not "plants"; they are bryophytes, but for the sake of simplicity, they will be referred to as plants in this document.

In addition, a number of issues were identified in comments on the DMTS risk assessment where the response indicated that the issue would be evaluated further in the risk management plan. These comment issues largely focused on the potential need for additional studies or monitoring to address areas of uncertainty in the risk assessment. These issues will be considered part of the context for development of the risk management plan and detailed implementation plans.

2.3.3.3 Mine Area Ecological Risk Evaluation

An ecological risk evaluation was conducted as part of the closure and reclamation planning process for the mine, which is part of the solid waste permitting for the area within the mine boundary (Exponent 2007c). The objective of this evaluation was to assess the potential for adverse effects to ecological receptors (e.g., wildlife and plants) from metals exposure under both current conditions and predicted future (post-closure) conditions, within active areas and surrounding tundra areas within the mine permit boundary.

Based on the evaluation of multiple scenarios for current and post-closure conditions, results indicated that caribou, fox, teal, and muskrat are unlikely to experience adverse effects from exposure to lead, zinc, and cadmium under either current conditions or post-closure conditions. However, results did indicate a potential for adverse effects to ptarmigan and small mammals under both current and post-closure conditions.

Specifically, the evaluation for ptarmigan, tundra vole, and tundra shrew indicated that these wildlife receptors may experience effects as a result of exposure to lead, zinc, and cadmium. Adverse effects, particularly from lead, could occur for ptarmigan that forage near the mine facilities and, more broadly, in the areas within the permit boundary under both current and post-closure conditions. Results for the tundra vole and tundra shrew also indicated a potential for adverse effects from lead, zinc, and cadmium under both current and post-closure conditions. However, the predicted effects, if occurring, were considered unlikely to translate into regional population-level effects, given the limited spatial extent of the mine area where adverse effects could occur.

Additionally, the uncertainty analysis showed that using more realistic assumptions in the models reduced or, in many cases, eliminated predicted risk to wildlife receptors.

2.3.3.4 Other Relevant Studies

A number of studies have been undertaken that address areas of uncertainty regarding metals transport and fate, and human health and ecological risk. These studies include the following:

- **Bioaccessibility Study—**The DMTS risk assessment (Exponent 2007a) used conservative bioaccessibility values for barium and aluminum of 100%. To explore actual bioaccessibility of Red Dog soils, a bioaccessibility study was conducted by Shock et al. (2007) to investigate the solubility and bioaccessibility of barium and aluminum using an in vitro test method to simulate the interaction of soil and dust with gastric juices. Soil samples were collected from tundra areas near the road, mine boundary, main waste stockpile, and the primary gyratory crusher. Results of the study indicated that bioaccessibility of barium in mine waste rock and gyro crusher ore dust samples was very low (0.07 to 0.36%), tundra soil samples ranged from 3.8 to 19.5%. Bioaccessibility of aluminum ranged from 0.31 to 4%. Both aluminum and barium bioaccessibility values were much lower than 100% value that was used in the risk assessment.
- **Dust Particle Fate and Weathering Studies—**Mineral weathering in soils collected in the vicinity of Red Dog Operations was studied using analytical techniques to identify lead and zinc-containing minerals. Also, diagnostic leaching techniques were used to estimate the distribution and extractability of metal ions. The main forms of lead and zinc identified in the soils were galena and sphalerite, and the presence of anglesite and plumbojarosite indicated galena weathering had occurred. Current studies are being undertaken to determine the effects of the metal ion leaching on the environment surrounding Red Dog Operations (Teck Cominco 2007a,b).

- **Bearded Seal (Ugruk) Assessment—**ADF&G conducted an assessment of metals concentrations in bearded seals collected near the DMTS port area and Kivalina in 2005 (DFG no date). The purpose was to compare metals concentrations in seals harvested near Kivalina and the port to concentrations in other seals collected at study control sites and other locations in Alaska and Canada. Results indicated that bearded seals harvested near Kivalina and the DMTS port did not have higher levels of metals (lead, zinc, cadmium, copper, arsenic) than seals harvested in other locations.

- **Vegetation Effects Studies in Mine Area—**A field survey was conducted in June 2006 by ABR Environmental Research and Services to assess vegetation effects in selected areas within the mine boundary (Tailings Area 2, Triangle Area, Red Dog Creek and Tailings Area 1) and reference areas (ABR 2007a). Four species of plant tissues and soil samples were collected for chemical analysis. Plant cover was estimated and assigned a damage index. Mosses and lichens were most severely affected, followed by evergreen shrubs. Deciduous shrubs and grasses, sedges and forbs were least affected. High lead concentrations were associated with some of the most significant effects. Observed effects on vegetation may be a result of a combination of excess metal uptake, direct foliar damage from deposition of fugitive dust on plant shoots, and winter exposure to dust-contaminated snow.

- **Vegetation Treatment Studies—**In 2006 and 2007, ABR Environmental Research and Services set up treatment plots in the areas at Red Dog Mine. Dolomitic lime was applied to randomly selected plots to increase soil pH and reduce soil aluminum levels. Soil aluminum concentrations were lower in treatment plots than control plots. Results are not yet available for vegetation responses, but recovery will be indicated by plant seedlings in treatment areas, reduced bare ground, and increases in vegetation cover for grasses, sedges and forbs (ABR 2007b).

- **Caribou Assessment—**Alaska Department of Public Health evaluated metals concentrations in caribou near Red Dog in 1996 and concluded that average metals concentrations in caribou were low and caribou consumption was safe. In 2002, 10 caribou that overwintered near the mine and road were analyzed for muscle, kidney, and liver tissue for lead, cadmium, arsenic, and zinc. Metals concentrations in caribou harvested from Red Dog were not elevated above caribou collected from other locations, and muscle lead concentrations were lower than most comparison groups, and were similar concentrations to store-bought meats (Exponent 2007a). Alaska Department of Fish and Game is continuing a caribou study program (Teck Cominco 2008). Teck Cominco also has an ongoing caribou monitoring program (Lawhead 2008).

2.3.4 Legal, Regulatory, and Institutional Context

The legal, regulatory, and institutional contexts for this risk management plan are described in the following sections. These sections include discussion on land ownership, use, and management; DEC's decision framework; reclamation and closure planning; mine-area memorandum of understanding; air permits and ambient air boundaries; and Teck Cominco corporate policies.

2.3.4.1 Land Uses/Land Ownership/Land Management

The different responsibilities of the various landowners and managers result in differing management objectives that are considered in development of the risk management plan. This section describes land use, ownership, and management for the following areas: Red Dog Mine, DMTS road and port, Cape Krusenstern National Monument, and Noatak National Preserve.

Red Dog Mine and DMTS Road and Port. Red Dog Mine is located on NANA land, and is operated by Teck Cominco. AIDEA owns and Teck Cominco operates the DMTS, which includes the port on the Chukchi Sea and the 52-mile road linking the mine and the port. Teck Cominco has a priority and non-exclusive contract to use the road and port for exporting its zinc and lead concentrates. Other parties wishing to use the DMTS need to meet regulatory requirements and have an agreement with AIDEA to finance any necessary capacity increase of the infrastructure. The DMTS road runs through lands owned by the State of Alaska, NANA, and the federally owned Cape Krusenstern National Monument, which is administered by the NPS. NANA traded lands it received under the Alaska Native Claims Settlement Act with lands managed by NPS to arrive at an agreement allowing for congressional action in establishing a corridor through the Monument. U.S. Congress granted a 100-year easement to NANA for the corridor through the Monument (43 U.S.C. §1629). Land ownership and use are illustrated on Figure 1.

Under a 1982 agreement with NANA, Teck Cominco financed, constructed, and has been operating the mine and mill, in addition to marketing the concentrates produced. Teck Cominco also has responsibility for employing and training NANA shareholders to staff the operations and to protect the subsistence lifestyle of the people in the region. At present, 56 percent of the workers and contractors employed by Teck Cominco are NANA shareholders. Continued educational commitments by NANA and Teck Cominco to the NANA shareholders of the region should enable the companies to continue to increase the percentage of native employment at the operation toward the 100 percent goal outlined in the 1982 agreement between NANA and Teck Cominco (DEC et al. 2002).

The DMTS road and port facility are currently used exclusively for the hauling of materials to and from the mine facility per the 1986 agreement between AIDEA, NANA, and Teck Cominco to support employment at Red Dog. The DMTS road crosses approximately 22 miles of NPS land within the Cape Krusenstern National Monument, which is subject to a transportation easement granted by Congress (43 U.S.C. §1629). Aside from this easement to NANA, the DMTS road and port facilities are owned by AIDEA. Use and access rights to the DMTS and port are defined by various agreements between NANA, the U.S. Department of the Interior, AIDEA, and Teck Cominco.

Cape Krusenstern National Monument (CAKR). The DMTS crosses through Cape Krusenstern National Monument. NPS states that “Cape Krusenstern is a vast area of exceptional natural and cultural significance, used by Native peoples for an estimated 9,000 years and entrusted to the NPS by the U.S. Congress for its long-term conservation.”

The NPS was established "to conserve the scenery and the natural and historic objects and the wildlife [of parks, monuments, and reservations] and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The 1986 Management Policies expand upon the principles of ecosystem management that direct each NPS unit, stating that: "The National Park Service will preserve the natural resources, processes, systems, and associated values of units of the national park system in an unimpaired condition, strive to perpetuate their inherent integrity, and provide present and future generations with the opportunity to enjoy them…" (NPS presentation, in Teck Cominco 2008).

At Cape Krusenstern, NPS has stated that their responsibilities include the following: "to protect habitat for seals and other marine mammals; to protect habitat for and populations of, birds, and other wildlife, and fish resources; and to protect the viability of subsistence resources." The 1986 General Management Plan for CAKR states that: "lands possessing significant natural features and values be managed with respect to ecological processes, and that the impacts of people upon these process and resources be mitigated. The concept of perpetuating a total natural environment or ecosystem…is a distinguishing aspect of the National Park Service's management of natural lands. … Of particular interest are the impacts on natural systems of existing and potential future modes of transportation across the monument…" (NPS presentation, in Teck Cominco 2008).

NPS has stated that reclamation is a requirement before Teck-Cominco and NANA vacate the easement in Cape Krusenstern National Monument. Exhibit B of the January 31, 1985 Land Exchange Agreement (*Terms and Conditions Governing Legislative Land Consolidation and Exchange Between NANA Regional Corporation, Inc., and the United States of America*, which was ratified in Public Law 99-96 that amended the Alaska Native Claims Settlement Act) includes section B. 4. Abandonment. This section specifies that NANA (or its operator Teck Cominco) must provide a reclamation plan to NPS prior to abandoning the road. The plan would:

- Prevent future interference with drainage
- Mitigate soil erosion
- Protect water quality, fish and wildlife and habitat, threatened and endangered species and cultural and paleontological resources
- Examine costs of road surface scarification, methods and benefits of recontouring material sites and road prism, removal of culverts for fish streams and alternative revegetation techniques.

The Agreement states that NANA and its assigns are required to implement dust control measures as required by DEC and after consultation with NPS. NANA and its assigns must return the DMTS to the NPS at the end of the easement period in an acceptable condition that meets DEC and EPA standards for management of a public park unit.

The previously stated position of the NPS is that "all reasonable and feasible dust control measures to limit metals pollution should occur throughout the life of the mine. Also, NPS requires that NANA conduct reclamation research during the life of the mine, and that this research should not wait until closure."

Noatak National Preserve (NOAT). Noatak National Preserve is located to the east of Red Dog Mine (Figure 1). NPS is charged with management of this preserve. NPS states that NOAT was established "To maintain the environmental integrity within the preserve in such a manner as to assure the continuation of geological and biological processes unimpaired by adverse human activity; …and to provide opportunities for scientific research [on unimpaired systems]." This preserve was also designated by the United Nations (UN) as an International Biosphere Reserve in 1986, as part of the UN Man and Biosphere program. NPS has expressed concerns about potential influence from fugitive dust from Red Dog. Although evidence of influence in NOAT appears inconclusive at this point, and NOAT is typically in the prevailing upwind direction of Red Dog, this preserve and NPS' management objectives provide context for consideration in the risk management process (NPS presentation, in Teck Cominco 2008).

2.3.4.2 DEC Decision Framework

This section describes the decision-making process used by the DEC Contaminated Sites Program (DEC et al. 2002). The decision framework shown in Figure 2, initially developed in DEC et al. (2002), continues to provide ongoing guidance to the risk assessment and risk management process.

Areas identified as “contaminated sites” are addressed through the Site Cleanup Rules found in 18 AAC 75.325-390. These rules set the processes and standards to determine the necessity for and degree of cleanup required to protect human health and the environment at sites where hazardous substances are located.

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 and conditions are expected to change over time, it would be most practical to develop alternative cleanup levels following closure of Red Dog Mine, 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 2. This risk management plan is being developed to more clearly define the actions to be taken.

As described in the DMTS risk assessment (Exponent 2007a), the approach described above will be protective of human health and the environment for the following reasons:

1. Human health risks were not found to be elevated. 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 and minimize risks.

2. Ecological risks that were observed or predicted for some receptors will be proactively addressed in this risk management plan. This plan will provide a variety of tools to monitor and minimize adverse changes in conditions and pursue environmental improvements.

2.3.4.3 Solid Waste Permitting and Reclamation and Closure Plan

Teck Cominco is preparing a reclamation and closure plan for the area within the Red Dog Mine boundary, as part of the solid waste permitting effort being overseen by DNR. The efforts include working closely with the land owner, NANA, local governments, and the indigenous people of the region in developing an updated reclamation plan, appropriate financial assurances, and solid waste permit for the mine. Permitting efforts will ensure that ongoing mine operations and post-mining land uses will be compatible with the environment and the subsistence lifestyle of the Inupiat people of the region. The DNR permitting efforts will also ensure the necessary steps are being implemented to minimize, monitor, and control acid rock drainage during and after closure of the mine, including long-term water treatment. The scope of the permitting efforts covers the Red Dog mine within the solid waste/ambient air boundary. The solid waste permit is expected to be issued in 2008 and will be reviewed every five years.

2.3.4.4 Mine Area Memorandum of Understanding

A memorandum of understanding (MOU) was entered into September 2005 (and updated in 2007) by and between DEC and Teck Cominco relating to fugitive dust originating upstream of the DMTS at the Red Dog Mine (DEC 2007). Emissions include those originating from activities or sources at the mine, the processing mill, associated facilities and activity zones, prior to transport of concentrate on the DMTS. The MOU also confirms the agreement between DEC and Teck Cominco that results of the risk assessment (Exponent 2007a) and the risk management plan will be incorporated into soil monitoring, vegetation monitoring, and total suspended particulate monitoring programs. The MOU also outlines actions Teck Cominco is taking to take to reduce fugitive dust emissions at the mine (DEC 2007). Regular reports on this work are being submitted to DEC and are posted on the DEC Division of Air Quality website for Red Dog Mine (www.dec.state.ak.us/air/reddog.htm).

2.3.4.5 Air Permits and Ambient Air Boundaries

Fugitive and point source air emissions from facilities at the Mine and DMTS Port are regulated by DEC under Title V Operating Permits No. AQ0290TVP01 issued effective January 1, 2004, and No. AQ0289TVPO1, respectively. Both permits have incorporated facility-specific terms and condition from several Air Quality Control Construction Permits and Minor Source Air permits. The air permits include provisions for the control and monitoring of fugitive dust, including provisions based on federal New Source Performance Standards, state ambient air quality standards and the requirement in 18 AAC 50.045(d) to take reasonable precautions to prevent particulates from being emitted into ambient air.

These air permits established ambient air boundaries around the perimeter of the facilities, which are intended to protect public health and welfare through ambient air quality standards. The areas inside ambient air boundaries are off limits to subsistence use, except for the use of trails to cross the DMTS. Ambient air boundaries for the port and mine, and trail crossings are shown on Figure 1. The ambient air boundary for the road is located 300 ft on either side of the road centerline.

2.3.4.6 Teck Cominco Corporate and Red Dog Policies and Programs

Teck Cominco operates under a Charter of Corporate Responsibility, a set of principles related to business ethics, environment, safety, health and community that govern Teck Cominco's operating practices. Teck Cominco has two Codes: The Code of Sustainable Conduct and the Code of Ethics. Teck Cominco developed a set of Environmental, Health and Safety Management Standards (EHSMS) that put the Charter and Codes into practice and serve as a guideline for all of the company's activities. The EHSMS was modeled after the International Standard organization's ISO 14001 management standards, OHSAS 18001 standards and EPA compliance-focused EMS guidance.

The Code of Sustainable Conduct outlines the Company's commitments to sustainable development. Some of the key sustainability measures include the following:

- Foster open and respectful dialogue with all communities of interest,
- Respect the rights and recognize the aspirations of people affected by our activities,
- Support local communities and their sustainability through measures such as development programs, locally sourcing goods and services, and employing local people,
- Continually improve safety and ensure programs that address workplace hazards are applied to monitor and protect worker safety and health,
- Conduct operations in a sound environmental manner,
- Integrate biodiversity conservation considerations through all stages of business and production,
- Promote the efficient use of energy and material resources in all aspects of business and production,
- Design and operate for closure.

For the complete Charter of Corporate Responsibility, including the Sustainability and Ethics Codes, please visit the Teck Cominco website.

At the Red Dog operation, ISO 14001 certification was established in April 2004 and recertification through third party auditing occurs every three years. Through this system, Red Dog has established an Environmental Management System that tracks compliance with various requirements, and tracks various measures designed to achieve continuous improvement on Red Dog's environmental performance. This system will be one important way in which action items identified in the risk management process are tracked, implemented, and verified.

2.3.5 Public Values

The public values of stakeholders are particularly important to the risk management plan. The following sections outline public values, including community and cultural, economic, consumptive, functional, recreational, and educational values.

2.3.5.1 Community and Cultural Values

Regional residents are rooted in a culture and community that is based on reliance on the land. Their traditional way of life ensures a continuation of a relationship between the people and land, and is a vital element of Inupiat values. The Inupiaq believe they are responsible to all other Inupiat for the survival of cultural spirit, and the values and traditions through which it survives. The Inupiat retain, teach, and live their ancestral traditions through the guidance and support of their Elders.

The Inupiaq values include the following:

- Knowledge of Language
- Knowledge of Family Tree
- Sharing
- Humility
- Respect for Others
- Love for Children
- Cooperation
- Hard Work
- Respect for Elders
- Respect for Nature
- Avoid Conflict
- Family Roles
- Humor
- Spirituality
- Domestic Skills
- Hunter Success
- Responsibility to Tribe

The subsistence lifestyle is very important to the economic, nutritional, and spiritual well-being of the local residents. The Inupiat people depend heavily on subsistence hunting and fishing. While the development of a modern economy has opened many opportunities, subsistence lifestyle continues to have a strong cultural and social significance. As a result, the health of the environment is not only a source of spiritual fulfillment and beauty to the local people, but also, safety of food and water is paramount concern for the residents of the communities in the region. They desire to continue their traditional subsistence lifestyle, and to have adequate information and peace of mind regarding the safety of food and water sources, so that they can be comfortable in teaching these traditions to their children and grandchildren. Thus, they also value participation and involvement with issues and decisions that affect them.

2.3.5.2 Economic Values

Economic opportunity and good-paying jobs are also important to the people of the region. Concerns related to limited regional job opportunities led NANA shareholders to develop the resources at Red Dog Mine. Expected to be productive for 50 years, Red Dog will likely provide lifetime job opportunities for many shareholders that reside in the area. At present, greater than 50 percent of the workers and contractors employed by Teck Cominco are NANA shareholders. Continued educational commitments by NANA and Teck Cominco to the NANA shareholders of the region should enable the companies to continue to increase the percentage of native employment at the operation toward the 100 percent goal outlined in the 1982 agreement between NANA and Teck Cominco (DEC et al. 2002). Red Dog is the primary private employer in the region, as well as the primary source of revenue to regional government.

2.3.5.3 Consumptive (Food and Resource) Values

Subsistence foods are very important to the economic well-being of Northwest Alaskan residents. Approximately one-third of local households are dependent on subsistence, and 55 percent of these households obtain more than half of their food supply by hunting, fishing and gathering. In villages that are far from larger towns, such as Kivalina and Noatak, imported food can be expensive, making subsistence economically important in the area (U.S. EPA 1984).

The local communities that rely on subsistence harvests for food resources value foods that are safe to eat, and water that is safe to drink. Subsistence food safety is of paramount concern to local residents.

2.3.5.4 Functional Values

The tundra and marine environments are valuable to local communities for their functional values. The land and water provide food resources that are relied upon as subsistence foods. These foods include plants and berries, caribou, ptarmigan, seal and other wildlife. The tundra and marine environments also provide key habitats and food resources for wildlife.

2.3.5.5 Recreational Values

Recreational activities that occur in the NANA region include hiking, flying, boating, hunting, fishing, winter sports, and sightseeing. However, many of these activities are done by local residents or are directly related to the subsistence lifestyle. Residents also go snowmobiling in the winter both for recreation and hunting. There are two snowmobile trails that cross the DMTS road (see Figure 1). Recreational activities by non-residents are limited because of the restricted and costly access to the area. However, there is a hunting lodge located on the Wulik River. Other tourist activities include wildlife viewing, photography, archaeology, backpacking, and visiting Cape Krusenstern National Monument. Boating for non-residents usually occurs in the Noatak River within the Noatak National Preserve. Sport fishing and sport hunting are allowed within the Noatak Preserve. Sport fishing usually includes Arctic char, Arctic grayling, and chum salmon. Sheep, bear, moose, and caribou are usually targeted for sport hunting. Very few non-residents visit Cape Krusenstern National Monument for recreational purposes because sport hunting is not permissible (U.S. EPA 1984).

2.3.5.6 Educational Values

The tundra environments surrounding Red Dog Mine, the DMTS road and port support a variety of wildlife and plants. The ecosystem is an outdoor classroom that acts as a valuable teaching tool, especially to local families that pass down traditional ecological knowledge and knowledge related to traditional subsistence lifestyles from generation to generation. The area also provides opportunity for scientific research.

3 Development of Risk Management Goals and Objectives

Goals and objectives for risk management clarify and define what matters to the people involved in the decision-making context. Achieving goals and objectives is the main motivation for making decisions and taking action. Therefore, goals and objectives should reflect what matters to society (U.S. EPA 2001; Stahl et al. 2001). A goal provides a general statement of the desired outcome, while objectives provide more descriptive and specific statements of desired outcome. An overall goal and objectives should be developed with a clear statement of the problem, issue, or opportunity related to the issue. The goals and objectives are important because they guide all remaining steps of the risk management process. The following sections describe what is important (i.e., what it is we want to protect), present an overall risk management goal, describe the characteristics of a good management objective, and present and discuss the fundamental objectives developed for this risk management effort.

3.1 What do we want to protect?

A critical first step in developing effective risk management objectives is to define what we are trying to protect with those objectives. U.S. EPA (2001) defines the objects of protection as "the entities, processes, or places" that may be susceptible to being harmed or that are relevant to the risks being managed. These can be defined more simply as "what matters" to people who have a stake in the process. U.S. EPA (2001) further describes three approaches to deciding what to protect. The first places focus on the "entities," or people, plants, and animals and the habitats in which they live. This is the most common approach and is consistent with standard methods by which risks are evaluated in the risk assessment process. The second is a whole-system approach, where the objects of protection are defined by their whole (e.g., tundra environments) or the functions those systems provide (e.g., subsistence foods, cultural and spiritual fulfillment) rather than the individual components (i.e., the "entities" within the system). In the third approach, the objects of protection are defined by specific geographic locations, termed "special places," such as unique or endangered ecosystems or national parks.

In practice, elements from all three approaches can be used to define the objects of protection. This is important because the list of things that matter may be different for different groups of stakeholders, and different stakeholders may define what matters in a different way. Thus, as part of the risk management process, a preliminary list of what matters was developed. The preliminary list was presented for discussion as part of the Risk Management Planning Workshop and was refined based on input from participants (Teck Cominco 2008). Additional context is provided above in Section 2.3, including the public values discussed in Section 2.3.5. A summary of "what we want to protect" is listed below.

3.1.1 Human Health

- Subsistence resources – caribou and other animal foods, plant foods, drinking water
- Safe living and subsistence food collection environments – soil, water, air
- Safe working environments – soil, air.

3.1.2 Environment

- Plant and animal species – endangered, or in this case, valued species, such as caribou and fish; representative animal species identified in the risk assessment, such as small mammal species (e.g., voles) and ptarmigan; representative or indicator plant species identified in the risk assessment (e.g., mosses, lichens)
- Habitats and ecosystems – terrestrial and aquatic systems, tundra habitats
- Vulnerable, critical, or indicator species for the tundra ecosystem – lichens and mosses, deciduous shrubs; in practice, such indicator species may be used as a measure of the health of habitats and ecosystems, given the baseline understanding available from the DMTS risk assessment (Exponent 2007a), and the mine-area ecological risk evaluation (Exponent 2007c)

- Functions and services of ecosystems – safe and abundant subsistence foods, drinking water, cultural and spiritual fulfillment, economic resources (e.g., recreational, industrial, or commercial use, including current use of the DMTS), livelihood
- Special places – Cape Krusenstern National Monument, Noatak National Preserve.

3.2 Overall Risk Management Goal

The overall goal for managing the fugitive dust issue at Red Dog is:

> *Minimize risk to human health and the environment surrounding the DMTS and Red Dog Mine over the life of the mine and post-closure operations.*

The following sections describe the characteristics of a good management objective, and present and discuss the seven fundamental risk management objectives that were developed to achieve this overall risk management goal.

3.3 Characteristics of a Good Management Objective

An objective is a statement of a desired outcome, indicating what is to be achieved. Three key features characterize a well-defined objective:

- An object – what we want to protect, what is valued
- A direction of preference (or a desired state) – the desired effect of the objective, including language that directs the outcome, such as “reduce” or “maximize”
- A decision context – this connects the result to the decision being made.

Stahl et al. (2001) provides an example of an objective that contains the three necessary elements related to maximizing safety for traveling in automobiles: the decision context is automobile travel, the object is safety, and the direction of preference is to maximize safety. In the case of the DMTS and Red Dog Mine, an example objective would be to "reduce fugitive dust emissions over the life of the mine." Here, the decision context would be "over the life of the mine," the object would be "fugitive dust emissions," and the direction of preference would be to "reduce" (emissions).

Well-defined objectives should also be:

- Complete (leave as little ambiguity as possible)
- Compact (concise, simple, specific)
- Controllable (you can do something about it)
- Measurable (either directly or indirectly)
- Understandable (as simple and clear as possible).

Some objectives are fundamental "ends" objectives, implying what one wants to accomplish; i.e., a desired endpoint. Other objectives are "means" objectives, which are more specific objectives aimed at accomplishing the fundamental ends objectives. Thus, means objectives define how one achieves the fundamental, or ends, objectives. To determine the fundamental objectives for specific means objectives, one must repeatedly ask the question, *"Why is this objective important?"* By answering the question, another objective may be raised that may be either another means objective, or ultimately a fundamental objective. Fundamental objectives are desired statements of the risk management objectives, and should be specific enough to provide guidance to an issue, but general enough to minimize the number of objectives presented.

Objectives should be clearly defined from the beginning of the project, so that all stakeholders are clear about the values at stake in the decision. The stakeholder involvement process is critical for developing clear and effective risk management objectives. A key part of the process for the DMTS risk management plan development was the Risk Management Planning Workshop held in Kotzebue, Alaska, in March 2008 (Teck Cominco 2008). Preliminary objectives were developed and presented at the Workshop for discussion. The objectives were then revised and refined based on stakeholder input, and are presented and discussed in the following sections.

3.4 Fundamental Risk Management Objectives

The following sections present and discuss seven fundamental risk management objectives that are associated with the overall risk management goal presented in Section 3.2.

3.4.1 Objective 1: Continue reducing fugitive metals emissions and dust emissions

The aim of this objective is to reduce the amount of fugitive dust released into the environment near the DMTS and Red Dog Mine to protect human health and the environment. Specifically, this objective is focused on minimizing fugitive dust emissions from the mine, road, and port site, by using effective fugitive dust control measures. The statement of the objective indicates the importance of reducing 1) the concentration of metals in dust (particularly that result from tracking or losses of metal concentrates, or emissions from other mineralized source materials), and 2) dust emissions in general, as dust can have an effect on the surrounding environment even if the composition of the dust does not reflect any significant component of metal concentrates or other mineralized sources. This objective is both current- and future-focused, and encourages and solicits the examination of alternatives for dust control and reduction now and for the future.

During the Workshop, dust control using engineering solutions was ranked as one of the top concerns and desires by many of the stakeholder groups, because it is focused on reducing and controlling the sources of dust. Many of the concerns associated with fugitive dust can be addressed through the reduction of dust emissions.

This objective is also related to Objectives 3 and 4, regarding monitoring, because monitoring is important to verifying the effectiveness of control measures for reducing fugitive metals and dust emissions and demonstrating the safety of subsistence foods. Also, this objective also relates to Objective 6, regarding communication, because providing stakeholders with information about emission control efforts and demonstrating their effectiveness will be key to achieving the goals of this objective.

3.4.2 Objective 2: Conduct remediation or reclamation in selected areas

The purpose of Objective 2 is to improve habitat for people and wildlife through remediation and/or reclamation of affected areas near the DMTS and Red Dog Mine. The focus is expected to be limited to areas near port, road, or mine facilities where metals concentrations are unacceptably high, such as the site of an ore concentrate spill. However, there may be certain limited areas where effects on vegetation are such that natural recovery is unlikely. In these circumstances, remediation and reclamation may also be appropriate.

This objective addresses many of the ethical, aesthetic, and spiritual values that stakeholders associate with the land in the area. It is important because it demonstrates respect for nature, improves the health of the environment, and generates pride for stakeholders in the area. This objective is also important because the availability and quality of subsistence hunting, fishing, and water quality relied upon by subsistence communities are directly related to the health of the ecosystem. Where appropriate, remediation may be followed by reclamation, such that the landscape will support wildlife, and will support the people who rely on the wildlife.

This objective ranked differently among different stakeholder groups present at the Workshop. Groups that ranked it lower cited the fact that remediation and reclamation are already being done or have been done in some areas.

This objective is related to Objective 6, regarding communication, as it is important to provide information on activities that are already being done to remediate and/or reclaim affected areas, so that everyone is aware of current efforts. Likewise, future remediation or reclamation activities should be outlined and shared with stakeholders. Communication will also facilitate the use of traditional ecological knowledge in the process of selecting remediation and reclamation projects.

This objective also relates to Objectives 3 and 4, because there will be a monitoring component involved. Some types of monitoring may serve all three of these objectives. A monitoring program that effectively tracks changes over time in areas where dust deposition occurs may help in determining whether there are specific areas that should be targeted for remediation or reclamation. Also, monitoring would provide information needed to determine whether areas that have already undergone remediation and/or reclamation are recovering in the expected manner, or if additional actions might be needed.

3.4.3 Objective 3: Verify continued safety of caribou, other representative subsistence foods, and water

The purpose of this objective is to ensure that traditional subsistence foods that are relied upon by the local people continue to be safe to eat. This would be accomplished through a monitoring program. An important part of this objective is to maximize the use of local traditional ecological knowledge when designing and implementing monitoring to verify the safety of subsistence foods. The monitoring results will enable the local people to make more informed personal decisions regarding where to hunt and harvest, and what to eat.

During the Workshop, many people expressed concerns regarding exposure to metals and dust from consumption of subsistence foods, including plant foods such as berries and sourdock. There were also general concerns about how metals in foods travel through the food chain, from plants and berries to wildlife that consume plants and berries, and finally to humans that consume plants, berries, and wildlife. Some concerns were very specific, including descriptions of how ptarmigan taste and smell different than they have in the past. Other concerns were more general, considering whether consumption of subsistence foods and water could affect human health. Based on input received during the Workshop, the statement of Objective 3 was modified to explicitly identify caribou because of their paramount importance as a food source, and for their cultural, spiritual, and social importance.

Some concerns were expressed at the Workshop regarding the condition of fish in the Wulik and Ikaklukrok Rivers. There was mention of fish with parasites, missing fins, missing skin, and abnormally shaped fish caught in the nets. Others have noted Dolly Varden stomachs full of salmon eggs but had not seen this before and were curious as to whether spawning areas are present in Ikaklukrok Creek. Others were interested in Dolly Varden migratory patterns in Russia and the North Slope, and whether Dolly Varden are exposed to contaminants in those areas that would render the Dolly Varden unsafe for human consumption. Some stakeholders have described more worms in fish than previously observed.

An effective monitoring program would help achieve the goals of Objective 3, and would involve examination of any specimens collected in the field that seem abnormal or unusual, in addition to other samples of harvested subsistence foods. Abnormal specimens would need to be submitted for examination and analysis to determine what may be causing the abnormalities, and whether the abnormalities are related specifically to fugitive dust from the mine area.

Designing a monitoring plan that will assist individuals in personal decision-making will be a major focus of this objective. Stakeholders expressed that monitoring guidelines that would assist with personal decision-making would be useful.

It will be important to incorporate traditional ecological knowledge into the design and implementation of the monitoring efforts. Some people at the Workshop expressed the need to ensure that sampled foods are representative of what people are actually harvesting. Samples for monitoring should be collected from areas where people harvest, and during the times of year when the harvest is occurring so that results are relevant. Details such as where and how often to collect samples will be determined as part of the implementation effort for this objective.

This objective was included as part of the risk management to exclusively focus on human consumption of subsistence foods and water. Monitoring of ecological habitats and wildlife is discussed in Objective 4.

Monitoring and verification of the safety of subsistence foods discussed in this objective is also related to Objective 6, regarding communication and collaboration. Communication and collaboration regarding monitoring design is important, as discussed above. Also, results from monitoring efforts should be communicated to local residents as efficiently and clearly as possible.

3.4.4 Objective 4: Monitor conditions in various ecological environments and habitats, and implement corrective measures when action levels are triggered

Objective 4 is focused on monitoring ecological habitats that both humans and wildlife rely on. The goal of this objective is to monitor ecological habitats to ensure safety for humans and wildlife. This objective is related to every other objective, and was ranked as a high priority for many of the groups that participated in the Workshop. The relationships between this objective and the other objectives are described in the following paragraphs.

Monitoring is an important component of Objective 1, because through monitoring, stakeholders will know whether emission controls for fugitive dust are effectively reducing fugitive dust at the sources. Monitoring is also important for Objective 2, regarding remediation and reclamation. A monitoring program that effectively tracks changes over time in areas where dust deposition occurs may help in determining whether there are specific areas that should be targeted for remediation or reclamation. Also, monitoring would provide information needed to determine whether areas that have already undergone remediation and/or reclamation are recovering in the expected manner, or if additional actions might be needed. Objective 4 also links closely with the subsistence-related monitoring that is the focus of Objective 3. There are likely to be some elements of a monitoring program that help to meet both Objectives 3 and 4, and possibly also the monitoring needs of Objective 2.

A number of Workshop participants expressed their perspective that monitoring is the most effective form of uncertainty reduction, which is why they rated it more highly than Objective 5, the purpose of which is to reduce uncertainty related to effects of fugitive dust to humans, wildlife, and the environment through additional studies. Many people at the Workshop expressed their desire to know how far metals dust travels from the trucks, conveyors, barges, and mine through the environment, and the levels of lead present. Others expressed concern for terrestrial vegetation, including mosses and lichens that surround the road system and beyond, and water bodies, including the Noatak River, Wulik River, Ikaklukrok Creek, Bons Creek, Evaingiknuk Creek, and marine waters near the barge- and shiploading facilities. Some Workshop participants indicated a desire to implement air sampling and monitoring programs for the villages of Kivalina and Noatak. Stakeholders expressed concerns about the respiratory health of people who live in the villages, particularly the children, and whether additional studies would need to be undertaken to address uncertainty related to the potential for health effects. Some Workshop participants were concerned about effects to the environment and the marine wildlife in the barge-loading nearshore and shiploading (offshore) waters, and wondered whether effects may be more far reaching than previously realized. Again, an effective monitoring program would be important to address these concerns.

As explained in this section, this objective regarding ecological monitoring of environments and habitats is linked to every other objective, including the improvement of communication (Objective 6) among all stakeholders. Developing effective monitoring programs that provide comprehensible monitoring results to all stakeholders, and aid in decision-making, will be paramount to the success of the goals of risk management.

3.4.5 Objective 5: Conduct research or studies to reduce uncertainties in the assessment of effects to humans and the environment

Objective 5 is concerned with reducing uncertainties related to the previous assessments of effects to humans, wildlife, and the environment. This objective is related to Objectives 3 and 4 regarding monitoring. Some reduction of uncertainty will result from monitoring programs, which will be developed using traditional ecological knowledge. However, the focus of

Objective 5 is to address areas of uncertainty that may require additional study or research efforts beyond the monitoring programs related to Objectives 3 and 4. Examples of studies to reduce uncertainty include the evaluation of weathering of dust particles in the environment, and assessment of the bioavailability of metal forms present in the environment at Red Dog. As described in Section 2.3.3.4, some work has already been done to address these areas of uncertainty.

Objective 5 is also related to Objective 6, regarding improving communication among stakeholders. It is possible that some uncertainty currently exists because of language barriers. In this case, uncertainty reduction could potentially be achieved through translation and use of traditional ecological knowledge and terms. For example, at the Workshop, stakeholders expressed concerns regarding effects of fugitive dust to soils, plants, animals, mosses and lichens, and human health. Previous assessments that have already been conducted to address these concerns might be more useful and informative if translated and described in terms familiar to all stakeholders, as opposed to only being in the format of an agency-reviewed risk assessment.

Objective 5 did not rank as highly as other objectives with the groups of stakeholders that were present at the Workshop. Some stakeholders mentioned that uncertainty reduction is important, but monitoring (addressed in Objective 4) would be considered a form of uncertainty reduction, and if done well and combined with improved communication (the goal of Objective 6) the need for additional studies may be reduced.

3.4.6 Objective 6: Improve communication and collaboration among all stakeholders

This objective is important because it is considered the most overarching of all the objectives listed in this risk management plan. The goal of this objective is to improve communication to build and maintain trust and collaboration among all stakeholders. This objective was ranked as a high priority for many of the stakeholder groups present the Workshop.

Communication and collaboration are the key goals of this objective. Multi-directional communication was stressed repeatedly as a goal throughout the meeting. This was noted because all stakeholders shared the desire to understand the concerns of other stakeholder groups. A series of presentations describing the ecological and human health risk assessments and other studies conducted previously were given during the Workshop. Although these presentations were intended for information-sharing purposes, some people commented on the need for translation, as many of the terms used in these presentations are technical. Clarification and translation of studies and documents that already exist could improve communication and collaboration.

Traditional ecological knowledge was another important aspect covered as part of Objective 6. Incorporating traditional ecological knowledge into study designs would benefit all parties by increasing common understanding and ensuring that information is shared with all stakeholders. Also, traditional ecological knowledge, combined with translation, would offset any confusion related to terminology between groups. For example, during the Workshop, someone questioned whether a plant species shared two different common names. In cases like this, incorporation of traditional ecological knowledge would increase understanding among all stakeholders. Ideas for this sort of information sharing were offered during the Workshop. Some stakeholders suggested hiring and training local people from Kivalina and Noatak to assist with designing monitoring strategies and plans. This would build trust among stakeholders; increase confidence in field sampling, study design, and study results; and improve communication among groups.

Another idea that was discussed during the Workshop involved the development of an Internet portal where study results, photos, announcements, and other information could be found one place, so that everyone would have access to the same information. For example, information about caribou migration could be assembled in the portal and updated regularly. This portal would need to be maintained on a regular basis to ensure that any dust-related information, such as results from monitoring programs (for subsistence foods such as caribou, fish, and ptarmigan), is communicated and shared regularly.

Another important aspect of multi-way communication is related to irregularities or abnormalities in items harvested during subsistence activities. For example, at the Workshop, one stakeholder mentioned that two caribou were harvested in March but they were disposed of due to sickness. Some Tribal Elders have noted differences in fish, and another stakeholder mentioned observations of missing fins. These are additional examples of where communication can be improved. When subsistence harvesters and fishermen find abnormalities in fish, other wildlife, or any other subsistence food, it is essential to report and preserve these items so that they can be studied. Through continued studies, along with the inclusion of traditional ecological knowledge, uncertainty would be reduced and communication and collaboration would be improved.

During the Workshop, people commented that one of the goals was for different groups to continue working together to develop a common understanding. One stakeholder expressed the desire for the villages of Kivalina and Noatak to meet on a scheduled basis, and another stakeholder expressed the need for Kivalina to build a strong tribal government so that it can implement its own environmental program to balance the state and federal government studies. This is another example of how communication can strengthen collaboration among and within stakeholder groups.

In summary, this objective related to communication and collaboration is intended to provide for multi-directional communication among stakeholders. By improving communication, uncertainty is reduced. More work is needed to ensure that information is presented in an understandable manner for all stakeholders involved. Communication and collaboration is an overarching objective that ties into every one of the other objectives.

3.4.7 Objective 7: Protect worker health

The goal of Objective 7 is to continue to protect worker health as it relates to exposure to fugitive dust. Objective 7 is the direct result of discussion that took place during the Workshop. During the Workshop, specific concerns were expressed related to the potential for dust exposure of employees at the mine. In addition, concern was expressed regarding the potential for employees to bring dust from the mine into their homes via clothing, boots, and other garments. It should be noted that the existing industrial hygiene and health and safety programs do address these issues. Thus, efforts made to achieve Objective 7 will tie into these existing programs.

Protection of worker health is related to communication and collaboration (Objective 6) and continued reduction of fugitive dust (Objective 1). Monitoring programs (Objective 4) that address worker health will be essential to determining whether exposures are being reduced through education and communication, as well as source controls (Objective 1).

4 Evaluation of Actions to Achieve Risk Management Objectives

4.1 Categories of Risk Management Actions

The risk management objectives discussed in the previous section can be achieved using a variety of types (categories) of actions. The categories of risk management actions are described below, followed by a discussion of their strengths and limitations and a review of general stakeholder preferences for each of these categories of actions.

4.1.1 Overview of Categories

The primary categories within which risk management actions can be classified are engineering controls, remediation/reclamation, institutional controls, monitoring, uncertainty reduction, and communication and collaboration.

- **Engineering Controls—**The category of engineering controls includes the use of both physical and procedural controls to reduce or eliminate fugitive dust emissions from activities throughout the operation (i.e., at the mine, along the DMTS, or at the port).
- **Remediation and Reclamation—**Remediation is used to remove contaminants from areas where they have concentrated and may pose a risk to humans or wildlife. Remediation activities are focused on removal as a remedy for areas with higher concentrations of metals that were not naturally occurring there. Reclamation seeks to improve disturbed or degraded areas to achieve a healthy and functional state.
- **Institutional Controls—**Institutional controls are used to minimize exposure by limiting access to areas that may pose a risk or to areas that are undergoing remediation or reclamation and should not be disturbed.

Institutional controls can include signage alerting people to potential risk, physical restrictions (including fences), or legal agreements to limit access.

- **Monitoring—**Monitoring is used to measure the status of specific human health, ecosystem, or environmental parameters, and changes in that status over time and/or space. Monitoring activities should be tied directly to the specific risk management objectives identified for the site, and tailored to address stakeholder concerns.

- **Uncertainty Reduction—**Uncertainty reduction involves the use of carefully planned scientific studies to address gaps in our current understanding of human health, ecological, or environmental processes that limit our ability to accurately characterize potential risks. Studies are designed to answer specific questions where further information would inform the risk management process.

- **Communication and Collaboration—**Communication and collaboration actions are overarching and integral to all of the other risk management action categories. This category of actions is included to ensure that all stakeholders are provided the opportunity for information sharing and continued input to risk management through a collaborative process. Communication and collaboration are intended to be multi-directional and may include public meetings, presentations that include traditional ecological knowledge, web portals, and opportunity for meaningful input into study planning, conduct, and reporting.

4.1.2 Strengths and Limitations

Each category of risk management actions has inherent strengths and limitations in its ability to address the fundamental objectives identified for the site. As part of an effort to determine which risk management actions best address each objective, stakeholders were asked at the Workshop to identify perceived strengths and limitations of the risk management action categories (Teck Cominco 2008). This exercise was planned to facilitate discussion about what each individual and stakeholder group considers most important for their areas of concern or responsibility.

Engineering Controls—A number of strengths associated with engineering controls were discussed, with most relating to the perception that engineering controls produce tangible results immediately. Specifically, engineering controls designed to limit dust emissions were seen to have a direct benefit. Engineering controls were thus characterized as a "Doing Something" option. Limitations discussed included technical feasibility or implementability, considering the situation and conditions at Red Dog. These limitations do not imply that it is not possible to incorporate additional controls. Rather, they are helpful in identifying which engineering controls will be the most effective.

Remediation/Reclamation—Remediation and reclamation activities were also characterized as the "Doing Something" option. These activities were perceived to result in greater protection of wildlife, with the potential to improve the integrity of the land and the outlook of local people who use the areas surrounding the mine. Limitations inherent in remediation and reclamation projects relate to the unintended consequences of these types of activities. For example, non-native plant species may colonize remediated or reclaimed areas, or other varieties of native species might accidentally be introduced to the areas. Site hydrology may present challenges for revegetating tundra areas. In most cases, it is not clear how long it may take native vegetation to return to the remediated or reclaimed area. For remediation activities, derivation of appropriate numeric target levels as a target for completion of remediation can be complex. If plants are used for phytoremediation of affected areas, those areas will need to be monitored and maintained. Finally, if remediation and reclamation are implemented, opportunities for natural attenuation and recovery may be missed.

Institutional Controls—Institutional controls are effective at alerting people to use caution near specific areas or to avoid the areas altogether. They are relatively easy to implement and relatively inexpensive. However, people may not heed warnings on signs, and it can be difficult to monitor compliance or effectiveness. In addition, there could be instances where an institutional control implemented to minimize one hazard increases another hazard. For example, signage placed along the roadway to indicate a safety hazard may become hidden in a snowdrift and constitute a hazard to snowmobilers. Aside from maintenance issues to ensure that signs are kept current and visible, the signs may not have much influence on people's activities if the recommendations are in conflict with people's needs or desires. Local knowledge, combined with community workshops, could improve compliance and effectiveness.

Monitoring—Monitoring activities provide a direct measure of current conditions and an indication of changes over time and space. Therefore, monitoring can serve as a form of uncertainty reduction, because the results help stakeholders understand the direct effects of fugitive dusts on their food supply, their water supply, and the surrounding environment and wildlife. Developed properly, monitoring plans can be implemented easily, will inform and guide future actions, and may help to evaluate the effectiveness of engineering controls. Limitations related to monitoring actions include potentially high costs, the potential for ambiguous results that may suggest a need for additional studies, and lack of confidence by some stakeholders in the results (particularly if they were not part of the monitoring program design or implementation process). In addition, it may be difficult to interpret the data, and to decide what actions to take based on the findings. These limitations could be overcome by developing well-designed monitoring plans, ensuring that adequate sample sizes are used, and incorporating traditional ecological and local knowledge into the monitoring designs. Results should be communicated in a manner that is clear and understandable for all stakeholders.

Uncertainty Reduction—Uncertainty reduction actions are designed to improve understanding of fugitive dust effects, exposure, and risk through additional studies, research, or analysis. In the process, stakeholders are provided with the information they need to make informed personal decisions related to risk management. Uncertainty reduction actions can provide an additional benefit by addressing specific stakeholder concerns and thereby improving trust. Uncertainty reduction is partially addressed through other risk management categories, such as monitoring activities, and communication. However, uncertainty is an inherent component of all aspects of life, including science. Thus, the major limitation related to uncertainty reduction is the inability to completely eliminate uncertainty. As a result, there will always need to be some level of uncertainty that is accepted in any of the scientific studies that are implemented, and assumptions will always need to be made based on scientific and cultural judgment. Once the inevitability of some degree of uncertainty is accepted, the primary challenge becomes determining the area of study that provides the greatest reduction in uncertainty. Using information and knowledge from all stakeholder groups during the planning process for uncertainty reduction studies may help improve effectiveness of the studies and confidence in the results.

Communication and Collaboration—Communication and collaboration actions were characterized as overarching risk management action categories, because they build trust, inform decisions, reduce confusion, and promote honesty. Multi-directional communication and collaboration will inform all stakeholders of uncertainty reduction studies and engineering control technologies that are already being incorporated. Participation by all stakeholders will provide a sense of ownership and understanding throughout the risk management process. By incorporating traditional local and ecological knowledge on a regular basis, issues can potentially be resolved more effectively and efficiently. Communication and education efforts can help to reduce the gap between perceived and actual risk. Potential limitations of communication and collaboration involve the challenges of keeping commitments on a regular interval, and the logistical considerations involved with developing communication networks that all stakeholders can access. Communication and collaboration of ideas and results may need to be presented in several different formats so that all stakeholders can understand the implications. There exists a language barrier between some stakeholder groups, and there also exists the potential for oversight and lack of representation if stakeholder groups choose not to participate.

4.1.3 Stakeholder Preferences

Six categories of risk management actions were listed as potential options for addressing the risk management objectives outlined earlier in this document. During the Workshop, stakeholder participants were asked to discuss each of the six risk management action categories, and for each stakeholder group to assign a score to each category. The purpose of this exercise was to assess which of the categories of risk management actions are more valued and preferred by the stakeholder groups as tools to help achieve the risk management objectives. The scores assigned by each stakeholder group were averaged to obtain an overall score for each action category. The action categories are listed below in order of the Workshop participants' overall preference.

- Engineering Controls = 1
- Monitoring = 2
- Remediation/Reclamation = 3
- Communication/Collaboration = 4
- Uncertainty Reduction = 5
- Institutional Controls = 6

Engineering controls scored number one overall, and five of the seven stakeholder groups present at the Workshop selected engineering controls as their most important category of risk management actions. Institutional controls had the overall lowest score, with five of seven groups rating it as the least preferred category. Monitoring activities were ranked second, and remediation/reclamation as third. Communication and collaboration was ranked fourth. However, during discussion in the Workshop, communication and collaboration was characterized as an overarching category that should be an integral component of all risk management actions.

Uncertainty reduction ranked fifth, but was tied in some participants' minds to the highly ranked monitoring category. Stakeholders felt that monitoring would reduce uncertainty if planned and executed well. Additional studies to reduce uncertainty might not provide as much information and in as timely a manner as monitoring results. Monitoring would also link to determining the success or failure of engineering controls and remediation/reclamation activities.

Remediation/reclamation ranked highly for some groups, because stakeholders felt that, similar to engineering controls, remediation/reclamation would reduce potential exposure. However, other groups did not rank remediation/reclamation as highly, not because they believe those are ineffective, but because they understood these activities to be already in progress or largely completed. The ranking differences between stakeholder groups illustrated differences in perception and highlighted the desire and need for a regular program of communication and information sharing.

4.1.4 Potential Risk Management Actions

During the Workshop, stakeholder groups were asked to list and discuss potential actions for each of the six risk management action categories described above. Table 1 presents the complete list of potential actions that would help achieve the risk management goals described above. Table 1 also presents a refined list of potential actions, which groups together duplicative or similar actions and clarifies the language or intent of each action where needed.

4.2 Evaluation Criteria for Potential Actions

As described in the previous section, a variety of potential actions were discussed during the Workshop. This section describes the criteria by which these potential actions were further evaluated and scored, to help prioritize those actions that may be more effective for achieving the fundamental objectives.

To evaluate the potential actions, they were grouped into several smaller tables (Tables 2–8), which are organized according to the individual fundamental objectives. Each potential action for each risk management action category was then scored based on three criteria: effectiveness, implementability, and level of effort. In addition to these criteria, two additional criteria were incorporated: "Stakeholder Preference for Risk Management Action Category" and "Stakeholder Preference for Potential Actions." These scores were calculated using input from the stakeholders at the Workshop. The methodology and the outcome of this evaluation are described below and summarized in Tables 2-8.

4.2.1 Effectiveness

The "effectiveness" criterion refers to whether the action is likely to meet the goals of the objective. This was evaluated in two parts: 1) Specificity—whether the action is directly relatable to the objective, and 2) Sensitivity—whether the action can detect or produce a measurable difference. Combining these two concepts, each action was scored on a scale of one to three for effectiveness, with one being extremely effective, and three being not effective. For example, the potential action "Implement operational monitoring program to evaluate effectiveness of dust control measures" (Table 2) was scored "1" for very effective, because this potential action would be specific to the objective of reducing dust, and it would be sensitive to the objective, meaning it would produce information that could be used to evaluate whether the objective is being met. In contrast, the potential action "Add hard pavement to the entire road surface" would not be effective, because it would not necessarily reduce dust and the effect would not be easily measured. As a result, this action received a score of "3," or not effective. The effectiveness scores are included in Tables 2–8.

4.2.2 Implementability

The "implementability" criterion refers to whether the potential action is feasible, already in use, or available for the region. Highly implementable potential actions received a score of "1," medium implementability scored a "2," and a score of "3" was used if implementability of the action was low, or if the action would require a great deal of study to be implemented. Although a technology or potential action may have been used at other sites, it may not necessarily be a good candidate for meeting the objectives in the vicinity of the Red Dog mine. For example, the potential action "Evaluate phytoremediation for removal of metals from soil" (Table 3) has been effective in areas of relatively stable climate, where plants grow fast, but the technology may not work as well in an Arctic ecosystem. Therefore, phytoremediation technology received a score of "3" for the implementability criterion, due to the uncertainty and lack of information for success of this technology in the region. The implementability scores are included in Tables 2–8. In a few cases, potential actions were considered not feasible, in which case the action was scored as "NF" and thus will not likely be considered further for risk management purposes.

4.2.3 Level of Effort

The "level of effort" criterion incorporates both the general amount of time and the general cost of the potential action as measures for accomplishing the action. Similar to the above two criteria, level of effort is also scored on a scale from 1 to 3, with the easiest and least costly actions scored as "1" and the most costly as "3." The level of effort scores are included in Tables 2–8.

4.2.4 Stakeholder Preference for Risk Management Action Categories

As described in Section 4.1.3, during the Workshop, each stakeholder group was asked to score the six risk management action (tool) categories that were identified during discussions. The scores assigned by each stakeholder group were averaged to obtain an overall score for each action category. The scores assigned by each stakeholder group were averaged to obtain an overall score for each action category. The action categories are listed below in order of the Workshop participants' overall preference.

- Engineering Controls = 1
- Monitoring = 2
- Remediation/Reclamation = 3
- Communication/Collaboration= 4
- Uncertainty Reduction = 5
- Institutional Controls = 6

In order to use these scores as one of the criteria for evaluating potential actions, they were normalized to a scale of 1 to 3, to be consistent with scale for the effectiveness, implementability, and level of effort scores. Thus, the engineering and monitoring categories received a score of "1," remediation/ reclamation and communication/collaboration received a score of “2,” and uncertainty reduction and institutional controls received a score of “3.” These scores are included in Tables 2–8 (see “Stakeholder Preference for Action Categories” column).

4.2.5 Stakeholder Preference for Potential Actions

During the Workshop, a similar exercise was conducted wherein the stakeholder groups scored each individual potential action within the action categories. A list of potential actions that were identified by the stakeholders was compiled and presented to the stakeholder groups. Each group was asked to score each potential action as “Very Effective,” “Effective,” Somewhat Effective,” or “Not Effective” at meeting the fundamental objectives. While discussing the scoring approach for the potential actions, it was noted that some of the actions were “Not Feasible,” and therefore, this category was added to the table.

In some cases, a few additional potential actions had been discussed earlier in the Workshop but were not included in the “scoring exercise.” As an effort to incorporate all potential actions, the list of actions was augmented with these additional items, and these additions are identified with a footnote in Table 1. Scores for these additional actions were assigned based on the stakeholder scores of similar actions.

The stakeholder group scores for each potential action were averaged to derive an overall score for each action. As with the category scores, potential action preference scores were normalized to a scale of 1 to 3 to be consistent with the other scoring criteria. Thus, the range of overall scores was divided into three equal parts, and the most highly rated third of the actions received a score of “1,” the middle third received a score of “2,” and the lowest rated third of actions received a score of “3.” These stakeholder preference scores are included in Tables 2–8 (see “Stakeholder Preference for Potential Actions” column). In this manner, stakeholder input was incorporated into the overall score through both the category scores and the individual scores for potential actions.

4.3 Priority Ranking Results

Once all criteria and stakeholder preferences were ranked, the five individual criteria scores were summed to derive a total score (Tables 2–8). The total scores ranged from 5 to 14. The total scores were then converted to a scale of 1 to 3 to be consistent with the individual criteria ranking system. Potential actions with a total score between 5 and 8 were assigned a priority ranking of "1," potential actions with a total score of 8 or 9 were assigned a priority ranking of "2," and potential actions with a total score greater than 9 were assigned a priority ranking of "3."

5 Implementation of Actions

This section outlines the planned scope for implementation of actions to achieve the risk management objectives. Emphasis will be placed on implementation of higher priority actions indentified in Tables 2–8; however, any and all actions that are appropriate may be incorporated to develop coherent plans to achieve the risk management objectives. The plans to be developed include the following:

- Communication plan (addressing Objective 6, and integral to all efforts)
- Dust Emissions reduction plan (addressing Objective 1)
- Remediation plan (addressing Objective 2)
- Monitoring plan (addressing Objectives 1, 3, and 4)
- Uncertainty reduction plan (addressing Objective 5)
- Worker dust protection plan (addressing Objective 7).

The scope for each of these plans is outlined in the following sections. For each plan, an overview of actions taken to date is provided, and further actions are discussed, wherein the scope for development of the plan is outlined. The scope elements for each plan include the following:

- **Objectives—**The scope identifies the previously defined fundamental objectives that each plan is associated with, and defines the specific goals for the plan to be developed. Any limitations to the scope of the effort are identified.
- **Tasks—**The general tasks for the plan are identified and described. Each plan will incorporate as many of the individual prospective actions (from the associated table(s) of prospective actions) as can reasonably be implemented, with particular emphasis on those that are ranked more highly. Actions taken

to date will also be reviewed and evaluated, and where appropriate, modified as needed and incorporated into the plan.

- **Milestones—**The major milestones are identified for subsequent use in establishing a project schedule for the plan. The stepwise process using milestones will facilitate stakeholder involvement, and establish incentives for the progress of plan development. For each milestone, the appropriate forms of communication and collaboration will be incorporated, for example, public presentations, and public review and comment. The public presentations may be implemented through the form of periodic updates on development and implementation status of the plans. Regardless, the communication and collaboration efforts that are ultimately implemented will be consistent with the communication plan to be developed.

- **Stakeholder Roles—**Stakeholder roles are identified, including the authors of the document and a suggested list of technical reviewers, as needed. These lists can be modified through comments made on the scope. Review and input will be invited from all stakeholders as well, at appropriate milestones throughout the plan development.

5.1 Communication and Collaboration

The following sections describe communication and collaboration actions taken to date, and outline a scope for future actions through development of a detailed communication plan.

5.1.1 Actions To Date

Many of the communication related actions identified in Table 7 have been or are currently being implemented in some form. Examples of past or current communication efforts include:

- Recent fugitive dust risk management Workshop held in Kotzebue for stakeholders (Teck Cominco 2008).

- Village meetings and workshops associated with reclamation and closure plan development. Reclamation and closure planning includes dust-related management issues for areas within the mine boundary.

- Developed and entered into an MOU with DEC to communicate actions being taken on fugitive dust related activities and invite agency participation in the development of the actions.

- Public process associated with the DMTS risk assessment between 2002 and 2007. Public involvement included public presentations and/or comments on the conceptual site model, work plan, sampling plans, and draft risk assessment. A chronological summary of public involvement is provided in the fact sheet for the risk assessment (Exponent 2007b).

- Formation of the Ikayuqtit Team to promote fugitive dust data exchange and communication between NANA, Teck Cominco, AIDEA, and the NPS.

- Periodic meetings and presentations to the villages in the region, which include collecting comments for Teck Cominco to provide follow-up.

- Working with state agencies to post documents on state websites for public access and review.

5.1.2 Further Actions

Additional actions to be taken to improve communication and collaboration will be defined in detail in a communication plan. A scope for the communication plan is outlined below, including discussion of objectives, tasks, milestones, and stakeholder roles.

5.1.2.1 Objectives

The development of a communication plan follows from risk management Objective 6, which is to "Improve collaboration and communication among all stakeholders." Thus, the goal of the communication plan is stated as follows:

Communication Plan Goal: "To establish consistent methods for communication and collaboration among stakeholders regarding efforts related to dust emissions issues."

Although the focus of the communication plan will be on dust-related issues, it will likely be of general value for other efforts at Red Dog that involve stakeholder communication and collaboration.

5.1.2.2 Tasks

To achieve the plan objective, preparation of the communication plan will involve the following tasks:

- **Review and selection of actions.** From the prospective actions associated with Objective 6 (summarized in Table 7), actions will be reviewed and selected for incorporation into the plan.
- **Evaluation of prior and ongoing actions.** The effectiveness of actions taken to date (i.e., those outlined above) will be reviewed and evaluated. Where appropriate, these actions will be modified or improved, and incorporated into the plan.
- **Define a standard set of communication and collaboration action items.** A standard set of communication and collaboration action items will be prepared for use in preparing new plans or programs related to fugitive dust issues. This will facilitate a consistent approach to collaboration and communication in future plans and programs.
- **Periodic review and reporting.** The plan will identify an appropriate frequency for reviewing the completeness and effectiveness of the plan in meeting fundamental Objective 6, and will describe an approach to providing a report and recommendations for improvement.

5.1.2.3 Milestones

The following steps in study planning, design, review, and reporting are points in the process where communication and review with stakeholders is likely needed. These milestones will be used in the draft communication plan to define a project schedule.

- Scope – the draft scope for the communication plan is provided within this document
- Draft plan
- Final plan
- Periodic review and reporting – see discussion above in Tasks.

5.1.2.4 Stakeholder Roles

Red Dog Operations will prepare the draft plan. Review will be invited from all stakeholders.

5.2 Dust Emissions Reduction

The following sections describe actions taken to date to reduce dust emissions, and outline a scope for future actions through development of a detailed dust emissions reduction plan.

5.2.1 Actions To Date

Teck Cominco has implemented a variety of dust control measures to reduce dust emissions. Efforts to reduce dust emissions are ongoing at facilities in the mine area, along trucking areas on the road, and at unloading, storage, transfer, barge-loading, and ship-loading facilities at the port. Dust control measures for the port and road are summarized in Appendix L of the DMTS Fugitive Dust Risk Assessment (Exponent 2007a), and for the mine in Appendix D of the Draft Evaluation of Ecological Risk within the Ambient Air/Solid Waste Permit Boundary (Exponent 2007c). Dust control measures that have been implemented include both physical and procedural controls. Examples of modifications and improvements made to road, port, and mine facilities and operations are described below. A more complete listing is provided in the references listed above.

5.2.1.1 Road

Truck Fleet Improvements—Since the fall of 2001, concentrate spillage and escapement has been significantly reduced by using newer trucks that produce less dust when unloading, have better handling characteristics to reduce the potential for rollover, and have hydraulically closed steel covers and solid sides that greatly reduce the potential for concentrate to escape during normal transit or in the event of an accident. Improvements were made to the loading and unloading facilities as well.

Road Dust Controls—Ongoing efforts to minimize transport mechanisms from the DMTS road surface include physical and procedural controls that were implemented to limit tracking, removal of metals-containing road material, application of dust control agents (palliatives) to road surfaces, and paving of road surfaces. Calcium chloride is applied regularly to road surfaces as the primary palliative. Other palliatives are being evaluated in an attempt to improve dust control on road surfaces. A test program was implemented to evaluate the effectiveness of paving the road surface using a "Hi-Float" product.

5.2.1.2 Port

Physical Dust Controls—Significant upgrades have been made at the DMTS Port facility to the surge bin and truck loading and unloading facilities, and full enclosures have been added to all conveyers between the CSBs and the shiploader.

Concentrate Storage Building Improvements—Improved dust control procedures have been instituted within the DMTS Port CSBs to reduce fugitive dust emissions during unloading and handling of the concentrates. Also, diesel exhaust particulate filters have been installed on dozers operating within the CSB, and loading hoppers were fitted with passive stilling bin hoods to reduce dust generation during ship loading operations.

Conveyer and Shiploading Enclosures and Improvements—The conveyors and surge bin between the CSBs and the shiploader have been upgraded to significantly reduce dust emissions from these facilities. Significant modifications were made in 2003 to the shiploader and barges, including full enclosure of the shiploader conveyor and installation of baghouses to actively collect dust within the barge offloading conveyer system.

5.2.1.3 Mine

Procedural Controls—Standard operating procedures for concentrate handling were modified and improved in 2001. Procedural changes were made to keep the water in the tailings impoundment as high as possible, given competing water management considerations, to reduce windblown dust from exposed tailings. However, in recent years to maintain water balance this practice has been reduced and the focus shifted to the use of palliative to control dust from exposed tailings. In-pit stockpiling of ore was re-introduced in 2004 to minimize exposure of the stockpiles to wind.

Vehicle Tracking Reductions—Additional dust controls have also been implemented in truckloading at the mine CSB to reduce tracking of dust from the mine on truck surfaces. The mine CSB was modified creating a loading drive-through, eliminating the practice of driving the trucks over the concentrate, within the CSB, for loading. A concentrate truck wash was installed for use during non-freezing conditions. Steel grating was installed at the CSB truck drive-through to control any concentrate spillage onto the floor, so that concentrate is not picked up by the tires and tracked.

Building Enclosures and Dust Control Systems— A dust control system was installed at the mine CSB truck loading bay to contain any entrained dust during loading operations, and fans to draw entrained dust back to the mine CSB, and away from concentrate trucks and trailers. Stilling curtains were installed to further enhance the collection of the loading generated dust. The mill site ore conveyer take-up pulleys and the mine CSB take-up pulley were relocated inside the mill to eliminate potential spillage and carry back. The mine CSB vents were covered, and the CSB truck loading bay and coarse ore stockpiles have been fully enclosed. In recent years several large dust collection systems were installed for the primary jaw and gyratory crushers, the Coarse Ore Storage Building, and the mine CSB.

Surface Area Controls—Watering trucks have been used since the 1990s to reduce road dust emissions. Water-truck cycle times in the pit and pit haul roads were increased in 2005 by adding new water fill stations and tanks to make water-truck filling more efficient. A large water truck was purchased to facilitate implementation of additional dust control measures (watering and palliative application) on roads and yards. Eight "windrows" were constructed using waste rock on the tailings beach. Soil-Sement® palliative was applied to a portion of the tailings beach to reduce windblown transport of fine tailings.

5.2.2 Future Actions

Additional actions to improve dust emission reduction measures will be defined in detail in the dust emissions reduction plan. In addition, the actions listed above will also be reviewed in that plan in detail, to determine whether modifications can be made to those actions to improve their effectiveness. A scope for the dust emissions reduction plan is outlined below, including discussion of objectives, tasks, milestones, and stakeholder roles.

5.2.2.1 Objectives

The development of a dust emissions reduction plan follows from risk management Objective 1, which is to "Continue reducing fugitive metals emissions and dust emissions." Thus, the goal of the dust emissions reduction plan is stated as follows:

Dust Emission Reduction Plan Goal: "To continue to evaluate, select, and implement effective dust control measures for reducing dust emissions at the mine, port, and along the road."

5.2.2.2 Tasks

To achieve the plan objective, preparation of the dust emissions reduction plan will involve the following tasks:

- **Review and selection of actions.** From the prospective actions associated with Objective 1 (summarized in Table 2), actions will be reviewed and selected for incorporation into the plan.
- **Evaluation of prior and ongoing actions.** The effectiveness of dust reduction actions taken to date (i.e., those outlined above) will be reviewed and evaluated. Where appropriate, these actions will be modified or improved, and incorporated into the plan.
- **Communication and collaboration.** Specific communication and collaboration actions will be defined within the dust reduction plan, considering both the current practices and the standard set of action items provided in the communication and collaboration plan.
- **Periodic review and reporting.** The plan will define a frequency for reporting (perhaps annually). It will describe an approach to reviewing the methodologies that have been implemented and discussing the significance of those methodologies within the periodic report. Such a review would also involve monitoring actions that are used to evaluate the effectiveness of dust reduction actions. Additionally, the plan will identify an appropriate frequency for reviewing and reporting on the effectiveness of the plan itself in meeting fundamental Objective 1, and will describe an approach to providing a report and recommendations for improvement.

5.2.2.3 Milestones

The following milestones will be used in the draft dust emission reduction plan to define a project schedule:

- Scope – the draft scope for the dust emissions reduction plan is provided within this document
- Draft plan
- Final plan
- Periodic review and reporting – see discussion above in Tasks.

5.2.2.4 Stakeholder Roles

Teck Cominco will prepare the draft plan, with the involvement of appropriate internal staff from different operational units at the mine, road, and port. Review of the draft plan will be invited from all stakeholders.

5.3 Remediation

The following sections describe remediation and reclamation actions taken to date, and outline a scope for future actions through development of a detailed remediation plan. Although this plan will likely include elements of reclamation, the plan will be referred to as a remediation plan, to avoid confusion with the reclamation and closure plan being prepared for the mine area.

5.3.1 Actions To Date

Teck Cominco has been implementing remediation and reclamation of localized areas as necessary throughout the history of the mine. Examples of past remediation efforts include the following:

Truck Spill Follow-up—There have historically been spills of lead and zinc concentrate from trucks along the DMTS corridor. Initial recovery of spilled concentrate typically followed each spill event as quickly as weather conditions permitted. The spill sites were systematically re-evaluated between 2002 and 2005. Those that needed additional action were investigated, and where necessary, additional remediation was implemented (Exponent 2007a).

Port Site Recovery and Recycling Activities—During the summer of 2002, several areas where lead concentrations were greater than 2,000 mg/kg were excavated, and material was recycled. Soil was removed to provide source control of residual concentrates and recover the fugitive concentrates from several of the highest concentration areas. These remediation activities were undertaken to eliminate higher concentration sources around the port site and reduce the sources of wind-blown fugitive dust (Teck Cominco 2003).

Road Surface Remediation—Road surface characterization work was completed for areas of the DMTS road that were being evaluated for test paving. After areas of the road with concentrations above the default cleanup values were identified, the road surface material in those areas was removed and returned to the mine (Exponent 2002b).

5.3.2 Future Actions

5.3.2.1 Objectives

The development of a remediation plan follows from risk management Objective 2, which is to "Continue remediation or reclamation in selected areas." Thus, the goal of the remediation plan is stated as follows:

Remediation Plan Goal: "To define a consistent method for identifying and selecting affected areas and implementing remediation and/or reclamation."

5.3.2.2 Tasks

To achieve the plan objective, preparation of the remediation/reclamation plan will involve the following tasks:

- **Review and selection of actions.** From the prospective actions associated with Objective 2 (summarized in Table 3), remedial or reclamation actions will be reviewed, prioritized, and selected for incorporation into the plan.

- **Evaluation of prior and ongoing actions.** The effectiveness of actions taken to date (i.e., those outlined above) will be reviewed and evaluated. Where appropriate, these actions will be modified or improved, and incorporated into the plan.

- **Communication and collaboration.** Specific communication and collaboration actions will be defined within the remediation/reclamation plan, considering both the current practices and the standard set of action items provided in the communication and collaboration plan.

- **Periodic review and reporting.** The plan will define a frequency for reporting (perhaps annually). It will describe an approach to reviewing the remediation and/or reclamation actions that have been implemented and discussing the significance of those actions within the periodic report. Such a review would involve evaluating the significance of new dust control measures with respect to all of the dust control measures that have been implemented over the past few decades. Additionally, the plan will identify an appropriate frequency for reviewing and reporting on the effectiveness of the plan itself in meeting fundamental Objective 2, and will describe an approach to providing a report and recommendations for improvement.

The actions related to remediation and reclamation were compiled and presented in Table 3 for Objective 2, and the list includes several categories or types of actions. These actions can be grouped as follows: 1) evaluate additional remediation and reclamation technologies, 2) incorporate traditional ecological knowledge to select culturally important areas for remediation, 3) develop and define action levels to determine whether areas should be remediated or allowed to recover naturally, and 4) implement monitoring to determine whether reclamation and/or remediation was effective and successful.

5.3.2.3 Milestones

The following milestones will be used in the draft remediation plan to define a project schedule:

- Scope – the draft scope for the remediation plan is provided within this document
- Draft plan
- Final plan
- Periodic review and reporting – see discussion above in Tasks.

5.3.2.4 Stakeholder Roles

Red Dog Operations will prepare the draft plan. Review will be invited from all stakeholders.

5.4 Monitoring

The following sections describe some monitoring actions taken to date, and outline a scope for future actions through development of a detailed monitoring plan.

5.4.1 Actions To Date

Many of the monitoring-related actions identified and discussed at the Risk Management Workshop have been or are currently being addressed in some form. Examples of past or current monitoring-related activities are described below.

5.4.1.1 Human Health

- Monitoring of metals concentrations in subsistence foods such as caribou, berries, and sourdock
- Blood lead monitoring in residents of Kivalina and Noatak
- Ambient air monitoring for lead in Kivalina and Noatak.

5.4.1.2 Ecological

- Monitoring of metals concentrations in moss over space and time
- Vegetation effects assessment and long-term vegetation monitoring study.

5.4.1.3 Human Health and Ecological

- Monitoring of caribou population health and movement
- Monitoring of fish population health and metals concentrations.

5.4.1.4 Environmental

- Dustfall (deposition) monitoring near the port and road
- Water quality monitoring in regional streams and rivers
- Ambient air quality monitoring.

5.4.2 Further Actions

5.4.2.1 Objectives

The development of a monitoring plan follows primarily from risk management Objective 3, "Verify continued safety of caribou, other representative subsistence foods, and water," and Objective 4, "Monitor conditions in various ecological environments and habitats, and implement corrective measures when action levels are triggered." However, several actions associated with other objectives are also relevant to the monitoring plan, particularly operational monitoring associated with Objective 1, "Continue reducing fugitive metals emissions and dust emissions." Thus, the goal of the monitoring plan is stated as follows:

Monitoring Plan Goal: "To monitor changes in dust emissions and deposition over time and space, using that information to: 1) assess the effectiveness of operational dust control actions,

2) evaluate the effects of the dust emissions on the environment and on human and ecological exposure, and 3) trigger additional actions where necessary."

5.4.2.2 Tasks

To achieve the plan objective, preparation of the monitoring plan will involve the following tasks:

- **Review and selection of actions.** From the prospective actions associated with Objectives 1, 3, and 4 (summarized in Tables 2, 4, and 5, respectively), actions will be reviewed and selected for incorporation into the plan. In addition, this task will include reviewing outstanding issues that were discussed in the comments on the DMTS risk assessment, to identify any additional items for inclusion in the plan. These were comments where the response indicated that the issue would be evaluated further in the risk management plan. These comment issues largely focused on the potential need for additional studies or monitoring to address areas of uncertainty in the risk assessment.

- **Evaluation of prior and ongoing actions.** The effectiveness of actions taken to date (e.g., those outlined above) will be reviewed and evaluated. Where appropriate, these actions will be modified or improved, and incorporated into the plan.

- **Communication and collaboration.** Specific communication and collaboration actions within the monitoring plan will be defined based on the standard set of action items provided in the communication and collaboration plan.

- **Periodic review and reporting.** The plan will define a frequency for reporting (e.g., annual monitoring report). It will describe an approach to reviewing monitoring results and discussing the significance of those data within the periodic report. Such a review would involve evaluating the significance of monitoring results to the overall understanding of risks to human health and the environment that has been developed through prior assessments and studies. Additionally, the plan will identify an appropriate frequency for reviewing and reporting on the effectiveness of the plan itself in meeting fundamental Objectives 3 and 4, and monitoring aspects of Objective 1. It will also describe an approach to reporting on this review and providing recommendations for improvement.

In developing a monitoring plan related to dust emissions issues, the tasks described above and the monitoring-related actions presented in Tables 2, 4, and 5 will be considered. In addition, specific monitoring-related actions described in the following documents will be considered:

- *DMTS Fugitive Dust Risk Assessment* (Exponent 2007a) and *Draft Evaluation of Ecological Risk within the Ambient Air/Solid Waste Permit Boundary* (Exponent 2007c). Monitoring of tissue concentrations of metals in mosses and/or lichens. Monitoring of tissue concentrations of metals in shrubs and/or herbaceous plants. Monitoring of mosses and lichen community composition (e.g., diversity, abundance, cover, etc.).
- *Memorandum of Understanding* (DEC 2007). Ambient air monitoring from the tailings dam and the personal accommodations complex sampling sites. Continued vegetation monitoring near the mine and in vegetation plots in affected areas. Monitoring for effectiveness of engineering improvements.

The plan will target three key categories of monitoring: subsistence foods, ecological, and operational. Although some actions may directly address only one category, other actions may address multiple categories. To the extent possible, actions will be coordinated across categories to ensure efficient use of resources. Most monitoring actions will have a defined set of criteria for specific triggers that result in modifications to the action. For example, trigger concentrations may be defined for moss metals that result in an increase or decrease in the frequency of monitoring. Therefore, the monitoring plan will need to define a review frequency appropriate for assessing the effectiveness of the actions and the need to trigger modifications.

5.4.2.3 Milestones

The following milestones will be used in the draft monitoring plan to define a project schedule:

- Scope – the draft scope for the monitoring plan is provided within this document
- Draft plan
- Final plan
- Periodic review and reporting – see discussion above in Tasks.

5.4.2.4 Stakeholder Roles

Teck Cominco will prepare the draft plan. Review will be invited from all stakeholders. DEC will provide oversight for elements of the plan that directly address risk management follow-up described in Section 8 of the DMTS fugitive dust risk assessment (Exponent 2007a).

5.5 Uncertainty Reduction

The following sections describe actions taken to date to reduce uncertainty, and outline a scope for future actions through development of a detailed uncertainty reduction plan.

5.5.1 Actions To Date

Some of the actions related to uncertainty reduction that were identified in Table 6 have been or are currently being implemented in some form. Examples of past or current uncertainty reduction efforts include the following studies:

- Study of particle weathering in the environment (Teck Cominco 2007a)
- Study of particle leaching in Red Dog soils (Teck Cominco 2007b)
- Bioaccessibility study for barium and aluminum (Shock et al. 2007).

5.5.2 Further Actions

5.5.2.1 Objectives

The development of an uncertainty reduction plan follows from risk management Objective 5, which is to "Conduct research or studies to reduce uncertainties in the assessment of effects to humans and the environment" (Table 6). Thus, the goal of the uncertainty reduction plan is stated as follows:

Uncertainty Reduction Plan Goal: "To identify and prioritize prospective research or studies to reduce uncertainties in the assessment of effects of fugitive dust to humans and the environment."

5.5.2.2 Tasks

To achieve the plan objective, preparation of the uncertainty reduction plan will involve the following tasks:

- **Review and selection of actions.** From the prospective actions associated with Objective 5 (summarized in Table 6), actions will be reviewed and selected for incorporation into the plan. In addition, this task will include reviewing outstanding issues that were discussed in the comments on the DMTS risk assessment, to identify any additional items for inclusion in the plan. These were comments where the response indicated that the issue would be evaluated further in the risk management plan. These comment issues largely focused on the potential need for additional studies or monitoring to address areas of uncertainty in the risk assessment.
- **Evaluation of prior and ongoing actions.** The effectiveness of actions taken to date (i.e., those outlined above) will be reviewed and evaluated. Where appropriate, these actions will be modified or improved, and incorporated into the plan.

- **Communication and collaboration.** Specific communication and collaboration actions will be defined within the uncertainty reduction plan, considering both the current practices and the standard set of action items provided in the communication and collaboration plan.

- **Periodic review and reporting.** The plan will define a frequency for reporting (perhaps annually). It will describe an approach to reviewing the studies that have been implemented and discussing the significance of those studies within the periodic report. Such a review would involve evaluating the significance of new study findings with respect to the overall understanding of risks to human health and the environment that has been developed through prior assessments and studies. Additionally, the plan will identify an appropriate frequency for reviewing and reporting on the effectiveness of the plan itself in meeting fundamental Objective 5, and will describe an approach to providing a report and recommendations for improvement.

5.5.2.3 Milestones

The following steps in study planning, design, review, and reporting are points in the process where communication and review with stakeholders is likely needed. These milestones will be used in the draft uncertainty reduction plan to define a project schedule.

- Scope – the draft scope for the uncertainty reduction plan is provided within this document

- Draft plan

- Final plan

- Periodic review and reporting – see discussion above in Tasks.

5.5.2.4 Stakeholder Roles

Teck Cominco will prepare the draft plan. Review will be invited from all stakeholders.

5.6 Worker Dust Protection

The following sections describe actions taken to date for worker protection, and outline a scope for future actions through development of a worker dust protection plan. The worker dust protection plan will specifically address issues related to dust emissions and exposure, drawing as needed from Red Dog's existing comprehensive health and safety program to address these issues.

5.6.1 Actions to Date

The worker health-related actions identified and discussed at the Risk Management Workshop have been or are currently being addressed in some form. Examples of past or current monitoring related activities include:

- A comprehensive blood lead monitoring program, including periodic testing and annual training for all employees regarding lead exposure risks, advice and guidance on how to decrease any potential exposure risks (e.g., proper respirator use, personal hygiene practices, policies prohibiting transport of work clothes and equipment from the site), and procedures and engineering in place to reduce exposure
- A cadmium monitoring programs similar to the lead monitoring program
- A specific and defined system for ongoing evaluation of the monitoring program, including continual evaluation of progress toward reduced lead exposure goals for all workers, quick intervention when individual workers show an elevated lead level before their health is placed at risk, and

evaluation of the effectiveness of dust control measures and the health and safety program as a whole

- Inclusion of a cross section of Red Dog employees from the workplace on the Occupational Health and Safety Committee to broaden communication and collaboration and help ensure the effectiveness of safety and health practices
- Ongoing work-area dust-level measurements made by TCAK and the Mine Safety and Health Administration.

5.6.2 Further Actions

5.6.2.1 Objectives

The development of a worker dust protection plan follows from risk management Objective 7, "Protect worker health." Thus, the goal of the worker dust protection plan is stated as follows:

> **Worker Dust Protection Plan Goal:** "To minimize worker exposure to fugitive dust, provide ongoing monitoring of exposure, and ensure a comprehensive communication system."

5.6.2.2 Tasks

To achieve the plan objective, preparation of the worker dust protection plan will involve the following tasks:

- **Review and selection of actions.** From the prospective actions associated with Objective 7 (summarized in Table 8), actions will be reviewed and selected for incorporation into the plan.
- **Evaluation of prior and ongoing actions.** The effectiveness of actions taken to date (e.g., those outlined above) will be reviewed and evaluated.

Where appropriate, these actions will be modified or improved, and incorporated into the plan.

- **Communication and collaboration.** Specific communication and collaboration actions will be defined within the worker health plan, considering both the current practices and the standard set of action items provided in the communication and collaboration plan.

- **Periodic review and reporting.** The plan will define a frequency for reporting (perhaps annually). It will describe an approach to reviewing data from worker health programs related to fugitive dust exposure, discussing the significance of those data within the periodic report, and maintaining strict confidentiality for all individuals participating in the worker health programs. Such a review would involve evaluating the significance of data generated from worker health programs with respect to the overall understanding of risks to human health that has been developed through prior assessments and studies. Additionally, the plan will identify an appropriate frequency for reviewing and reporting on the effectiveness of the plan itself in meeting fundamental Objective 7, and will describe an approach to providing a report and recommendations for improvement.

The worker dust protection plan will specifically address issues related to dust emissions and exposure, but will draw from Red Dog's existing comprehensive health and safety program where appropriate. Some actions/programs are already well defined, and this plan may tie into those as they currently exist (e.g., the blood lead monitoring program). Other actions may require inclusion of additional elements or modification of existing elements. The worker dust protection plan should be viewed as a part of the comprehensive health and safety program and, as such, the plan must be consistent with the overall program.

5.6.2.3 Milestones

The following milestones will be used in the draft worker health plan to define a project schedule:

- Scope – the draft scope for the worker health plan is provided within this document
- Draft plan
- Final plan
- Periodic review and reporting – see discussion above in Tasks.

5.6.2.4 Stakeholder Roles

Teck Cominco will prepare the draft plan. The Red Dog Occupational Health and Safety Committee will provide review. Additional review will be invited from all stakeholders.

6 Review and Reporting

The previous section outlined the scope for individual implementation plans aimed at achieving the fundamental risk management objectives defined in Section 3.3. These plans and their relationship to the objectives are summarized in Figure 4. This section describes an approach to integrating the periodic review and reporting efforts described within each of those plans. The purpose of this periodic review and reporting is two-fold:

1. To review data collected from studies or programs during the prior period and evaluate the significance of those data relative to existing information about human and environmental exposure and risk, and
2. To review the completeness and effectiveness of the plans in meeting the fundamental objectives defined within this document (Section 3), and to provide recommendations for improvement.

To improve the clarity, transparency, and effectiveness of fugitive dust risk management over time, the periodic review and reporting on one or both of these purposes may be combined into one annual Fugitive Dust Risk Management Progress Report. Such a report would include a section pertaining to each implementation plan. Depending on the frequency of activities implemented under each plan, some sections of the report may be brief, and others may be longer for any given reporting period. The details of reporting for each implementation plan will be as defined in that individual plan.

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Figures

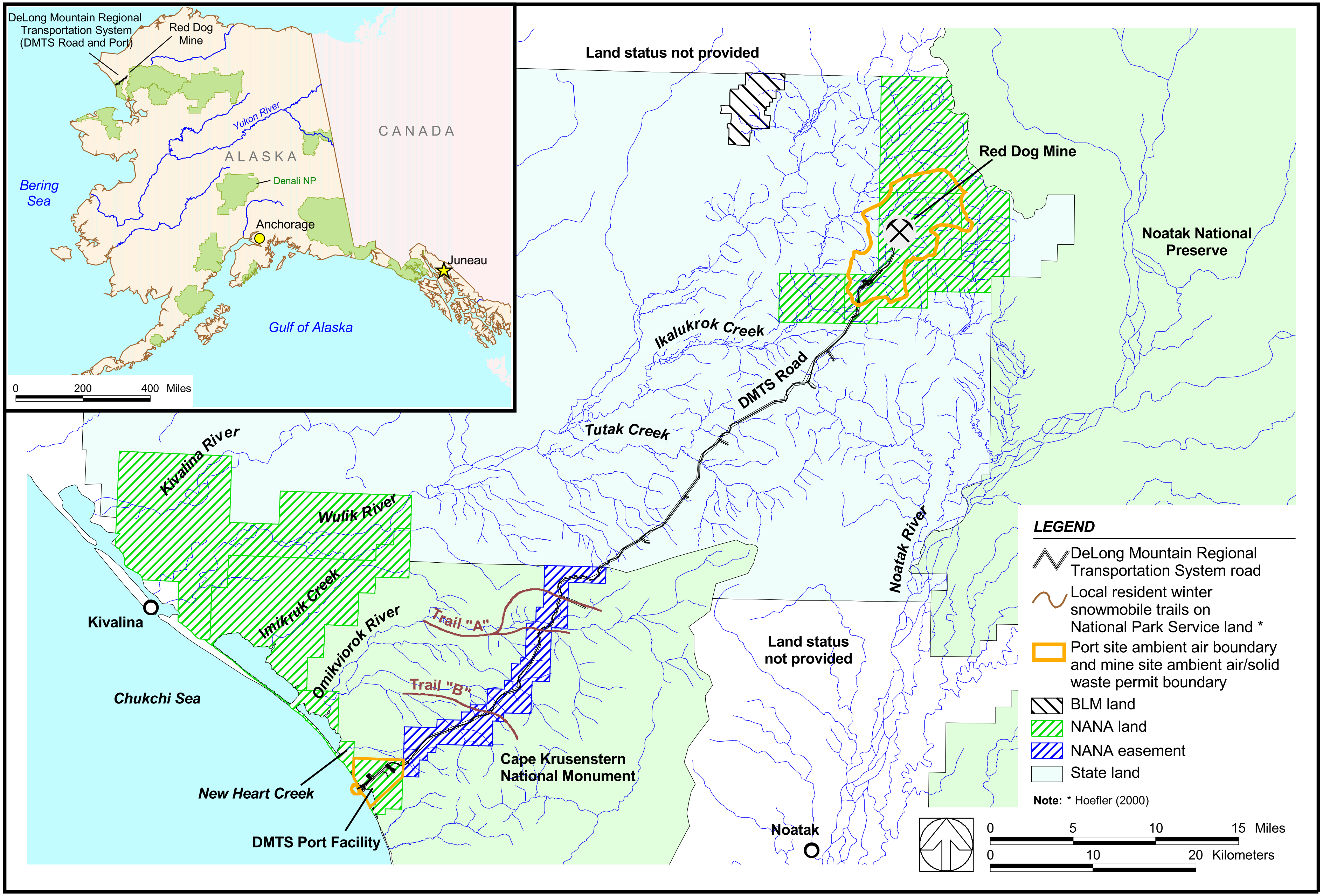

Figure 1. Vicinity map with land ownership and use

Exponent

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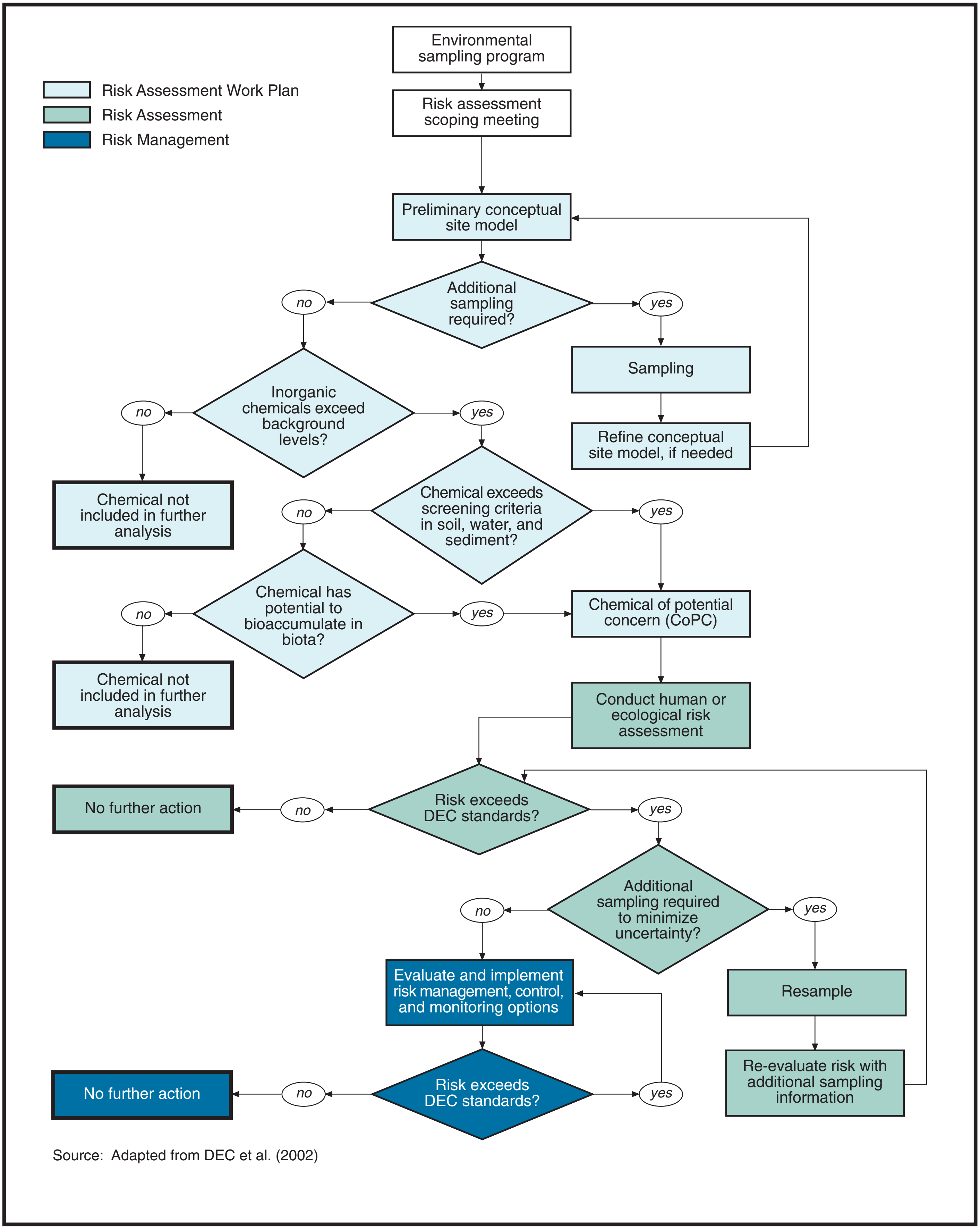

Figure 2. Decision-making framework for evaluating risk to human health and ecological receptors

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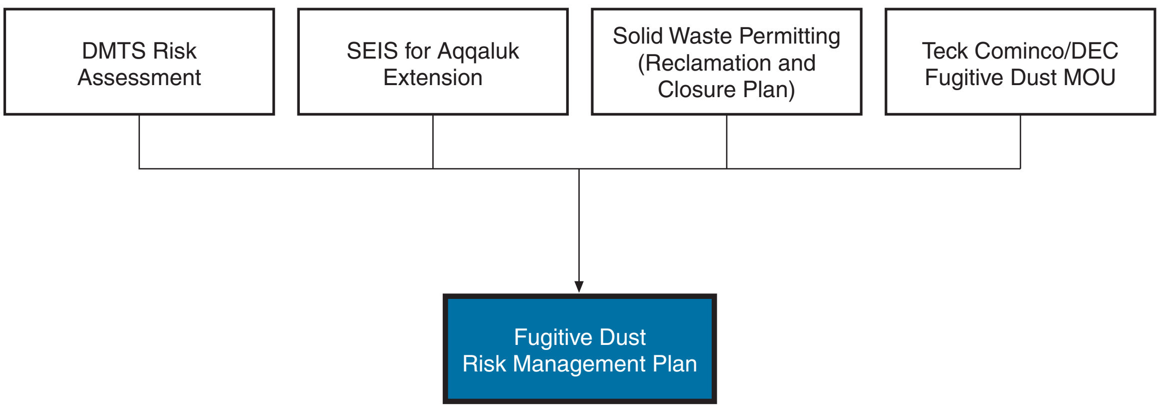

DEC – Alaska Department of Environmental Conservation
DMTS – DeLong Mountain Regional Transportation System
MOU – memorandum of understanding
SEIS – supplemental environmental impact statement
Teck Cominco – Teck Cominco Alaska Incorporated

Figure 3. Convergence of fugitive dust management efforts

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Fugitive Dust Risk Management Plan

RISK MANAGEMENT OBJECTIVES	Communication Plan	Dust Emission Reduction Plan	Remediation/ Reclamation Plan	Monitoring Plan	Uncertainty Reduction Plan	Worker Dust Protection Plan
1. Continue reducing fugitive metals emissions and dust emissions	□	■	□	■	□	
2. Conduct remediation or reclamation in selected areas	□		■	□	□	
3. Verify continued safety of caribou, other representative subsistence foods, and water	□			■	□	
4. Monitor conditions in various ecological environments and habitats, and implement corrective measures when action levels are triggered	□			■	□	
5. Conduct research or studies to reduce uncertainties in the assessment of effects to humans and the environment	□			□	■	□
6. Improve communication and collaboration among all stakeholders	■	□	□	□	□	□
7. Protect worker health	□	□	□	□	□	■

■ Implementation plan directly addresses objective

□ Implementation plan indirectly addresses objective

Figure 4. Risk management objectives and associated implementation plans

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Tables

Table 1. Compilation of potential risk management actions

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
1	Communication and Collaboration	Develop and communicate a timeline for improvements[b]	Develop a timeline for dust control improvements, past, present, and future plans
1		Share information with the public regarding engineering controls already being implemented[b]	Share information with the public regarding engineering controls already being implemented
1	Engineering Controls	Sprinkler system to reduce dust while loading at the mine	Install sprinkler systems at mine truck-loading facility
1		Water curtains for blasting at the mine	Implement water curtains for blasting at the mine
1		Water capping at the mine	Implement water cover for tailings at the mine
1		Conveyer system for loading port to ship	Design and install a conveyer system for loading from port to deepwater ships
1		Covered lightering barges	Improve covers on lightering barges
1		Set roadbed cleanup levels for resurfacing	Define action levels to trigger road resurfacing (regrading and palliative treatment)
1		Evaluate frequency of road resurfacing to reduce dust	
1		Hard paved road surface to reduce dust	Add hard pavement to entire road surface
1		Road dust control agents	Identify and evaluate dust control agents (palliatives), implement most effective program
1		Alternative truck loading system at the mine to prevent dust accumulation on trucks	Evaluate alternative truck loading systems
1		Conveyer system for loading trucks at the mine	Install a conveyer system for loading trucks
1		Container system for truck transport and port loading	Implement container system for truck transport and port loading

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
1		Look at options for year-round truck wash	Install year-round vehicle wash
1		Tire washing center (all vehicles) before going to port	
1		Warm bath for transportation vehicles	
1		Traffic control measures to limit which vehicles leave the mine	Limit vehicles that leave the mine area
1		Evaluate winter dust control options for mine and road	Evaluate winter dust control options for mine and road
1		Physical deposition controls - snow fences[b]	Implement physical deposition controls, such as snow fences
1		Additional building enclosures at the mine	Install additional building enclosures at the mine
1		Additional building enclosures at the port	Install additional building enclosures at the port
1		Procedural source controls[b]	Evaluate and develop procedural source controls, such as blast control measures
1		Develop a program to reduce emissions by changing operational practices and modifying facilities[b]	
1		Blast control measures to reduce fugitive dust at the mine	
1	Monitoring	Measure fugitive dusts near identified sources to assess the factors that cause dust generation and transport, as well as the effectiveness of engineering control methods to control improvements	Implement operational monitoring program to evaluate effectiveness of dust control measures [e.g., through short-term (daily, monthly, annual frequencies) methods such as air monitoring (dustfall, TEOM), and water monitoring of streams at road crossings, tundra ponds, and coastal lagoons].
1		Evaluate effectiveness of fugitive dust engineering controls through short-term (daily, monthly, annually frequencies) methods such as air monitoring (dustfall, TEOM), and water monitoring of streams at road crossings and tundra lagoons[b]	

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
1		Determine tissue concentrations in shrubs and/or herbaceous plants to track rate of change[b]	Monitor tissue concentrations in shrubs or herbaceous plants to track rate of change (1 year frequency)
1		Monitor tissue concentrations in mosses and lichens to track the rate of change[b]	Monitor tissue concentrations in mosses or lichens to track rate of change (3–5 year frequency)
1		Evaluate effectiveness of fugitive dust control engineering controls through medium term (3–5 year frequencies) methods such as moss sampling[b]	
1	Remediation and Reclamation	Quickly remove hot spots or areas that are identified as major sources of fugitive dusts or major sources of exposure	Remediate hot spots that may be sources of metals-bearing dust, such as former truck spills
1		Remove and recycle affected soils within facility areas[b]	
1	Uncertainty Reduction	Physical source controls - conduct a source contribution evaluation to determine the contribution from various sources (source apportionment). This study may include a systematic evaluation of all potential past and current emissions, the ranking of existing source contributions, factoring in changes in the operation (including production rate and grade), and utilization of an appropriate air dispersion and deposition model, which could possibly be confirmed with existing monitoring information[b]	Conduct a source contribution evaluation (source apportionment) study
1		Conduct a literature review to determine feasible control measures[b]	Conduct a literature review to determine feasible control measures
2	Communication and Collaboration	Select areas for remediation and restoration based on traditional knowledge to determine culturally important areas[b]	Use traditional ecological knowledge to select culturally important areas for remediation
2		Establish short- and long-term goals and schedule, and share plans and progress with the public[b]	Share short- and long-term goals with stakeholders

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
2	Institutional Controls	Place signage in areas that are undergoing restoration to allow for recovery[b]	Place signage in remediated areas to prevent impacts during recovery process
2	Monitoring	Monitor restored areas to ensure that efforts are long-lasting and sustainable[b]	Monitor remediated or reclaimed areas to ensure long-term effectiveness
2	Remediation and Reclamation	Quickly remove hot spots or areas that are identified as major sources of fugitive dusts or major sources of exposure	Remediate hot spots that contribute to exposure, such as former truck spill areas
2		Perform remediation and restoration on truck spill site for focused removal and recycling, to eliminate sources of metals-bearing dust[b]	
2		Explore bioremediation (using bacteria) to help break down forms of metals removing them from surface soil/tundra	Evaluate bioremediation to remove metals from surface soil or tundra
2		Explore phytoremediation (using plants) as a method for taking up metals from contaminated soil	Evaluate phytoremediation for removal of metals from soil
2		Consider using biosolids (organic material from sludge processing) for rehabilitating soils	Use biosolids for rehabilitating soils
2		Develop cleanup levels[b]	Develop action levels to determine if areas should be remediated or allowed to recover naturally
2		Select areas based on concentrations, degree of effects[b]	Define areas based on concentrations and/or degree of effects[b]
2		Develop criteria for determining when remediation benefits outweigh the negative aspects of removing tundra habitat[b]	Define decision criteria for determining when remediation benefits outweigh the negative aspects of removing tundra habitat
2		Conduct pilot studies on test plots to explore how to best rehabilitate tundra areas[b]	Conduct pilot studies to evaluate tundra rehabilitation methods
2		Consider methods that focus on rehabilitation of tundra over other types of vegetation; this includes identifying the rate of natural change from grasslands to tundra	Study the natural progression of grasslands into tundra to evaluate the potential for natural recovery following reclamation

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
3	Communication and Collaboration	Use traditional ecological knowledge to determine agreed-upon subsistence foods list for monitoring[b]	Use traditional ecological knowledge to determine agreed-upon subsistence foods list for monitoring
3		Regularly share information on monitoring results and studies conducted, for personal decision-making[b]	Report monitoring results and study results to all stakeholders
3	Monitoring	Identify changes in subsistence food and water metals concentrations through ongoing monitoring; for example, caribou (5–10 years), berries and sourdock (3–5 years), ptarmigan (5–10 years), fish (3–5 years), water (tbd)[b]	Develop monitoring plan for foods and water
3		Hire local people (perhaps two from Noatak, two from Kivalina) with respect to dust and other monitoring (e.g., of rivers)	Hire local people to assist with monitoring
3	Uncertainty Reduction	Develop standard methods for sampling and reporting[b]	Develop standard methods for sampling, analysis, and reporting
3		Determine agreed-upon triggers for adjusting monitoring frequency[b]	Determine agreed-upon triggers for adjusting monitoring frequency
3		Determine safe consumption levels in subsistence foods and water[b]	Determine safe consumption levels in subsistence foods and water
4	Monitoring	Apply a consistent sampling and analysis method to check the metals levels in key subsistence foods on a periodic basis	Develop standard methods for sampling, analysis, and reporting
4		Apply a consistent method for monitoring humans for potential exposure to metals and metal-related effects	(Develop standard methods for sampling, analysis, and reporting — bracketed with row above)
4		Develop mechansisms for including observations and information from community members as part of the monitoring program - include traditional knowledge and ecological observations by locals	Use traditional knowledge and ecological observations for development of monitoring program

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
4		Develop appropriate chemical benchmarks for judging effects on metals (e.g., lead, zinc, and cadmium) in the tundra, in plant foods, and in fish and other animals and the potential for effects on people	Develop appropriate action levels to evaluate potential for effects of metals in tundra, plants, and fish and other animals, and for people
4		Safety first; monitoring food, lands, animals, children, Elders, other communities of all peoples in affected areas	
4		Monitor health of local populations of animals that tend to be resident in the area (moose, small mammals, muskox, fish such as slimy sculpins) to determine if there is an indication of mine-related exposures and effects	Monitor health of local populations of animals that tend to be resident in the area (moose, small mammals, muskox, fish such as slimy sculpins) to determine if there is an indication of mine-related exposures and effects
4		Monitor presence of caribou along the road	Monitor caribou health, movement, and population levels
4		Monitor caribou health, movement, and population levels[b]	
4		Conduct monitoring (metals, presence of dusts) in special areas such as Noatak National Preserve	Monitor (metals, presence of dusts) in special areas such as Noatak National Preserve
4		Conduct monitoring along snowmobile trails that cross areas where dust may be present	Monitor tracking of metals dust at snow-machine trail crossings
4		Hire local people (perhaps two from Noatak, two from Kivalina) with respect to dust and other monitoring (e.g., of rivers)	Hire local people to assist with monitoring
4		Monitor levels of metals in roadbed dusts	Monitor levels of metals in roadbed surface soil
4		Monitor changes in the vertical distribution of metals in peat soils	Monitor changes in the vertical distribution of metals in surface tundra and underlying soils
4		Incorporate remote monitoring tools as appropriate to enhance collection of information (satellite imagery, Doppler radar, meteorological stations)	Incorporate remote monitoring tools to enhance collection of information (satellite imagery, Doppler radar, meteorological stations)
4		Track changes in stream habitat for fish spawning, nursery habitat, and foraging habitat (water flow, creek bed color, etc)[b]	Monitor streams for changes in fish spawning, nursery, and foraging habitats

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
4		Determine tissue concentrations in shrubs and/or herbaceous plants to track rate of change	Monitor tissue concentrations in shrubs or herbaceous plants to track rate of change (1 year frequency)
4		Monitor tissue concentrations in mosses and lichens to track the rate of change at port, road, and mine areas[b]	Monitor tissue concentrations in mosses or lichens to track rate of change (3–5 year frequency)
4		Determine tissue concentrations in mosses and/or lichens along and with distance from source areas to determine trends over time	
4		Examine moss and lichen community composition (diversity, abundance, cover, etc) at various distances from the DMTS road, to track changes over time in moss and lichen condition	Monitor moss and lichen community composition, to evaluate bryophyte community health
4		Evaluate effectiveness of fugitive dust control engineering controls through long-term (5 year frequencies) methods such as soil and sediment sampling to determine if natural recovery is resulting from sedimentation[b]	Evaluate and implement long-term monitoring programs for soil and sediment (5-year frequency)
5	Communication and Collaboration	Provide stakeholders with opportunities for input during study planning processes, provide updates during studies, and provide results of studies in timely manner to all stakeholders[b]	Provide stakeholders with opportunities for input during study planning processes, provide updates during studies, and provide results of studies in timely manner to all stakeholders
5	Uncertainty Reduction	Need to understand cumulative (combined) effects of dust (and associated metals) with other potential mine-related impacts	Evaluate the potential effect of cumulative deposition on future exposure levels for humans and ecological receptors
5		Evaluate the potential effect of cumulative deposition on future exposure levels for humans and ecological receptors[b]	
5		Continue to develop and display information on a spatial (place to place) and temporal (year to year) basis so that individual data can be understood in larger context	Develop and display information on a spatial and temporal basis for trend identification

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
5		Develop a better understanding of "cocktail effect" of elevated metals associated with the mine	Develop a better understanding of "cocktail effect" of elevated metals associated with the mine
5		Better understanding is needed of the factors influencing subsistence animals and fish food sources on the land (near the mine and road) and in the sea (near the port)	Develop a better understanding of the factors influencing subsistence animals and fish food sources on the land (near the mine and road) and in the sea (near the port)
5		Develop appropriate chemical benchmarks for judging effects of metals in tundra, plant foods, fish, and in other animals.	Develop appropriate action levels to evaluate potential for effects of metals in tundra, plants, fish and other animals, and for people
5		Survey seeps to determine their relative contribution of metals to water bodies and how this varies over time	Determine if changes in tundra and streams are due to natural phenomena (e.g., climate change, natural slumps or seeps) or Red Dog dust or mine discharge
5		Conduct studies to distinguish between natural changes in tundra (natural seeps) versus changes Red Dog dust or mine discharge and effects on streams[b]	
5		Include evaluations of sub-lethal effects (animal or plant does not die but may get weak); include examination for symptoms of exposure/sickness/organ damage/other signs of exposure	Include evaluations of sub-lethal effects to animals or plants; include examination for symptoms of exposure/sickness/organ damage/other effects of exposure
5		Conduct additional characterization outside the mine boundary to clarify the mine dust impacts and relevance; determine if the risk assessment study area size was sufficient[b]	Through additional characterization, determine if the size of the risk assessment study area was sufficient
5		Determine if berry and sourdock sampling with respect to weather affected results of risk assessment[b]	Determine if timing of berry and sourdock sampling with respect to weather could have affected the results of risk assessment
5		Evaluate potential effects of climate change on mobility of metals[b]	Evaluate potential effects of climate change on mobility of metals

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
5		Evaluate potential for changes in mobility and migration of metals from oxidation or other changes in forms of minerals[b]	Evaluate potential for changes in mobility and migration of metals from oxidation or other changes in forms of minerals
5		Identify mechanisms causing tundra effects and develop predictive tools to assess where effects will be observed and when[b]	Develop predictive tools to predict when and where remediation will be needed
6	Communication and Collaboration	Monthly or quarterly KOTZ radio updates	Provide monthly or quarterly KOTZ radio updates
6		Email group for residents and agencies to share updates and news/progress	Establish email group for all stakeholders for information sharing
6		Community-level meetings and distributing information on regular schedule (vs. only region wide)	Organize community meetings and distribute information on regular schedule (vs. only region wide)
6		Communicate and educate all participants to work together - talk to villages	Facilitate collaboration between all participants
6		Improve level and effectiveness of participation[b]	
6		Get local contacts to follow up with appropriate agencies	Improve communication between local contacts and appropriate agencies
6		Get State more involved with studies	Facilitate State agency involvement with studies for third-party review and oversight
6		Sampling program for food currently in freezers	Develop sampling program for food currently in freezers

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
6		Simplify technical reports	Simplify technical reports and facilitate better comprehension of technical information for all stakeholders
6		Train technical people how to present information in an understandable way	
6		Learn more about language and cultural differences[b]	Facilitate education on language and cultural differences
6		Local resident employed in Kivalina, Noatak, and Kotzebue as a village/mine liason	Employ local residents in Kivalina, Noatak, and Kotzebue as a village/mine liason
6		Hire a local person to assist with sampling program for food currently in freezers[b]	Employ local residents to assist with sampling programs
6		Local person responsible for collection of unusual or abnormal subsistence foods	Identify local person responsible for collection and submittal of unusual or abnormal subsistence foods
6		Websites, periodic meetings/presentations, etc.	Develop an information-sharing portal/clearinghouse for regular reporting of studies, monitoring programs, and dust control efforts
6		Develop an information-sharing portal/clearinghouse for regular reporting of studies, monitoring programs, and dust control efforts[b]	

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
6		Annual conference in the Borough on results of studies and gathering resident input	Provide presentations of study plan design, study progress, and results by all stakeholders (e.g., through web-based presentations, in-person workshops, conferences, etc.)
6		Have web-based or in-person presentations for sharing of study-plan design, study progress, and results[b]	
6		Coordinate with all stakeholders on study designs[b]	
6		Provide peer review of study results and reporting[b]	
6		Organize periodic conferences for stakeholders[b]	
6		Invite Fish&Game to give presentations in the villages (e.g., Jim Dau, Bill Morris)	
6		Local involvement with engineering controls or other practical methods for contributing to reducing dust	Offer public tours of mine operations and dust control efforts
6		Offer public tours of mine operations and dust control efforts[b]	
6		Provide environmental education at schools and community groups[b]	Provide environmental education at schools and community groups
6		Technical training program (e.g., summer session)	Provide technical training for environmental jobs in the region (capacity-building)
6		Provide specific training for environmental jobs (capacity-building) in the region[b]	

Table 1. (cont.)

Objective	Risk Management Action Category	Complete List of Potential Actions[a]	Refined List of Potential Actions[a]
6		Involve local people in the study design	Incorporate local traditional ecological knowledge into study planning and study designs
6		Provide stakeholders with opportunities for input during study planning processes, provide updates during studies, and provide results of studies in timely manner to all stakeholders[b]	
6		Provide reports on prior-year programs and planned programs for upcoming year[b]	Provide reports on prior-year programs and planned programs for upcoming year
6	Institutional Controls	Increase education and communication about institutional controls through community meetings (use door prizes to increase participation)	Improve signage and other institutional controls, and increase awareness of institutional controls through community meetings
6		Improved signage at trail crossings	
6		Place notices on contaminated property	
6		CDC guidance on exposure and levels for children and adults	Provide agency guidance on exposure and levels for children and adults
6	Uncertainty Reduction	Long-term effects were identified as an area of uncertainty; therefore, funding commitments are needed for long-term studies/monitoring of people and the environment	Provide information on funding commitments and financial assurances for long-term studies and monitoring, given uncertainty of long-term effects
7	Communication and Collaboration	Open and ongoing dialogue and networking with miners	Have open and ongoing dialogue and networking with miners
7		Educate workers to avoid bringing home metals dust from the mine via work clothing and equipment[b]	Inform workers to avoid bringing home metals dust from the mine via work clothing and equipment
7	Institutional Controls	OSHA guidance on exposure and levels for workers	Provide OSHA guidance on exposure and levels for workers
7	Monitoring	Implement human biomonitoring program for local residents and mine workers[b]	Implement human biomonitoring program for local residents and mine workers

Footnoteson following page.

Table 1. (cont.)

Notes:

CDC	-	Centers for Disease Control and Prevention
DMTS	-	DeLong Mountain Transportation System
OSHA	-	Occupational Safety and Health Administration
TEOM	-	tapered element oscillating microbalance
tbd	-	to be determined

[a] Potential actions were identified during the Workshop and were originally listed in the Tools/Options Ranking Results, which can be found in Teck Cominco (2008).

Teck Cominco. 2008. Summary of the Red Dog Fugitive Dust Risk Management Workshop, March 25–27, 2008, Kotzebue, AK. CD-ROM. Teck Cominco Alaska Incorporated, Red Dog Operations Alaska, Anchorage, AK.

[b] This potential action was added to the list of actions, because it was discussed during the Risk Management Workshop as being a potential action for risk management. The potential actions listed represent a comprehensive digest of actions discussed during the Workshop.

Table 2. Priority ranking of actions for Objective 1 (continue reducing fugitive metals emissions and dust emissions)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Communication and Collaboration	Share information with the public regarding engineering controls already being implemented	1	1	1	2	2	7	1
	Develop a timeline for dust control improvements, past, present, and future plans	3	1	1	2	1	8	2
Engineering Controls	Evaluate alternate truck loading systems	1	1	1	1	2	6	1
	Limit vehicles that leave the mine area	1	1	1	1	3	7	1
	Install additional building enclosures at the port[a]	NF	NF	NF	1	NF	NF	NF
	Identify and evaluate dust control agents (palliatives), and implement most effective program	2	1	2	1	2	8	2
	Design and install a conveyer system for loading from port to deepwater ships	1	1	3	1	2	8	2
	Define action levels to trigger road resurfacing (regrading and palliative treatment)	2	1	2	1	2	8	2
	Install a conveyer system for loading trucks	2	1	2	1	2	8	2
	Install year-round vehicle wash	1	2	2	1	2	8	2
	Install additional building enclosures at the mine	1	1	2	1	3	8	2
	Evaluate and develop procedural source controls, such as blast control measures	1	1	2	1	3	8	2
	Evaluate winter dust control options for mine and road	2	2	1	1	3	9	2
	Improve covers on lightering barges	3	2	2	1	2	10	3
	Implement water curtains for blasting at the mine	2	2	3	1	3	11	3
	Implement water cover for tailings at the mine	1	3	3	1	3	11	3
	Implement physical deposition controls, such as snow fences	3	2	2	1	3	11	3
	Add hard pavement to entire road surface	NF	NF	NF	1	NF	NF	NF
	Install sprinkler systems at mine truck-loading facility	NF	NF	NF	1	NF	NF	NF
	Implement container system for truck transport and port loading	NF	NF	NF	1	NF	NF	NF

Table 2. (cont.)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Monitoring	Implement operational monitoring program to evaluate effectiveness of dust control measures [e.g., through short term (daily, monthly, annual frequencies) methods such as air monitoring (dustfall, TEOM), and water monitoring of streams at road crossings, tundra ponds, and coastal lagoons].	1	1	1	1	1	5	1
	Monitor tissue concentrations in shrubs or herbaceous plants to track rate of change (1 year frequency)	1	1	1	1	3	7	1
	Monitor tissue concentrations in mosses or lichens to track rate of change (3- to 5-year frequency)	2	1	1	1	3	8	2
Remediation and Reclamation	Remediate hot spots that may be sources of metals-bearing dust, such as former truck spills	1	1	2	3	1	8	2
Uncertainty Reduction	Conduct a source contribution evaluation (source apportionment) study	1	1	1	2	3	8	2
	Conduct a literature review to determine feasible control measures	1	1	1	2	3	8	2

Note: NF - not feasible
TEOM - tapered element oscillating microbalance

[a] All buildings at the port have already been enclosed.

Table 3. Priority ranking of actions for Objective 2 (conduct remediation or reclamation in selected areas)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Communication and Collaboration	Use traditional ecological knowledge to select culturally important areas for remediation	1	1	2	2	1	7	1
	Share short- and long-term goals with stakeholders	2	1	1	2	1	7	1
Institutional Controls	Place signage in remediated areas to prevent impacts during recovery process	1	1	1	3	2	8	2
Monitoring	Monitor remediated or reclaimed areas to ensure long-term effectiveness	1	1	1	1	1	5	1
Remediation and Reclamation	Develop action levels to determine if areas should be remediated or allowed to recover naturally	1	1	1	3	1	7	1
	Remediate hot spots that contribute to exposure, such as former truck spill areas	1	1	2	3	1	8	2
	Define areas based on concentrations and/or degree of effects	1	1	2	3	1	8	2
	Conduct pilot studies to evaluate tundra rehabilitation methods	2	2	2	3	2	11	3
	Study the natural progression of grasslands into tundra to evaluate the potential for natural recovery following reclamation	2	2	2	3	2	11	3
	Define decision criteria for determining when remediation benefits outweigh the negative aspects of removing tundra habitat	2	2	3	3	2	12	3
	Evaluate bioremediation to remove metals from surface soil or tundra	3	3	2	3	3	14	3
	Evaluate phytoremediation for removal of metals from soil	3	3	2	3	3	14	3
	Use biosolids for rehabilitating soils	NF	NF	NF	3	NF	NF	NF

Note: NF - not feasible

Table 4. Priority ranking of actions for Objective 3 (verify continued safety of caribou, other representative subsistence foods, and water)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Communication and Collaboration	Use traditional ecological knowledge to determine agreed-upon subsistence foods list for monitoring	1	1	1	2	1	6	1
	Report monitoring results and study results to all stakeholders	1	1	1	2	1	6	1
Monitoring	Develop monitoring plan for foods and water	1	1	1	1	1	5	1
	Hire local people to assist with monitoring	1	1	1	1	1	5	1
Uncertainty Reduction	Develop standard methods for sampling, analysis, and reporting	1	1	1	2	1	6	1
	Determine agreed-upon triggers for adjusting monitoring frequency	1	1	1	2	1	6	1
	Determine safe consumption levels in subsistence foods and water	1	2	2	2	1	8	2

Table 5. Priority ranking of actions for Objective 4 (monitor conditions in various ecological environments and habitats, and implement corrective measures when action levels are triggered)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Monitoring	Develop standard methods for sampling, analysis, and reporting	1	1	1	1	1	5	1
	Hire local people to assist with monitoring	1	1	1	1	1	5	1
	Monitor levels of metals in road-bed surface soil	1	1	1	1	1	5	1
	Develop appropriate action levels to evaluate potential for effects of metals in tundra, plants, and fish and other animals, and for people	1	1	2	1	1	6	1
	Monitor streams for changes in fish spawning, nursery, and foraging habitats	1	2	2	1	1	7	1
	Monitor (metals, presence of dusts) in special areas such as Noatak National Preserve	1	1	2	1	2	7	1
	Monitor moss and lichen community composition to evaluate bryophyte community health	1	1	2	1	2	7	1
	Use traditional knowledge and ecological observations for development of monitoring program	1	1	1	1	3	7	1
	Monitor tissue concentrations in shrubs or herbaceous plants to track rate of change (1 year frequency)	1	1	1	1	3	7	1
	Monitor tissue concentrations in mosses or lichens to track rate of change (3–5 year frequency)	1	1	1	1	3	7	1
	Evaluate and implement long-term monitoring programs for soil and sediment (5 year frequency)	2	1	1	1	3	8	2
	Monitor caribou health, movement, and population levels	1	1	2	1	3	8	2
	Monitor changes in the vertical distribution of metals in surface tundra and underlying soils	2	1	1	1	3	8	2

Table 5. (cont.)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
	Monitor tracking of metals dust at snow-machine trail crossings	3	1	1	1	3	9	2
	Monitor health of local populations of animals that tend to be resident in the area (moose, small mammals, muskox, fish such as slimy sculpins) to determine if there is an indication of mine-related exposures and effects	2	3	3	1	1	10	3
	Incorporate remote monitoring tools to enhance collection of information (satellite imagery, Doppler radar, meteorological stations)	2	2	2	1	3	10	3

Table 6. Priority ranking of actions for Objective 5 (conduct research or studies to reduce uncertainties in the assessment of effects to humans and the environment)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Communication and Collaboration	Provide stakeholders with opportunities for input during study planning processes, provide updates during studies, and provide results of studies in timely manner to all stakeholders	1	1	2	2	1	7	1
Uncertainty Reduction	Develop and display information on a spatial and temporal basis for trend identification	1	1	1	2	1	6	1
	Determine if timing of berry and sourdock sampling with respect to weather could have affected the results of risk assessment	1	1	1	2	1	6	1
	Determine through additional characterization if the size of the risk assessment study area was sufficient	1	1	2	2	1	7	1
	Evaluate potential for changes in mobility and migration of metals from oxidation or other changes in forms of minerals	1	1	2	2	2	8	2
	Determine if changes in tundra and streams are due to natural phenomena (e.g., climate change, natural slumps or seeps) or Red Dog dust or mine discharge	1	2	2	2	2	9	2
	Evaluate the potential effect of cumulative deposition on future exposure levels for humans and ecological receptors	2	2	2	2	1	9	2
	Develop predictive tools to predict when and where remediation will be needed	2	2	2	2	1	9	2

Table 6. (cont.)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
	Better understanding is needed of the factors influencing subsistence animals and fish food sources on the land (near the mine and road) and in the sea (near the port)	2	2	3	2	1	10	3
	Develop appropriate action levels to evaluate potential for effects of metals in tundra, plants, fish and other animals, and for people	2	2	3	2	1	10	3
	Evaluate potential effects of climate change on mobility of metals	2	2	2	2	2	10	3
	Develop a better understanding of "cocktail effect" of elevated metals associated with the mine	2	2	3	2	2	11	3
	Include evaluations of sub-lethal effects to animals or plants; include examination for symptoms of exposure/sickness/organ damage/other effects of exposure	3	2	3	2	2	12	3

Table 7. Priority ranking of actions for Objective 6 (improve communication and collaboration among all stakeholders)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Communication and Collaboration	Establish email group for all stakeholders for information sharing	1	1	1	2	1	6	1
	Facilitate State agency involvement with studies for third-party review and oversight	1	1	1	2	1	6	1
	Simplify technical reports and facilitate better comprehension of technical information for all stakeholders	1	1	1	2	1	6	1
	Facilitate education on language and cultural differences	1	1	1	2	1	6	1
	Employ local residents in Kivalina, Noatak, and Kotzebue as a village/mine liason	1	1	1	2	1	6	1
	Employ local residents to assist with sampling programs	1	1	1	2	1	6	1
	Identify local person responsible for collection and submittal of unusual or abnormal subsistence foods	1	1	1	2	1	6	1
	Develop an information-sharing portal/clearinghouse for regular reporting of studies, monitoring programs and dust control efforts	1	1	1	2	1	6	1
	Provide reports on prior-year programs and planned programs for upcoming year	1	1	1	2	1	6	1
	Organize community meetings and distribute information on regular schedule (vs only region wide)	1	1	2	2	1	7	1
	Improve communication between local contacts and appropriate agencies	1	1	1	2	2	7	1
	Offer public tours of mine operations and dust control efforts	1	1	1	2	2	7	1

Table 7. (cont.)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
	Incorporate local traditional ecological knowledge into study planning and study designs	1	1	2	2	1	7	1
	Provide monthly or quarterly KOTZ radio updates	1	1	1	2	3	8	2
	Develop sampling program for food currently in freezers	1	1	1	2	3	8	2
	Provide environmental education at schools and community groups	1	1	2	2	2	8	2
	Provide technical training for environmental jobs in the region (capacity-building)	1	1	2	2	2	8	2
	Provide presentations of study plan design, study progress, and results by all stakeholders (e.g., through web-based presentations, in-person workshops, conferences, etc.)	1	1	2	2	3	9	2
Institutional Controls	Improve signage and other institutional controls, and increase awareness of institutional controls through community meetings	2	1	1	3	2	9	2
	Provide agency guidance on exposure and levels for children and adults	2	1	1	3	2	9	2
Uncertainty Reduction	Provide information on funding commitments and financial assurances for long-term studies and monitoring, given uncertainty of long-term effects	1	1	1	2	1	6	1

Table 8. Priority ranking of actions for Objective 7 (protect worker health)

Risk Management Action Category	Potential Actions	Effectiveness	Implement-ability	Level of Effort	Stakeholder Preference for Action Categories	Stakeholder Preference for Potential Actions	Total Score	Priority Ranking
Communication and Collaboration	Inform workers to avoid bringing home metals dust from the mine via work clothing and equipment	1	1	1	2	2	7	1
	Have open and ongoing dialogue and networking with miners	1	1	1	2	3	8	2
Institutional Controls	Provide OSHA guidance on exposure and levels for workers	1	1	1	3	2	8	2
Monitoring	Implement human biomonitoring program for local residents and mine workers	1	1	2	1	1	6	1