**Draft**

# Fugitive Dust Background Document

## DeLong Mountain Regional Transportation System, Alaska

May 17, 2002

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**Part C**

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# List of Tables

*Tables are provided at the end of the main text.*

# Acronyms and Abbreviations

| | |
|---|---|
| AAC | Alaska Administrative Code |
| ADFG | Alaska Department of Fish and Game |
| AHPA | Alaska Historic Preservation Act |
| AIDEA | Alaska Industrial Development and Export Authority |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act of 1980 |
| CSB | concentrate storage building |
| CSM | conceptual site model |
| DEC | Alaska Department of Environmental Conservation |
| DHSS | Alaska Department of Health and Social Services |
| DMTS | DeLong Mountain Regional Transportation System |
| EPA | U.S. Environmental Protection Agency |
| ESA | Endangered Species Act |
| FWS | U.S. Fish and Wildlife Service |
| GCO Minerals | General Crude Oil and Minerals |
| MCL | maximum contaminant level |
| MIBC | methyl isobutyl carbinol |
| MLLW | mean lower low water |
| NAAQS | National Ambient Air Quality Standards |
| NANA | NANA Regional Corporation |
| NHPA | National Historic Preservation Act |
| NPDES | National Pollutant Discharge Elimination System |
| NPS | National Park Service |
| PAC | personnel accommodation complex |
| PAX | potassium amyl xanthate |
| PEX | potassium ethyl xanthate |
| PSMP | Port Site Monitoring Program |
| RCRA | Resource Conservation and Recovery Act |
| SAG | semiautogenous grinding |
| SHPO | State Historic Preservation Office |
| SMBS | sodium meta bi-sulfite |
| TSP | total suspended solids |
| Teck Cominco | Teck Cominco Alaska Incorporated |
| TEOM | tapered-element oscillating microbalance |
| WACH | western Arctic caribou herd |

# Plant and Animal Species Mentioned in This Report

| | |
|---|---|
| alders | *Alnus crispa* |
| alkali grass | *Puccinellia* spp. |
| angelica | *Angelica lucida* |
| Arctic char | *Salvelinus alpinus* |
| Arctic flounder | *Liopsetta glacialis* |
| Arctic fox | *Alopex lagopus* |
| Arctic grayling | *Thymallis arcticus* |
| arctic pendant grass | *Arctophila fulva* |
| arctic terns | *Sterna paridisaea* |
| arrow grass | *Triglochin maritimum* |
| Atka mackeral | *Pleurogrammus monopterygius* |
| Baird's sandpiper | *Calidris bairdis* |
| balsam poplar | *Populus balsamifera* |
| beach pea | *Lathyrus maritimus pubescens* |
| bearded seals | *Erignathus barbatus* |
| beluga whales | *Delphinapterus leucas* |
| blackberry | *Empetrum nigrum* |
| | *Rubus* spp. |
| blueberry | *Vaccinium* spp. |
| bluejoint | *Calamagrostis Canadensis* |
| bluethroats | *Luscinia svecica* |
| bog cranberry | *Vaccinium vitis idaea* |
| bowhead whales | *Balaena mysticetus* |
| brant | *Branta* spp. |
| brittle stars | *Ophiuroidea* spp. |
| caribou | *Rangifer tarandus* |
| chamisso willow | *Salix chamissonis* |
| chum salmon | *Oncorhynchus keta* |
| cotton grass | *Eriophorum angustifolium* |
| | *Eriophorum vaginatum* |
| cranberry | *Oxycoccus* spp. |
| crowberry | *Empetrum nigrum* |
| diamondleaf willow | *Salix planifolia* |
| Dolly Varden char | *Salvelinus malma Walbaum* |
| dwarf arctic birch | *Betula nana* |
| eider | *Somanteria* spp. |
| entire-leaf mountain avens | *Dryas integrifolia* |
| ericaceous species | *Vaccinium* spp. |
| golden eagles | *Aquila chrysaetes* |
| golden plover | *Pluvialis fulva* |
| grayleaf willow | *Salix glauca* |
| grayling | *Thymallus arcticus (Pallus)* |
| grey whales | *Eschrichtius gibbosus* |
| grey-cheeked thrushes | *Catharus minimus* |
| grizzly/brown bear | *Ursus horribilis* |
| harbor porpoises | *Phocaena phocoena* |
| hares | *Lepus* spp. |
| helmet crab | *Telmessus cheiragonus* |
| holy grass | *Hierochloe alpina* |
| horned lark | *Eremophila alpestris* |
| horsetail | *Equisetum arvense* |
| king eiders | *Somateria spectabilis* |
| Lapland longspurs | *Calcarius lapponicus* |
| lapland rosebay | *Rhododendron lapponicum* |
| lichens | *Cetraria cucculata* |
| | *Cladina rangiferina* |
| | *Cladonia* spp. |
| | *Parmelia* spp. |
| | *Thamnolia subuliformis* |
| long-tailed jaeger | *Stercorarius longicaudus* |
| lupine | *Lupinus arcticus* |
| lyme grass | *Elymus arenarius mollis* |
| Manzanita burl | *Arctostraphylos* spp. |
| mare's tail | *Hippuris vulgaris* |
| milk vetch | *Astragalus* spp. |
| moose | *Alces alces* |
| moss | *Hylocomium splendens* |
| | *Sphagnum* spp. |
| | *Tomenthypnum nitens* |
| mountain cranberry | *Vaccinium vitis-idaea* |
| murres | *Uria* spp. |
| muskox | *Ovibos moschatus* |
| narrow-leaf Labrador tea | *Ledum decumbens* |
| nine-spine stickleback | *Pungitius pungitius* |
| northern pike | *Esox lucius* |
| northern sculpin | *Icelinus borealis* |
| northern wheatear | *Oenanthe oenante* |
| oldsquaw | *Clangula hyemalis* |
| Pacific herring | *Clupea harengus pallasi* |
| polar grass | *Arctagrostis latifolia* |
| | *aurundinaceae* |
| prostrate willows | *Salix phlebophylla* |
| | *Salix reticulata* |
| rainbow smelt | *Osmerus mordax dentex* |
| red-fruit bearberry | *Arctostaphylos rubra* |
| red king crab | *Paralithodes camtschaticus* |
| red-necked phalaropes | *Phalarous lobatus* |
| redpolls | *Carduelis flammea* |
| rhubarb | *Rheum* spp. |
| ringed seals | *Phoca hispida* |
| river beauty | *Epilobium latifolium* |
| rock ptarmigan | *Lagopus lagopus* |
| rough-legged hawks | *Buteo lagopus* |
| saffron cod | *Eleginus gracilis* |
| salmonberry | *Rubus spectabilis* |
| savannah sparrow | *Passerculus sandwichensis* |
| seabeach sandwort | *Arenaria peploides* |
| | *Honckenya peploides peploides* |
| seastar | *Asterias amurensis* |
| | *Evasterias echinosoma* |
| sedge | *Carex microchaeta* |
| | *Carex scirpoidea* |
| | *Carex* spp. |
| semi-palmated sandpipers | *Calidris pusilla* |
| sheefish | *Stendous leucichthys* |
| shrimp | *Caridae* spp. |
| | *Crangonidae* spp. |
| singing vole | *Microtus miurus* |
| smelt | *Osmerus* spp. |
| snake prickleback | *Lumpenus sagitta* |
| sourdock | *Rumex arcticus* |
| spotted seals | *Phoca largha* |
| starry flounder | *Platichtys stellatus* |
| stiff sedge | *Carex bigelowii* |
| surf smelt | *Hypomesus pretiosus* |
| sweet coltsfoot | *Petasites frigidus* |
| tomcod | *Microgadus tomcod* |
| tundra vole | *Microtus oeconomus* |
| walruses | *Odobenus rosemarus* |
| water pipit | *Anthus spinoletta* |
| water sedge | *Carex aquatilis* |
| western sandpiper | *Calidris mauri* |
| white Arctic bell heather | *Cassiope tetragona* |
| white-crowned sparrows | *Zonotrichia leucophrys* |
| white fish | *Coregonys* sp. |
| | *Prosopium* sp. |
| white mountain avens | *Dryas octopetala* |
| wild camomile | *Tripleurospermum phaeocephalum* |
| wild chive | *Allium schoenoprasum sibiricum* |
| willow ptarmigan | *Lagopus mutus* |
| willows | *Salix glauca* |
| | *Salix lanata* |
| | *Salix planifolia* |
| yellowfin sole | *Pleuronectes asper* |
| yellow wagtails | *Motacilla flava* |

# Measurement Conversion Table

| Standard to Metric | | | Metric to Standard | | |
|---|---|---|---|---|---|
| 1 cubic foot per second (cfs) | = | 28.3 liters per second (L/s) | 1 L/s | = | 0.0353 cfs |
| 1 foot (ft) | = | 0.304 meter (m) | 1 m | = | 3.281 ft |
| 1 $ft^3$ | = | 0.028 $m^3$ | 1 $m^3$ | = | 35.31 $ft^3$ |
| 1 gallon (gal) | = | 3.79 liter (L) | 1 L | = | 0.26 gal |
| 1 gallon per minute (gpm) | = | 0.063 L/second (L/s) | 1 gpm | = | 15.85 gpm |
| 1 inch (in.) | = | 2.54 centimeters (cm) | 1 cm | = | 0.39 in. |
| 1 knot | = | 1.852 km/hour (km/h) | 1 km/h | = | 0.540 knot |
| 1 mile | = | 1.609 kilometers (km) | 1 km | = | 0.621 miles |
| 1 pound (lb) | = | 0.453 kilograms (kg) | 1 kg | = | 2.21 lb |
| 1 square mile ($m^2$) | = | 2.590 square kilometers ($km^2$) | 1 $km^2$ | = | 0.386 $m^2$ |

# Executive Summary

This background document presents a compilation of available information pertaining to fugitive dust and hazardous substance releases from Red Dog operations related to transport, handling, and storage of the ore concentrate between the concentrate storage building (CSB) at the mine and the deep sea vessels off the coast. Fugitive dust is any dust or particulate matter that is emitted to the ambient air as a result of activities at a facility. At the Red Dog Mine, the associated DeLong Mountain Regional Transportation System (DMTS) road and at the DMTS port, fugitive dust may be either ore concentrate, road dust, or a combination of both.

The primary objectives of the background document are to:

- Compile and summarize information pertinent to the fugitive dust issue
- Present a preliminary conceptual site model (CSM) describing sources and transport mechanisms for fugitive dust, potential exposure pathways, and human and ecological receptors
- Identify where additional data collection is needed (data gaps)
- Outline a decision-making framework for addressing current and future fugitive dust issues.

The background document is organized into three main parts: Part A—*Introduction*, Part B—*Background Information on Fugitive Dust*, and Part C—*Regulatory Review and Data Gaps*. Parts A and C were prepared by the Alaska Department of Environmental Conservation (DEC) and its contractor. Part B was prepared by Teck Cominco Alaska Incorporated (Teck Cominco) and Exponent.

## Background

The Red Dog Mine is located approximately 50 miles east of the Chukchi Sea, in the western end of the Brooks Range of Northern Alaska (Figure ES-1). Metallic mineralization has been found to occur naturally throughout much of the western Brooks Range, and strongly elevated zinc, lead, and silver concentrations have been identified in many areas.

The Red Dog Mine has been in operation since 1989. Ore is mined in an open pit, and is transferred to a nearby processing facility where it is crushed, ground, and concentrated using a flotation process. At the mine site, the concentrates are temporarily stored in a CSB. Trucks are used to transport the concentrates from the mine CSB over the DMTS road, which connects the mine to the coastal port site. At the port site, the trucks empty the concentrates into a hopper, which feeds the concentrates into a fully enclosed conveying system that carries them to one of the two CSBs. The storage capacity allows mine operations to proceed year-round, between shipping seasons. The concentrates from the storage buildings are loaded into a fully enclosed conveyor system and transferred to the shiploader, and then into barges. The barges have a built-in and enclosed conveyor that is used to transfer the concentrates to deepwater ships.

Red Dog operations are governed by a number of major permits and other authorizations issued by various federal, state, and local regulatory agencies. While some of the dust control measures have been taken in anticipation and response to enforcement actions, many engineering and operational improvements have been voluntarily implemented by Teck Cominco, both in the past and at present, to control fugitive dust emissions. The ambient air boundaries for the port and mine are illustrated in Figure ES-2. The ambient air boundary for the road is located 300 ft on either side of the road centerline.

Many environmental studies and monitoring programs have been conducted since Red Dog mining operations began. These programs have been designed to evaluate baseline conditions, monitor environmental impacts from the operations, and measure the effectiveness of emission control measures. A summary of these programs is provided in Table ES-1.

## Nature and Extent of Fugitive Dust

Metals concentrations in soil at the port site are elevated in several areas near operational parts of the facility, but concentrations decline rapidly with distance away from the concentrate storage and handling areas. Soil sampling conducted in 2001 along the DMTS road indicated that the soils making up the road base are not a significant source of metals. This sampling showed that elevated metals concentrations occurred on the road surface and road shoulder. Soil samples collected on transects in 1991 and 1992 showed that concentrations decrease rapidly with distance from the road.

Surface water samples recently collected from five creeks at locations along the DMTS road had no exceedances of water quality criteria in 4 months of data collection (July, August, September, and October 2001). Surface water data from those creeks show little if any impact from the DMTS road. Most of the samples had concentrations below analytical detection limits and none of the concentrations exceeded DEC’s surface water criteria.

At the port site, patterns observed based on dustfall collector sampling, snow sampling, and high-volume air sampling indicated that the primary sources of fugitive dust were at the ends of the CSBs, the roadway where trucks exit from the truck unloading building, and the surge bin (at the dock area) that evens out concentrate flow on the conveyors at the dock area. Along the DMTS road, dustfall collector results from September 2001 indicated that the total dustfall rate was greatest near the port site and relatively consistent along the rest of the road.

Alaska Department of Fish and Game (ADFG) sampled juvenile Dolly Varden tissues from two streams (Aufeis Creek and Omikviorok River) in the vicinity of the DMTS road in 2001. Juvenile Dolly Varden was chosen because it is a species and age class that can rapidly reflect the environmental metals concentrations in its tissues, and therefore is a good indicator of metals contamination. The results did not show a relationship of fugitive dust to the metals concentrations in juvenile Dolly Varden samples.

The National Park Service (NPS) performed a preliminary study in Cape Krusenstern National Monument in June–July 2000 to determine whether there were elevated lead, zinc, and cadmium levels in moss near the road. 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. As part of Teck Cominco's fugitive dust study in 2001, Exponent collected moss, lichen, willow, and salmonberry samples 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.

Unwashed salmonberry samples collected by both Exponent and DEC at the port had elevated mean lead, zinc, and cadmium concentrations relative to unwashed salmonberry samples collected in offsite areas.

## Preliminary Conceptual Site Model

The preliminary CSM identifies potential sources, transport mechanisms, exposure media, exposure routes, and human and ecological receptors. The CSM provides an initial description of the network of relationships between chemicals released from a site and the human or ecological receptors that may be exposed to the chemicals through pathways such as ingestion of food or water. The CSM for Red Dog operations delineates hypothesized transport of metals from sources at the mine, along the DMTS road, and at the DMTS port facility into surrounding terrestrial and aquatic ecosystems, and the pathways by which human or ecological receptors may be exposed to these metals. The primary mechanisms by which metals escape from these sources are through fugitive dust and concentrate spillage. In addition, runoff from precipitation and snowmelt could also transport metals from the DMTS road, mine, and port operations into surrounding ecosystems.

### Sources and Transport Mechanisms

Sources of metals from the mine include air transport of dust and surface water runoff. These sources are managed through DEC permitting processes. Air emissions from the mine have been modeled as part of the air permitting process. Air modeling demonstrates that the air permit requirements are met at the mine's ambient air boundary. All surface water from the mine area is collected behind the tailings dam and is treated prior to release to Red Dog Creek. Metals concentrations in the surface water discharge are subject to limits defined in the National Pollutant Discharge Elimination System (NPDES) discharge permit.

The primary sources and mechanisms of fugitive dust transport along the DMTS road include tracking (adhering to the tires or other surfaces of the haul trucks, and subsequently being deposited onto the road), and windblown dust from the road surface. Dust on truck surfaces may be blown from those surfaces and carried onto the road or into the surrounding environment. Surface water runoff from the road can carry metals containing dust from the surface of the road to the tundra just off the road shoulder. In the past, concentrate spillage and escapement from trucks was likely a significant factor; however, new trucks with hydraulically closed steel covers that seal tightly may have minimized or possibly eliminated this source.

In addition to those mechanisms described above for the DMTS road, other fugitive dust sources and transport mechanisms may occur at the port site. These include windblown dust from the unloading process at the truck unloading building, handling of concentrates in the CSBs, and moving the concentrates through the conveyor loading system. Concentrates are now carried by a closed conveyor from the CSBs to the barges. Before the system was enclosed, however, some spillage of concentrate from the conveyors occurred.

During barge loading, there is some potential for concentrate dust to emerge from the covered barge and be carried into the surrounding environment by the wind. There is low potential for spillage or windblown dust during transport between the shiploader and the deepwater ship. Once within the ship, there is low potential for spillage or generation of windblown fugitive dust.

## Human Health

The potential for people to be exposed to metals related to the DMTS road and the port area is limited, because of the remote nature of the affected area. Worker exposure is controlled through a closely monitored industrial hygiene program. The local subsistence users that fish, hunt, and gather plants and berries may also be exposed through consumption of food items.

Potential exposure pathways may be categorized under three environments: marine, terrestrial, and freshwater. In each of these environments, there may be some potential for exposure to metals through consumption of food (e.g., plants, fish, and/or other animals) and incidental ingestion or contact with soil/sediment. In the freshwater environment, potential exposure to metals may also exist through ingestion or contact with affected water.

Metals could be transported to the marine environment through surface water runoff, fugitive dust deposition, or spillage in the barge transfer operation, and could subsequently be taken up by marine animals that are consumed by people. Local residents could be exposed to metals taken up by plants or animals downwind of the DMTS road or port site through consumption of subsistence harvest foods. Metals from the DMTS road or port facility that have been transported onto plants or tundra soils could be consumed by animals (e.g., ptarmigan and caribou) that are in turn consumed by people. People could also consume plants and berries that have taken up metals from the soil or onto which dust has been deposited. Incidental ingestion and dermal contact with soil (if it contains elevated metals concentrations) could possibly lead to human exposure as well. Inhalation of airborne particulates from soil is another potential exposure pathway, although it is likely to be limited relative to other pathways. Berry sampling conducted by DEC and Exponent suggested elevated concentrations of some metals relative to reference conditions. However, preliminary risk calculations conducted by the Alaska Department of Health and Social Services did not indicate any elevated risks associated with consumption of berries or other subsistence foods.

Although current data indicate minimal effects, surface water quality could potentially be impacted by metals from the DMTS road, port, or the mine. If surface water quality is affected, fish in the streams may accumulate metals, which could then be consumed by subsistence users. If freshwater sediments are affected by metals, exposure could theoretically occur through incidental ingestion or dermal contact with the sediments. Surface water runoff from the mine is collected behind the tailings dam, treated, and discharged to Middle Fork Red Dog Creek (subject to the permit issued under NPDES), which ultimately flows into the Wulik River. The Wulik River is a source of drinking water for Kivalina residents. Sampling of Kivalina drinking water has been conducted on an ongoing basis and has not shown elevated metals concentrations. This sampling program will continue.

### Ecological

Pathways by which ecological receptors may be exposed to metals associated with Red Dog operations exist for both aquatic and terrestrial communities in the vicinity of the mine, DMTS road, and port facility. The mine is located in an area of naturally occurring mineralization and therefore naturally elevated metals concentrations. Primary exposure pathways for aquatic receptors include the ingestion or uptake of surface water, consumption of plant material or prey, incidental ingestion of sediment during foraging, and direct contact with surface water. Primary exposure pathways for terrestrial receptors include the consumption of plant material or prey and the incidental ingestion of soil. For plants, the primary pathways are the uptake of metals incorporated into soil and the uptake of metals deposited onto plant surfaces as fugitive dust. For most receptors, direct contact with affected sediment or soil would be brief, and thus constitutes only a minor exposure pathway.

Ecological receptors that may be exposed to metals from Red Dog operations occur in aquatic systems such as creeks, tundra ponds, marshes, bogs and other wetlands, coastal lagoons, and the marine ecosystem. Receptors also occur in terrestrial systems such as shrub and tussock tundra and coastal sand dunes. Receptors that would be considered for use in an ecological risk assessment would be identified in consultation with local subsistence users.

## Identification of Potential Data Gaps

This section provides a preliminary list of additional information that may be needed to understand the effects of fugitive dust on the environment (referred to as data gaps). The following list of data gaps emerges from a review of the various background information and analytical data, as well as the site conceptual model reviewed and described in this document. Additional data gaps may be identified through the public review process, which would include consultation with the subsistence committee, as well as local, state, and federal agencies.

The potential data gaps listed below should be viewed as a starting point for public review, and may not be a complete list of needed information. As these potential data gaps are evaluated, and available data reviewed, some of the items may be removed from the list, if sufficient information is already available.

Additional background information that may be needed to evaluate fugitive dust transport, deposition, and effects includes:

- Current subsistence information (e.g., percentages of villagers relying on subsistence activities, most important subsistence foods, consumption rates)
- Regional metals occurrences and background concentrations of metals (in order to distinguish between naturally occurring metals concentrations and metals concentrations resulting from dust emissions from the mining and transport operations).

Data gaps related to the characterization of the nature and extent of fugitive dust deposition may include:

- Soil data to define the extent of ore concentrate deposition around operational features at the port site (e.g., conveyor storage area, P8 conveyor, etc.), and along the road
- Water from tundra ponds in the vicinity of the DMTS road
- Sediment data from nearshore areas, the deepwater ship area, and stream sediment and/or tundra pond sediment from along the DMTS road
- Aquatic biological data, possibly including aquatic organisms in tundra ponds along the DMTS road
- Terrestrial biological data needs may include:
  - Extent of metals in moss around the DMTS port and along the DMTS road (unclear where elevated numbers approach background)
  - Metals uptake into subsistence harvest plants—metals within versus on plant (potentially for addressing human health concerns)
  - Ecological impacts of fugitive dust (ecological risk screening evaluation)
  - Small animal tissue data to support ecological risk screening evaluation.

Data needs related to monitoring fugitive dust emissions and the effects of fugitive dust deposition may include:

- Periodic soil sampling (road, port)
- Periodic water sampling (lagoons, streams at road crossings)
- Periodic sediment sampling (lagoon and offshore sediment)
- Air monitoring (at ambient air boundary of road, port and mine)

- Air monitoring in villages (already planned)
- Juvenile Dolly Varden tissue (additional monitoring near road already planned)
- Periodic moss sampling
- Caribou sampling (field work completed in April 2002, analyses in progress)
- Other species (e.g., ptarmigan, receptors in risk assessment process).

## Decision Making Framework (DEC)

Areas that qualify as "contaminated sites" will be addressed through the Site Cleanup Rules found in 18 Alaska Administrative Code (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 general decision framework shown in Figure ES-3 will be used to make cleanup decisions at contaminated sites associated with the Red Dog Mine operations between the CSB at the mine and the deep sea vessels off the coast. Taken together, paragraphs 21, 22, 23, 49, and 115 of 18 AAC 75.990 define a contaminated site as an area containing hazardous substances at concentrations exceeding applicable cleanup levels. Cleanup levels are defined as concentrations of hazardous substances that may be present in environmental media under specified exposure conditions without posing a threat to human health, safety, or welfare, or to the environment. Environmental monitoring options to evaluate and determine dust control measures at the Red Dog Mine CSB, and the DMTS road and port facilities will be evaluated throughout the project.

# Figures

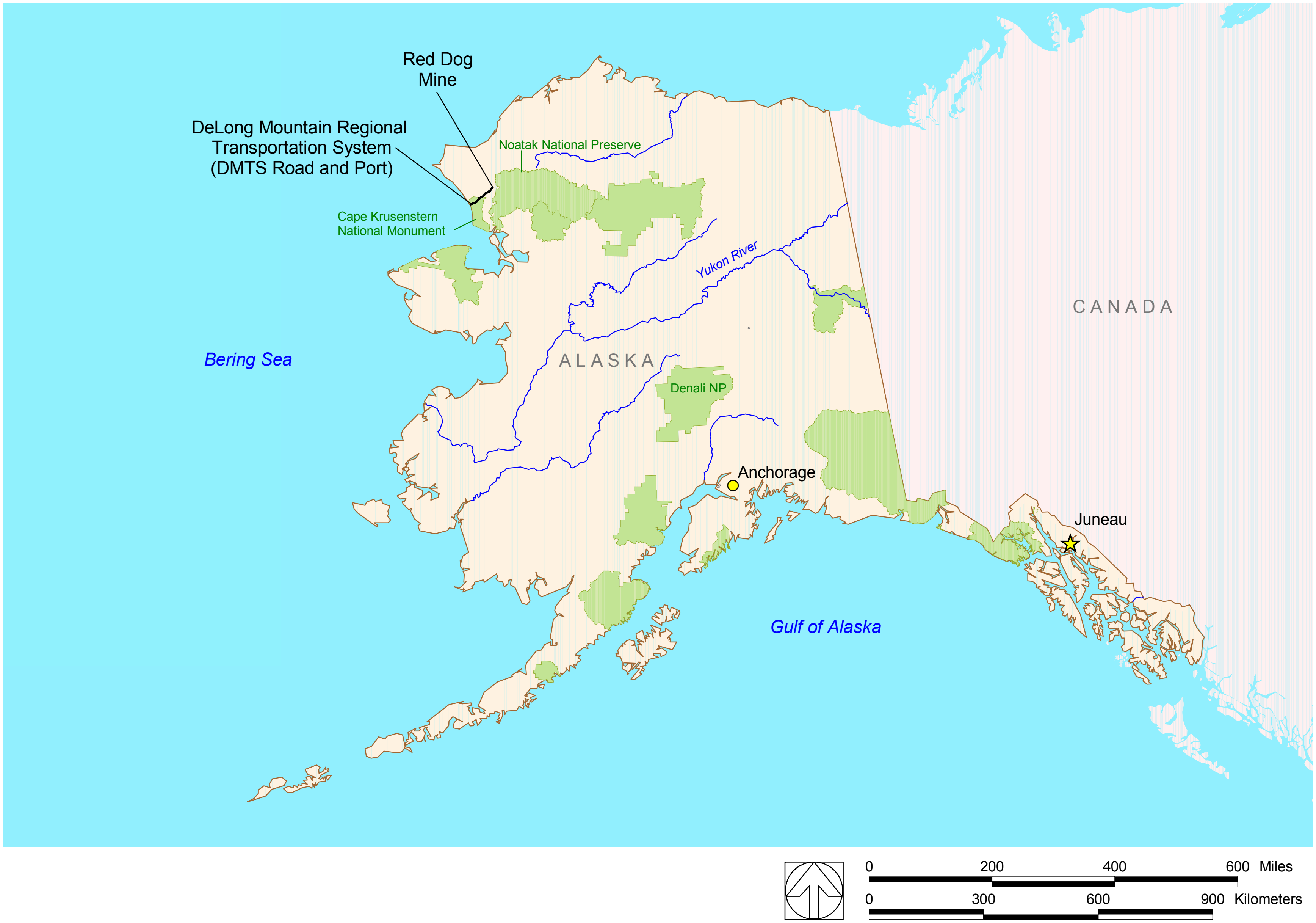


Figure ES-1. Location map

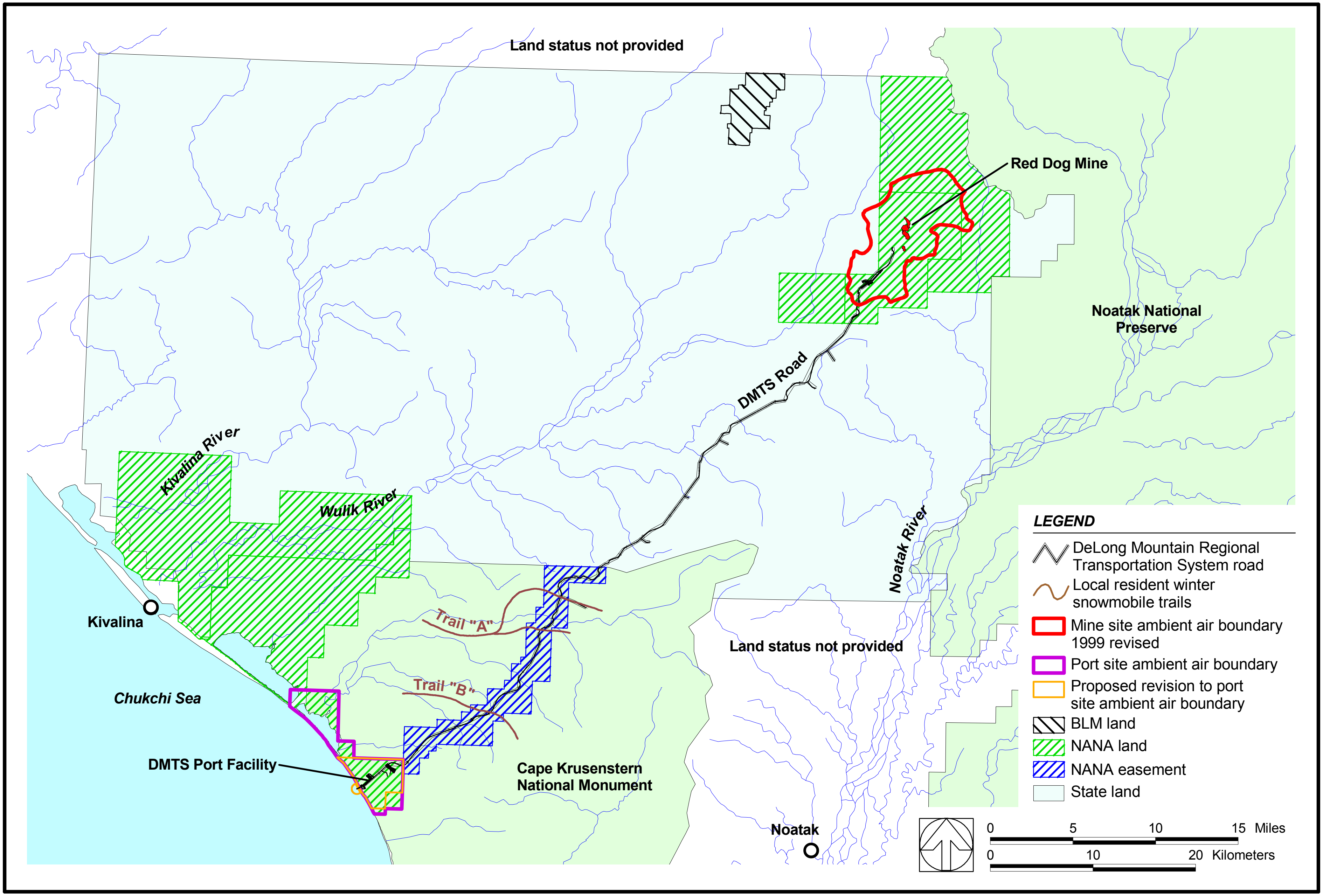
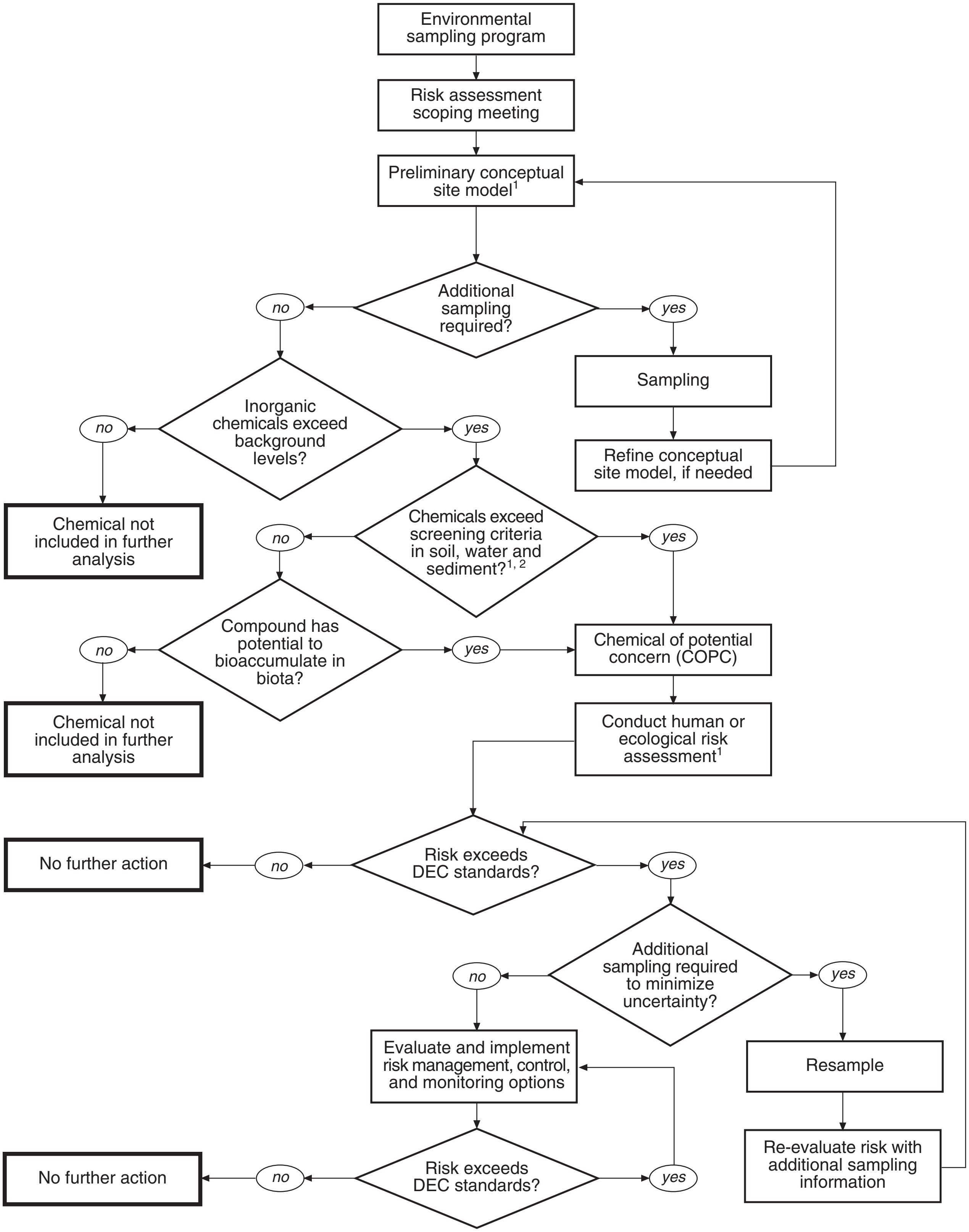


Figure ES-2. Land ownership and use map

8601997.001 0302 | May 16, 2002 | Fig 1-6 Land ownership | Fig ES-2 land ownership layout | j:\red_dog\projects\bckgrnd_0202.apr



1 Human and ecological receptors will be evaluated separately

2 Water quality standards and contaminant migration will be evaluated

Figure ES-3. Decision making framework for evaluating risk to human health and ecological receptors

# Tables

**Table ES-1. Summary of studies by media**

| | | | | | | | | Biological Media | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Environmental Media | | | | Plant | | | | | | | | Animal | | | |
| Lead Organization | Study Type | Citation | Study Dates | Soil | Water | Sediment | Air | Algae | Moss | Lichen | Willow | Salmonberry | Blackberry | Sourdock | Plant Communities | Invertebrates | Fish | Caribou | Human Blood |
| **Pre-Mine/Baseline** | | | | | | | | | | | | | | | | | | | |
| Teck Cominco | Environmental baseline study | Dames & Moore (1983) | 1981–1983 | | A | | | | | | | | | | | O | A | | |
| General Crude Oil and Minerals | Environmental baseline study | Ward and Olson (1980) | 1978–1979 | | A | | | | | | | | | | | | A | | |
| Alaska Department of Environmental Conservation | Aquatic baseline study | EVS and Ott Water (1983) | 1982 | | | | | | | | | | | | | | A | | |
| U.S. Fish and Wildlife Service | Baseline study for Selawik NWR | Mueller et al. (1993) | 1987–1988 | | A | A | | | | | | | | | | | A | | |
| **Post-Mine** | | | | | | | | | | | | | | | | | | | |
| Teck Cominco | Port site monitoring | ENSR (1990, 1991, 1993, 1996); RWJ (1997) | 1990–1996 | A | A | A | | | | | | | | | | | | | |
| | Transportation corridor monitoring | ENSR (1991) | 1991–1992 | A | A | | | | | | | | | | | | | | |
| | Port site air monitoring | | 1997–present | | | | A | | | | | | | | | | | | |
| | Vegetation and soil monitoring | RWJ (1997) | 1992, 1993, 1997 | A | | | | | | | | | | | O | | | | |
| | Fugitive dust study | Exponent (2002) | 2001 | A | A | | | | A | A | A | A | | | | | | | |
| | Kivalina drinking water study | RWJ (1997); DHSS (2001) | 1991–2001 | | A | | | | | | | | | | | | | | |
| Alaska Industrial Development and Export Authority | Sediment quality survey | Cominco, RWJ, and PN&D (1999) | 1998 | A | | A | | | | | | | | | | | | | |
| | Marine biota survey | RWJ (2001) | 2000 | | | | | | | | | | | | | O | O | | |
| Alaska Department of Environmental Conservation | Subsistence foods investigation | ADEC (2001); DHSS (2001) | 2001 | | A | | | | | | | A | A | A | | | | | |
| Alaska Department of Fish and Game | NPDES monitoring | Weber-Scannell and Ott (2001) | 1991–1994 | | | | | | | | | | | | | | O | | |
| | NPDES monitoring, expanded scope | Weber-Scannell and Ott (2001) | 1994–2001 | | A | | | O | | | | | | | | O | A | | |
| | Juvenile fish tissue study | Morris and Ott (2001); DHSS (2001) | 1993, 1998–2001 | | | | | | | | | | | | | | A | | |
| | Caribou monitoring | Pollard (1994) | 1993–1994 | | | | | | | | | | | | | | | O | |
| | Caribou tissue study | DHSS (2001) | 1996 | | | | | | | | | | | | | | | A | |
| National Park Service | DMTS road dustfall study | Ford and Hasselbach (2001) | 2000 | A | | | | | A | | | | | | | | | | |
| | | Ford and Hasselbach (2002)[a] | | A | | | | | A | | | | | | | | | | |
| Kivalina Village | Kivalina drinking water sampling | DHSS (2001) | 1995, 1996, 2001 | | A | | | | | | | | | | | | | | |
| Alaska Department of Health and Social Services | Public health evaluation | DHSS (2001) | 1992–2001 | | | | | | | | | | | | | | | | A |

**Note:** A - analytical data available
O - other data types available

[a] Study release is pending.

# Part A

## Introduction

# 1 Introduction

The purpose of this document is to provide an overview of the fugitive dust and ore concentrate release issues from Red Dog operations related to transport, handling, and storage of the ore concentrate, and to outline a framework within which these issues can be addressed. Fugitive dust is any dust or particulate matter that is emitted to the ambient air as a result of activities at a facility. At the Red Dog Mine, the associated DeLong Mountain Regional Transportation System (DMTS) road, and at the DMTS port, fugitive dust may be either ore concentrate, road dust, or a combination of both.

The information in this document has been assembled to provide background and context for the numerous and varied environmental concerns that have been raised since the summer of 2001. Because the Red Dog Mine is an active facility, this document focuses on fugitive dust and hazardous substance releases during transport and handling of the ore concentrate between the doors of the concentrate storage building (CSB) at the mine and the deepwater ships off the coast only.

The Red Dog Mine, operated by Teck Cominco Alaska Incorporated (Teck Cominco), is a zinc and lead mine located approximately 100 miles north of Kotzebue. The DMTS, owned by the Alaska Industrial Development and Export Authority (AIDEA), consists of the haul road and the port facility. Ore concentrate from the mine is transported in trucks to the port facility, where it is stored in CSBs before it is loaded onto barges via a conveyor belt system and transported to larger ships off the coast.

The 52-mile, gravel DMTS road connects the Red Dog Mine with the port facility and traverses through roughly 20 miles of the Cape Krusenstern National Monument. In June 2001, the National Park Service (NPS) published the study: *Heavy Metals in Mosses and Soils on Six Transects Along the Red Dog Mine Haul Road Alaska* (Ford and Hasselbach 2001). NPS tested moss and lichen along the road for heavy metal contamination. Laboratory analysis showed elevated levels of lead, zinc, and cadmium in samples taken up to 1 mile away from the DMTS road.

The information summarized in this report includes the mine, port, and DMTS road operations, regulatory and monitoring history, permits, current and historic monitoring, and sample results. This information was obtained by reviewing previous studies performed by the Alaska Department of Environmental Conservation (DEC), NPS, U.S. Fish and Wildlife Service (FWS), Teck Cominco, AIDEA, the Alaska Department of Fish and Game (ADFG), the Village of Kivalina, and the Alaska Department of Health and Social Services (DHSS).

The primary objectives of this document are as follows:

- Compile and summarize information on Red Dog operations.
- Provide an overview of all the issues associated with fugitive dust and the hazardous substance releases connected with it, in a way that will be useful for educating the interested public and government agency staff on the

subject, and which will help to distinguish concerns that have been attributed to, but are unrelated to, fugitive dust.

- Document concerns of local residents. Identify the concerns attributed to fugitive dust and those related to other mine issues, which will need to be addressed in another forum.
- Define the potential nature and extent of contamination based on existing data.
- Present a preliminary conceptual site model (CSM) describing sources and transport mechanisms for fugitive dust, potential exposure pathways, and human and ecological receptors.
- Document data gaps to identify additional study and monitoring needs.
- Develop a decision-making framework to implement actions that satisfactorily address existing contamination and identify and prevent further fugitive dust releases.

The background document was independently developed by DEC and Teck Cominco, and is divided into three sections. The first and third sections (Parts A and C) were prepared by DEC and its contractor, Ecology and Environment, Inc. Part B was prepared for Teck Cominco by its contractor, Exponent, and summarizes information and data concerning fugitive dust at the mine, road, and the port facility. This document is a work in progress, with the goal of identifying areas where additional research and information are needed to fully understand the source and extent of fugitive dust deposition and impact. As the data gaps are filled and more is learned about fugitive dust and ore concentrate release issues, DEC will consult with and share this information with the public. In the meantime, this background document compiles information and research from various sources to help provide direction and identify future steps.

Part A, written and assembled by DEC, consists of this introduction and a list of observations and concerns that DEC has gathered to date from residents living in the general vicinity of the mine, DMTS road, and port. This section is only a brief summary of comments; in order to complete this section, more information and feedback from local communities and individual residents are needed.

Part B, developed by Teck Cominco and reviewed by DEC and state resource management agencies, provides information about the region surrounding the mine, including details on climate, plants and wildlife, geology and soils, surface water and groundwater, and land use and ownership. The section also describes operations at the mine site, road, and port facility. Topics covered include regulatory history, findings from studies and monitoring programs (both pre-mine and post-mine), the nature and extent of fugitive dust and ore concentrate release, and a preliminary CSM. The CSM is a planning tool for identifying chemical sources, exposure pathways, and potential receptors on which to focus any further human health or ecological risk assessment. The CSM examines the range of potential exposure pathways and identifies those that are present and may be important for human receptors or for vegetation and wildlife, and eliminates those pathways that are incomplete and therefore cannot pose significant risk.

Part C provides a list of state and federal regulations that may affect the management and cleanup of fugitive dust and hazardous substance releases. Potential data gaps are identified and sampling and monitoring efforts are described to better characterize the extent and potential effects of the heavy metals release associated with the fugitive dust and ore concentrate releases. A decision-making framework discusses the principle of decision-making and key decisions that need to be made during the fugitive dust study process.

In the remainder of the document, we will refer to the fugitive dust and hazardous substance releases simply as fugitive dust.

# 2 Local Observations and Concerns

This chapter is intended to document the concerns, opinions, and observations from members of the native communities surrounding the Red Dog Mine. Following is a summary of the comments, suggestions, and concerns that village residents have shared with DEC staff to date.

The mine operations have raised many concerns in the region. The specific comments and concerns, as they were mentioned to DEC staff, will be listed in Appendix A. These statements were recorded in writing by DEC staff in conversations with villagers and are deliberately kept brief to act as a starting point for further discussions. So far, few people have voiced their concerns and DEC would appreciate more information and feedback, including on the comments that were made previously.

Not all comments relate to fugitive dust and ore concentrate release. In this chapter, we will focus on the comments and suggestions concerning fugitive dust and ore concentrate release, while for completeness, all comments that have been shared with DEC are listed in Appendix A. Comments which pertain to issues other than fugitive dust will be forwarded to the appropriate resource agencies for further follow-up.

Local residents have expressed concern about impacts to human health, the environment, and the subsistence lifestyle resulting from metals in fugitive dust from mine operations along the DMTS road and the port. Generally, the types of concerns that have been expressed by residents include:

- Metals concentrations in subsistence foods, as well as drinking water, and implications for safety of consuming traditional foods and drinking water supplies
- Metals concentrations in air in the villages and subsistence use areas
- Adequacy of controls on fugitive dust to protect human health and the environment over the long-term life of the mine
- Effects of mine and transport operations on migration patterns of animals important to residents (e.g., caribou).

The purpose of the background document is to provide all interested stakeholders with as much information as possible about the fugitive dust issue. With this document, DEC intends to establish a framework through which these and any future concerns can be addressed by further evaluation of the possible effects on human health and the environment.

To adequately capture and document the concerns of residents in the regions, DEC would like to get input from a broad cross-section of the communities. If you have additional concerns, suggestions, or comments to share with DEC and other stakeholders, please call Sandra Smith at (907) 465-5365, e-mail to: sandy_smith@envircon.state.ak.us, or mail to her at 410 Willoughby Ave., Suite 303, Juneau, AK 99801.

# Part B

## Background Information on Fugitive Dust

# 1 Local and Regional Information

This section provides an overview of the following subjects, as they pertain to the DMTS road and port, and the Red Dog mine:

- General Location
- Physiography
- Climate
- Ecology
- Soils and Geology
- Hydrology
- Land Ownership and Use.

## 1.1 General Location

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 (see Figure 1-1), which is an area of widespread natural mineralization containing exceptionally high concentrations of metals. The mine is connected to the Chukchi Sea by the DMTS road and port facility (see Figure 1-2).

## 1.2 Physiography

The principle settlements in the region are the villages of Noatak, Kivalina, Kotzebue, Point Hope, the Red Dog Mine complex, and the DMTS port complex. The geography of the region is varied, ranging from the rugged steep peaks and valleys in the DeLong Mountains, to more moderate rolling topography on the Brooks Range foothills and Lisburne Hills, to extensive areas of relatively flat tundra cover between the hills and the coasts (see Figure 1-2).

The Red Dog study area lies within moderately sloping hills, lowlands, and broad stream valleys. This region is composed of hills and upland areas that gradually grade into coastal plains (RWJ 1997). An active layer of permafrost (usually less than 3.3 ft [1 m] thick) underlies this region, but thawing at greater depths can occur beneath large rivers. The gradient of the slopes can range from 0 to 5° (USGS 2001). The nearby DeLong Mountains have ridges that rise to 5,000 ft above mean sea level and lower ridges elevated at heights between 1,500 to 3,000 ft (Ward and Olson 1980).

The area is usually dominated by ice-related surface features such as pingos, solifluction lobes, ice-wedge polygons, beaded drainages, and stone stripes. Pingos are mounds of soil with a core of ice. Solifluction lobes are tongue-shaped masses of the active layer (soil lying above the permafrost) that overlap each other and form a staircase slope profile. In the coastal area, ice-wedge polygons are formed by the contraction of cracks in the permafrost. These cracks fill with water and freeze. Eventually, a network of deep ice wedges forms and these wedges create troughs that are bounded by ridges. These ridges are made by the ice wedge pushing up the ground surface (RWJ 1997). The center of these polygons can also form small, shallow ponds when the active layer thaws in the summer. These thaw ponds can expand and coalesce to form small lakes. If these small lakes can become deep enough, they can become permanently unfrozen thaw bulbs (RWJ 1997). The thaw ponds can remain small, and connected by a stream to resemble a beaded necklace. This formation is called a beaded drainage. Stone stripes are a pattern of surface stones and surrounding soil, on unvegetated slopes, oriented up and down the slope.

The Kivalina and Wulik River floodplains consist mainly of unconsolidated alluvial material deposited by streams and rivers. The river drainages can also have areas of thick ice cover due to aufeis formations. These formations occur when the ice fractures because of confinement pressure of the water by ice. These fractures will allow water to escape, which is subsequently frozen in thin surface sheets (U.S. EPA 1984).

In general, the underlying bedrock structure controls the flow of most streams. During the winter months, smaller streams can completely dry up or freeze solid. These smaller streams usually have sand or gravel bottoms, while streams that flow throughout the year usually have rocky bottoms covered with algae. When spring snowmelt occurs, channel shifting of the water and flooding are normal. The lakes in this region are usually oxbow lakes, with organic muck and sand in the lake bed (USGS 2001).

Large rivers such as the Wulik and Kivalina Rivers begin to freeze over in October, and have low flows between January and April. The peak flows generally occur in May or June, due to spring snowmelt. The rivers have a rapid response to sudden precipitation events because of the shallow permafrost depths and, consequently, the small groundwater storage capacity (USGS 2001).

## 1.3 Climate

Because there are very few weather stations in this region and limited (<12 years) onsite meteorological data, the climate information provided in this section may not be completely representative of the entire area around the Red Dog Mine and DMTS road and port. The northwestern region of Alaska, where the Red Dog Mine and port are located, is slightly less cold than other Arctic regions, due to the ameliorating effects of the Chukchi Sea (USGS 2001). The climate in this area is classified as a cold continental climate (Gough et al. 1988). Despite the area being close to the coast, the moderating effects of the water are still limited because of the large extent of freezing throughout most of the year and the shallow depths of the water near the port site. Because the mine and port sites are only 52 miles apart, their climate is essentially the same, with minor differences due to the DMTS coastal location and the Red Dog Mine's proximity to the DeLong Mountains. In summer, the coast is dominated by polar maritime climate, with cooler air temperatures, more frequent fog and clouds, and stronger westerly winds compared to the inland areas and the DeLong Mountains. The summer Red Dog (inland) climate is more continental, with more sunshine, greater daily temperature swings, and variable winds. In winter months, the two area climates are generally similar, with some differences in wind, precipitation, and temperature depending on proximity to the DeLong Mountains and local topography.

Near the seacoast, typical summer temperatures range from 39 to 55ºF (4 to 13ºC) and winter temperatures range from −15 to 5ºF (−26 to −15ºC). Seacoast temperature extremes are −53ºF (−47ºC) in winter and 84ºF (29ºC) in summer. Summer temperatures at Red Dog Mine typically fluctuate between 36 and 64ºF (2 and 18ºC), with maximum high temperatures near 90ºF (32ºC). Winter temperatures at Red Dog are commonly −20ºF (−29ºC) with annual extremes of −40 to −50ºF (−40 to −46ºC), and one recorded winter temperature of −60ºF (−51ºC) since mining began.

Mean monthly cloudiness ranges from 50 to 80 percent, with most clear days occurring in the winter. Fog occurs about 10 percent of the time on the coast. The sun is continuously above the horizon for approximately 7 weeks centered around June 22 (the summer solstice). Because of shading by surrounding mountains, the sun sets below the terrain for a few hours in the Red Dog valley, even in June. The sun is continuously below the horizon for approximately 4 weeks centered around December 22 (the winter solstice).

Mean annual precipitation at the DMTS port is approximately 18.2 in. Over an 8-year period of record, the port annual precipitation ranged from a low of 8.4 in. to a high of 28.8 in. Annual precipitation observations at the Red Dog Mine during the 1992–2001 period ranged from 11.5 to 26.3 in., with a mean of 18.1 in. At both the Red Dog Mine and the DMTS port, more than one-half the annual precipitation occurred as rain during July through September. August is the wettest month of the year, receiving more than one-quarter of the annual precipitation.

Snowfall has been recorded every month of the year, but consistent snow cover generally occurs only from the middle of October to the middle of May. Considerable blowing and drifting of snow occurs in coastal locations and on exposed peaks and ridges, accumulating in depressions and in the lee of banks, buildings, or other structures.

There are marked seasonal differences in wind regime, particularly at the port facility. During the winter the predominant winds at the port are from the northeast. Summer winds at the port are much more variable.

In the Red Dog valley, local topography influences wind directions and velocity. Predominate winter winds are northeast to southeast and summer winds are variable. Mean annual wind speeds average 2.5 to 3 m/s, and near-calm conditions can be expected approximately 20 percent of the time.

Figure 1-3 includes annual composite windrose diagrams for years 2000 and 2001, as well as quarterly composites for year 2000. The windrose diagrams show wind direction, frequency, and speed, both for the port and the mine's meteorological stations.

# 1.4 Ecology

## 1.4.1 Regional Animal and Plant Communities

The vegetation over this region is classified as mesic graminoid herbaceous (grass and sedge) and dwarf scrub/shrub communities. The mesic graminoid herbaceous communities consist of tussock-forming sedges such as cotton grass and stiff sedge.[1] Co-existing with the sedges and grasses are mosses and lichens (USGS 2001).

The dwarf shrubs found in this region include dwarf arctic birch, crowberry, narrow-leaf Labrador tea, and mountain cranberry. The dwarf scrub communities consist of Dryas species, prostrate willows, ericaceous species, white Arctic bell heather, and Manzanita burl. In areas with low scrub vegetation, the most prevalent trees are alders and willows (USGS 2001).

The Red Dog site includes three areas that have distinct animal and plant communities. They are discussed in further detail below.

### 1.4.1.1 Mine Area

The vegetation found in the mining area is dominated by a dwarf shrub community, mainly white mountain avens. In areas with thicker soil (4–6 in. thickness), dwarf arctic birch and narrow-leaf Labrador tea are prominent. Communities found on the leeside of slopes and ridges are typically holy grass, sedge, milk vetch, red-fruit bearberry, and lupine. At the toe of slopes, entire-leaf mountain avens, Lapland rosebay, bog cranberry, sedge grasses and moss are prevalent (Dames & Moore 1983).

The bird community observed at the mine site (prior to commencement of mining) was smaller in comparison to the other areas. Prevalent birds are the northern wheatear, water pipit, grey-cheeked thrushes, golden plover, and horned lark. Golden eagles, rough-legged hawks, and long-tailed jaegers are common predatory birds (Dames & Moore 1983).

The most abundant fish in Red Dog Creek are the Arctic grayling and Arctic char. Juvenile fish enter Mainstem Red Dog Creek from Ikalukrok Creek or from North Fork Red Dog Creek (graylings only). These areas are important for spawning and rearing of juveniles (Ward and Olson 1980). Baseline studies conducted before mining began reported that Arctic graying migrated through Mainstem Red Dog Creek to the North Fork Red Dog Creek during spring high flows when metals concentrations were lower (Dames & Moore 1983). Pre-mining concentrations of zinc in Mainstem Red Dog Creek were elevated above the reported chronic toxic concentrations of 0.09−7.21 mg/L for salmonid fish (U.S. EPA 1980). Fish were observed in Mainstem Red Dog Creek within the influence of the North Fork Red Dog Creek (Dames & Moore 1983) and fish mortalities were documented in Mainstem Red Dog Creek (EVS and Ott Water 1983; Ward and Olson 1980). Since the initiation of mine discharge and construction of the mine drainage bypass system, metals levels in the mainstem have been reduced (Weber-Scannell et al. 2000).

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[1] Please refer to the list of plant and animal species on page vii for scientific designations.

In recent years, work conducted by ADFG has documented the presence of juvenile and adult Dolly Varden and Arctic grayling in Mainstem Red Dog Creek. Dolly Varden and Arctic grayling use has been documented since 1994. Young-of-the-year Dolly Varden were present in Mainstem Red Dog Creek in 1999. Arctic grayling have been caught by ADFG in 1999 in a portion of Mainstem Red Dog Creek (Weber-Scannell et al. 2000).

#### 1.4.1.2 Port Area

In the port area, lyme grass and beach pea dominate along the sand dunes. Other species that grow in the port area include seabeach sandwort, polar grass, wild chamomile, and wild chive. In small ponds and coastal wetlands with salt water influxes, alkali grass, mare's tail, and arrow grass were the only species found. Horsetail, angelica, and seabeach sandwort grow in the freshwater ponds along the coast (Dames & Moore 1983). Cranberry and blackberry species occur along the coastal sand dune. Salmonberry and sourdock species occur in areas near the coastal lagoons (Glavinovich 2001; Exponent 2002).

Riparian areas near the port are habitats for birds such as bluethroats, arctic terns, and occasionally, the savannah sparrow. In shallow-water lagoons, shorebirds, ducks, geese, and sandhill cranes use the region as a staging area during spring migration (Dames & Moore 1983).

#### 1.4.1.3 DMTS Road

Most of the area surrounding the DMTS road corridor is tussock tundra, dominated by willow and cotton grass with lichens interspersed. Along the streams, diamondleaf willow is predominant with sweet coltsfoot, bluejoint, and moss as prominent undergrowth. Other species occurring in the area include river beauty, balsam poplar, blueberry, and narrow-leaf Labrador tea. Shrub vegetation on hills and riparian areas are dominated by dwarf arctic birch, bog blueberry, crowberry, and entire-leaf mountain avens. Chamisso willow and grayleaf willow can be found along stream terraces (Dames & Moore 1983).

There are numerous wetland habitats along the DMTS road. The vegetation in this community is predominately water sedge, arctic pendant grass, mare's tail, and cotton grass (Dames & Moore 1983).

The abundance of small tundra ponds along the DMTS road attracts many species of waterfowl, such as shorebirds, swans, geese, and ducks during the fall migration. In riparian areas, rock ptarmigan, willow ptarmigan, savannah sparrows, tree sparrows, white-crowned sparrows, redpolls, and yellow wagtails can be found. In marsh habitats, Lapland longspurs, red-necked phalaropes, semi-palmated sandpipers, Baird's sandpiper, and western sandpiper dominate (Dames & Moore 1983).

### 1.4.2 Wildlife Observations

A total of 104 species of birds were observed by Dames & Moore (1983) in the mine, port, and DMTS road area. In particular, the sedge-grass habitats found in lakes, ponds, and lagoons along the DMTS road were ideal for Canada geese and other water-oriented birds. Peregrine falcon sightings were documented around the mine area.

Caribou, moose, and muskox sightings are frequent at the foothills of the DeLong Mountains and along riparian areas of the DMTS road. The grizzly/brown bear has also been seen in various habitats along the DMTS road and mine site. Small mammals, such as the tundra vole, were observed in shrub tundra areas of the DMTS road and evidence of the singing vole was found in the mine area (Dames & Moore 1983). Other terrestrial mammals include the Dall sheep, wolf, wolverine, and the red fox (RWJ 1997).

Marine mammals were observed along the nearshore waters of the port site, including ringed seals, bearded seals, and spotted seals, of which the ringed seals were most abundant. Dames & Moore (1983) also reported occasional sightings of walruses, beluga whales, harbor porpoises, bowhead whales, and grey whales. Birds in the open water, such as seaducks, king eiders, oldsquaw, and long-tailed jaeger, were also observed (Dames & Moore 1983).

The most abundant migratory fish species in the nearshore area are chum salmon and Arctic char, which use the open lagoons as a transportation corridor between their spawning rivers and the Chukchi Sea. Marine fish near the port area include starry flounder, Arctic flounder, saffron cod, Atka mackeral, rainbow smelt, nine-spine stickleback, Pacific herring, surf smelt, and larval smelt (Family osmeridae) (Dames & Moore 1983).

Marine life such as crabs (helmet crab and red king crab) and shrimp species have also been observed. The seastar is the single most abundant animal at the bottom of the marine waters, followed by the helmet crab. Red king crab has also been observed, although it is not abundant due to the lack of suitable bottom habitats. Marine worms dominate in the sediment (RWJ 2001).

The local residents in the vicinity of the Red Dog area rely on wildlife for subsistence (see Section 1.7.2, *Subsistence Hunting and Harvesting*). Mammals such as caribou, moose, Arctic fox, and hares are routinely hunted for food, and marine mammals include bearded seals (ugruk), ringed seals, spotted seals, beluga whales, and bowhead whales. Birds that are hunted include ptarmigan and various waterfowl. Local residents fish for Arctic char, chum salmon, sheefish, whitefish, tomcod and smelt.

## 1.5 Geology and Soils

The following sections describe the geology and soil types of the Wulik and Noatak drainages and the surrounding region.

### 1.5.1 Geology

There are few studies discussing the bedrock geology of the region because the extreme remoteness of the region has hampered scientific study, and the extensive presence of glacial and river gravels blanket much of the bedrock geology in the region.

The general geology and mineralization characteristics of the region are described in more detail below.

### 1.5.1.1 General Geology

Bedrock in most of the region is composed of sedimentary rocks (including siltstones, shales, sandstones, cherts, and limestones) of the Kuna, Siksikpuk, Otuk, and Okpidruak formations. The sediments in these rocks were deposited in a marine environment during the Paleozoic and Mesozoic Eras, approximately 63 to 570 million years ago. Minor amounts of iron and magnesium-rich (mafic) igneous rocks, which have intruded into the sedimentary bedrock of the region, are also present in the area. The geologic structure of the area is complex, due to extensive folding and faulting as a result of mountain-building processes during the Cretaceous Period (approximately 100 to 120 million years ago) and additional faulting during the Tertiary Period (approximately 75 million years ago).

Glaciation in the Tertiary and Quaternary Periods (about 63 million years ago to the present), and associated erosion by rivers and streams, have led to a significant removal of the bedrock materials. In the Red Dog area, erosion processes have cut deep into the Mesozoic and Paleozoic rock formations, creating eroded materials that were transported and redeposited as unconsolidated cobbles, gravels, sands, and silts. These unconsolidated gravels form the substrate on which most of the DMTS roadway and port facilities have been built. It is of interest to note that as much as one-half of the original Red Dog deposit was eroded by these glacial processes, with much of the mineralized material subsequently dispersed in the gravels down-ice (toward the south and west) of the Red Dog Mine.

A study by AGRA (2001) found that the underlying bedrock in the port area is a gray or lavender sandstone (AGRA 2001).

### 1.5.1.2 Mineralization

Metallic mineralization has been found to occur throughout much of the Western Brooks Range and includes several well-documented world-class mineral deposits (see Figure 1-4). The most notable of these is the Red Dog Mine, the largest and one of the highest grade zinc-lead mines in the world (Figure 1-5).

The Red Dog Mine itself is situated on one of a significant cluster of well documented deposits and showings (including Red Dog Main, Aqqaluk, Paalaaq, Qanaiyak, Anarraaq, Su, Lik, Wulik, and SUDS-Alvinella) occurring over a roughly 100-square-mile (260 km$^2$) area centered on the Upper Wulik and Ikalukrok River drainages (see Figure 1-4). The mineralization in the Red Dog area is primarily hosted in black, carbon-rich shales and limestones. The metals are thought to have been introduced into the rocks by naturally occurring hydrothermal fluids circulating through the sediments during and very shortly after the time the sediments formed (over 300 million years ago). The principal metals involved in the mineralization are zinc, lead, barium, iron, and silver.

Geochemical sampling of soils and stream sediments has been carried out in the region by Teck Cominco as well as other companies and government agencies since the mid-1970s. These programs have identified numerous areas with strongly elevated zinc, lead, and silver values. Follow-up prospecting of these geochemical anomalies has lead to the discovery of metallic mineralization in bedrock throughout the region.

Outcropping (surface expression) of mineral occurrences similar in style to the Red Dog area are not confined to the Red Dog mining district in the Wulik-Ikalukrok River area. Zinc-lead mineralization has been found at several locations elsewhere in the Wulik River drainage basin. Strong zinc-lead mineralization has been discovered in bedrock in the upper part of Tutak Creek, east of the DMTS road. Additionally, cobbles of presumed Red Dog mineralization have been found along the lower reaches of the Ikalukrok River, from the southern edge of the mountains to its confluence with the Wulik River. These cobbles are thought to be glacially deposited materials eroded from the Red Dog deposit itself.

Within the Noatak River Basin, areas of similar mineralization are also known. Several occurrences of zinc and barite (barium sulfate) mineralization have been documented in the Wrench Creek-Kelly River area. Another area of mineralization is found along the Kugururok River area between Nunaviksak Creek and Trail Creek (the Ginny Creek show) where zinc, lead, and pyrite (iron sulfide) mineralization has been documented at several locations over a minimum of a 10-mile-long area. Further up-stream in the Noatak River Basin are the Nimuiktuk River barite occurrences. To the northeast of the Nimuiktuk River barites, on the north slope of the Brooks Range in the headwaters of the Kiligwa River is the Drenchwater zinc-lead deposit.

To the west of the Red Dog district, geochemical indications of zinc-lead mineralization have been found over a wide area in the headwaters of the Kivalina and Kukpuk Rivers. Further west still, zinc-lead-barite mineralization has been found in bedrock over a very wide area covering much of the southern Lisburne Hills. Extensive stream silt sampling in this region has shown very strong geochemical anomalies in zinc, lead, and cadmium over a widespread area.

The Red Dog zinc-lead-silver deposit is located in the DeLong Mountains, in the western Brooks Range. The ore-containing rocks on the property include silicas, barites, and sulfides. Together, these rocks make up the exhalite rock package, which, in turn, are facies of the Ikalukrok Member. The host shale was silicified, making it resemble a chert. The sulfide minerals are predominantly (in decreasing order) sphalerite (zinc sulfide), pyrite and marcasite (iron sulfide), and galena (lead sulfite). The silver deposits are found within the crystal structure of the galena. Sphalerite is almost amorphous and is commonly found with silica. The ores at the site are massive, fragmental, chaotic, veined, and rarely show classic sulfide sedimentary layering.

There are four deposits at the Red Dog site. The Main Deposit where mining is currently underway, the Aqqaluk Deposit (north of the Main Deposit), the Hilltop Deposit (south of the Main Deposit), and the Paalaaq Deposit (north and below the Aqqaluk Deposit).

### 1.5.2 Soil

The soils are poorly developed due to low soil temperatures, low precipitation, and poor drainage caused by the permafrost (Ward and Olson 1980). The cold climate inhibits chemical weathering and leaching and surface runoff. However, the freeze-thaw cycle increases physical and chemical weathering and can cause mixing of the soil horizons. Because the cold weather also hinders plant decomposition, organic materials build up in the soil and immobilize chemical elements (Gough et al. 1988). Soil depths range from 20 to 40 in. in vegetated areas, and can range up to 10 ft deep in non-vegetated hillsides (U.S. EPA 1984). The soils in valleys and long slopes are often silty or loamy colluvial sediments, while soils found on hills and ridges originated from eroded sedimentary rock. In the nearby Noatak Valley, the soils are derived from the glaciofluvial material that originated from limestone in the surrounding mountains. The soils on moraines in the valley are well drained and developed from calcareous drift. Peat soils are often found in depressions on terraces (USGS 2001). At the port site, the soil consists of a dense silt and sand mixture. Deeper layers are more sandy and gravelly. Observations from boreholes at the port site in 1998 showed no cobbles or boulders (AGRA 2001).

The soil type is a result of climate, geologic parent material, vegetation, topographic position, and time. The amount of seasonal thaw or active permafrost depends on the area. The active layer of soil above the permafrost can range from 20 to 39 in. deep in areas covered by vegetation, and can be as deep as 10 ft beneath large rivers and non-vegetated, rocky hillsides. The slopes of the hills are dominated by mineralized silty soils and sphagnum peat (RWJ 1997).

The entire Red Dog operations area is underlain by continuous permafrost that varies in thickness. Near the ocean, soils can be below the freezing point, but not frozen hard because of saline pore water (U.S. EPA 1984). The permafrost in the Red Dog area is approximately 100-ft thick in surface water drainages, to over 650-ft thick at higher elevations. The minimum permafrost temperatures are usually 30.2 to 27°F (−1 to −3°C) (Hagley 2002, pers. comm.).

## 1.6 Hydrology

The following sections provide an overview of surface water, groundwater, and coastal marine hydrology in the vicinity of Red Dog Mine and the DMTS road and port.

### 1.6.1 Surface Water

The two primary drainages in the DeLong Mountains area are the Wulik and Kivalina Rivers, which flow to the Chukchi Sea (see Figure 1-2). Both of these rivers are located to the north of the DMTS road. To the south of the DMTS road corridor lies the Noatak River. With the exception of one creek (Evaingiknuk) that flows to the Noatak River, all of the streams crossed by the DMTS road drain to the Wulik River. Red Dog Creek, which flows through the mine area, also drains to the Wulik River. The tributaries in this area tend to have high flows in the spring due to snow melt. Summer rainstorms will often cause water levels to fluctuate rapidly (Ward and Olson 1980). The 2-year and 50-year flood discharges are 16,810 and 43,508 $ft^3$/s, respectively, for the Wulik River, and 11,866 and 32,631 $ft^3$/s, respectively, for the Kivalina River (U.S. EPA 1984).

Mainstem Red Dog Creek has a watershed area of 24.6 mi$^2$. A tailings dam prevents about 4 mi$^2$ of the drainage area (surrounding the mine) from draining directly into the creek. Instead, the water is treated prior to release. The width of the creek ranges from 12 to 60 ft and depth ranges from 0.2 to 1.7 ft (Kemnitz, pers. comm. as cited by Weber-Scannell and Ott 2001). An average of the daily average flows from the months of June through September during the years 1997 through 2001 was 75 ft$^3$/s at Station 10. The creek ranges from 11.5 to 59 ft wide and 0.2 to 1.6 ft deep. The creek starts to freeze in late October until there is no flowing surface water in the winter (Weber-Scannell 1996).

The estimated mean annual runoff is 1 ft$^3$/s per square mile in the DeLong Mountains area, while the low mean monthly runoff is as low as 0 ft$^3$/s per square mile. The mean annual peak runoff averages 25 ft$^3$/s per square mile and 50 ft$^3$/s per square mile in lowland and upland areas, respectively (Dames & Moore 1983).

The lagoons in the Red Dog area have variable physical and chemical parameters. Closed coastal lagoons are slightly brackish. Lagoons that are open to streams and creeks have more fresh water than the more saline waters near the opening to the coast (ENSR 1993). The bottoms of the more inland lakes are usually composed of mineralized, organic, silty sediment (RWJ 1997).

### 1.6.2 Groundwater

Due to the permafrost, water infiltration is restricted, and therefore groundwater storage is limited (Ward and Olson 1980). Wells in the area yield less than 22 gal/min (Dames & Moore 1983).

Shallow groundwater flow occurs in the active layer, above the permafrost, or in the zone of the near-surface seasonal thaw. Shallow groundwater flow does not significantly occur within the Red Dog area because of the short thaw period (only during July–September) and the shallow thaw depths. Also, the tundra vegetation quickly takes up any available moisture in the active layer during the short growing season, or the travel distance downgradient is short towards surface water drainages. There may be thicker zones of shallow groundwater flow in the alluvium in the creek bed areas, but this occurs in very short periods of time in the summer and is usually associated with the creek surface water flow (Hagley 2002, pers. comm.)

Deep groundwater flow can occur below the permafrost. This groundwater was recharged in the past, when permafrost was absent or discontinuous. Some sub-permafrost groundwater samples have been dated to be 15,000 to 25,000 years old. Subpermafrost flow is dictated by the geology of the area, primarily fracturing and faulting. Currently, subpermafrost groundwater does not discharge in the Red Dog area (Hagley 2002, pers. comm.).

### 1.6.3 Coastal Marine

Transport of nearshore sediment is greatly affected by wind and wave conditions along the coast. Sediment is transported in a net southeasterly direction. The majority of the sediment transport occurs in the summer, when the winds are predominately from the west and northwest.

Some sediment transport occurs perpendicular to the shoreline. Storm events can move beach sand and deposit it at the wave break point, forming a sand bar. However, under normal marine conditions, the sand will be re-transported back to the beach. In the winter, relatively insignificant amounts of sediment are redeposited by ice action, as compared to the wind-induced transport in the summer (RWJ 1997).

The water in the nearshore zone of the Chukchi Sea is relatively low in salinity because of the freshwater influence from the shore. This freshwater originates from the melting during ice breakup and stream runoff in late May. The salinity of the water increases in the offshore zone from late June through late August. The seawater temperatures remain constant in both the offshore waters and the nearshore waters during the summer and are not significantly different from each other (RWJ 1997).

In early October, ice will begin to form along the coast. However, high winds and high waves can halt the formation of a solid cover until January (RWJ 1997). The Chukchi Sea is covered in ice from mid-November through May or June. In the areas near to the shore, there are frequent ice ridge formations in mid-winter. In 2000, the ice thickness was measured in the range of 40.5 to 52.8 in. (AGRA 2001). Usually, this ice cover will dissipate in early July (RWJ 1997).

The Chukchi Sea nearshore zone at the port site is shallow. The wind conditions at the port site is the primary parameter in determining wave, current, and water level conditions (AGRA 2001).

The water levels at the port site are determined by wind-driven surges and, to a lesser degree, by tides. Based on measurements in the summers of 1998–2000, the water levels are dominated by wind-driven surges. An average surge has amplitude of 3 (± 3) ft and extreme surges can be greater than 10 ft or in excess of –6 ft. Water level measurements show that tides in Corwin Lagoon, Kivalina, can have a mean higher high water of 0.90 ft mean lower low water (MLLW), a mean high water of 0.77 ft MLLW, mean tide level of 0.43 ft MLLW, and mean low water level of 0.10 ft MLLW (AGRA 2001).

The open water current speeds were measured, and a statistical distribution shows that currents are greater than 0.5 knot for a frequency of 28 percent of the time, and greater than 1.0 knot for 2 percent of the time. The currents move in a northward direction 75 percent of the time, and are usually three times the speed of currents in other directions (AGRA 2001).

## 1.7 Land Ownership and Use

The following sections describe land ownership, management, and use in the vicinity of Red Dog Mine and the DMTS road and port. Figure 1-6 illustrates land use and property boundaries relative to these areas.

### 1.7.1 Land Ownership and Management

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 AIDEA. AIDEA owns and 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 99-year easement to NANA for the corridor through the Monument.

Under the 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, 59 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 someday offer 100 percent native employment at the operation, as outlined in the agreement.

### 1.7.2 Subsistence Hunting and Harvesting

Subsistence is very important to the economic, nutritional, and spiritual 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 Kivalina and Noatak villages are the closest communities to the Red Dog Mine. Large areas around these villages are extremely important for their subsistence economies. Noatak residents depend on the Noatak River, while Kivalina residents rely on the Kivalina and Wulik Rivers for chum salmon, char, whitefish, and grayling. The Wulik River attracts fish from other drainages during winter, providing Kivalina residents with an ample fish supply (Dames & Moore 1983).

Sea mammals are another important food source for the Kivalina and Noatak people. Ugruk (bearded seal), seal, walrus, beluga, and bowhead whale meat are usually consumed. Seal oil is also a staple ingredient in meals and is often used as a remedy for sickness. The greatest proportion of sea mammal meat is from ugruk and walrus, which are hunted as long as there is sufficient ice cover (Dames & Moore 1983).

Local residents also hunt caribou for consumption. However, because caribou migration routes can be unpredictable from year to year, reliance on caribou meat as a primary food source is tenuous. Caribou foraging is concentrated in the Mulgrave Hills, where prevailing northeast winds prevent snow accumulation. As a result, this area is a high-use hunting area between the months of September and May (Dames & Moore 1983).

Kivalina and Noatak residents will also use moose, fur-bearing animals, birds, eggs, berries, and plants to supplement their diet. Since these resources are often sparse, they do not make up a large portion of their diet. Residents will hunt fur-bearing animals such as wolf, wolverine, and fox (arctic, red, and cross) for money. Birds such as ptarmigan, snowy owls, and waterfowl are another source of fresh meat. Blueberries, salmonberries, crowberries, and masu (wild potato) provide additional variety to diets. On occasion, people will also hunt sheep during the open season in Punupkakroak Mountain (Dames & Moore 1983).

Depending on the location and season, subsistence hunting usually includes caribou, moose, Arctic fox, hares, bearded seals, ringed seals, spotted seals, beluga whales, bowhead whales, ptarmigan, and waterfowl. Fishing generally includes Arctic char, chum salmon, sheefish, whitefish, tomcod, and smelt. Subsistence gathering usually includes berries and other edible plants. Local residents also gather driftwood for heating and cooking (U.S. EPA 1984).

Subsistence hunting and gathering is an important traditional and cultural practice for cooperative food-gathering and food-sharing. It provides a way to bind communities together and provide some social organization. Kivalina residents usually hunt for marine mammals in nearshore areas off Kivalina and in nearby areas to the north and south. Noatak residents rely more on land mammals as a food source than sea mammals. Both Kivalina and Noatak residents are dependent on fishing and hunting waterfowl (U.S. EPA 1984).

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 impacts on subsistence lifestyles.

Subsistence hunting and harvesting areas have been partially mapped on several occasions. Figures 1-7 and 1-8 illustrate the areas used for subsistence hunting and gathering as mapped between 1977 and 1982 for Noatak and Kivalina, respectively (Dames & Moore 1983). Figure 1-9 shows subsistence berry harvesting areas used by Kivalina residents in the vicinity of the DMTS port site. Sourdock is found mostly in marshy areas and salmonberries are found further inland from the coast. Cranberries and blackberries are harvested along the beach dunes. Not shown on this map are the blueberries that are harvested along river corridors (especially the Wulik River) and rhubarb, which grows in dry sandy areas. Historically (before construction of the port), berries were collected from the area where the DMTS port facility is now located (Glavinovich 2001).

### 1.7.3 Recreational Land Use

Recreational activities that are usually undertaken in the Red Dog area include hiking, flying, boating, hunting, fishing, winter sports, and sightseeing. However, many of these activities are done by local residents for subsistence living. Residents also go snowmobiling in the winter both for recreation and hunting. There are two snowmobile trails that cross the DMTS road (see Figure 1-6). 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).

### 1.7.4 Industrial Land Use

The DMTS road and port facility are currently used exclusively for the hauling of materials to and from the mine facility per the 1986 agreements between AIDEA, NANA, and Teck Cominco to support employment at Red Dog. The ambient air boundaries for the port and mine are illustrated in Figure 1-6. The ambient air boundary for the road is located 300 ft on either side of the road centerline. Ambient air boundaries are boundaries established around the perimeter of a facility, and are intended to protect public health and welfare through ambient air quality standards. This boundary determines where air quality needs to be evaluated against the National Ambient Air Quality Standards (NAAQS) using computer dispersion models. Operational areas within the facility boundary/ambient air boundary are protected and regulated by occupational health and safety standards. Dispersion modeling required under the air permits for Red Dog has demonstrated that ambient air quality standards are met at the ambient air boundaries.

The overall purpose of the DMTS was to provide basic infrastructure for a regional transportation system to open the area to commercial mining and the northwest Alaska region for transportation, commerce, development, and increased employment. Since 1976, extensive mineral exploration has been conducted in the region, with numerous zinc and lead deposits being identified in addition to the Red Dog deposits mentioned above. The outlying deposits are the Lik and Su prospects some 10 miles northwest of Red Dog, the Anarraaq deposit some 9.6 miles north to northwest of Red Dog, and numerous other mineral occurrences. The Kennecott Corporation currently is conducting mineral exploration on ASRC lands located some 3 miles north of the Anarraaq deposit.

# 2 Red Dog Operations

The following sections describe operations at the Red Dog Mine and the DMTS road and port.

## 2.1 Red Dog Operations

Teck Cominco began its mining operations at the Red Dog Mine in 1989. Mineral reserves provide an expected mine life of about 40 or more years. Lead and zinc ore is mined, processed into concentrates, and then trucked to CSBs 1 mile from the coast. The concentrates are then transported from the storage buildings to barges by an enclosed conveyor system. Initially, this system was covered but not fully enclosed. In the summer of 1992, the conveyor from the CSB to the dock was enclosed with an industrial tent-like structure. During the construction of the second CSB in 1996–1998, all of the conveyors associated with it were enclosed in steel tubes. In 2001, the tent covering the long conveyor from CSB-1 to the surge bin near the dock was replaced with a steel tube enclosure. (Refer to Table 3-3 for a chronology of improvements).

After the barges are loaded by the conveyor system, they then transfer the concentrates to larger ships offshore, which deliver the concentrates to customers around the world. Approximately 6 times more zinc concentrate is produced and shipped than lead concentrate.

The following sections describe the mining operation, the composition of the ore before milling, and the composition of the concentrates produced by the milling process. The chemicals used in the milling process are also discussed.

### 2.1.1 Brief Description of the Mining Operation

The Red Dog Mine has been in open-pit operation since 1989. Ore is mined in the open pit, and then hauled to a stockpile. From there it is transferred to a nearby processing facility where it is crushed, ground, and concentrated using a flotation process. From the point where processing begins, the entire processing operation is enclosed.

Because the ores at Red Dog Mine are fine-grained, a fine grind is used to recover the zinc and lead (which contains silver) bearing minerals. A primary crusher is used to crush the ore to pieces smaller than 6 in. in diameter, and these pieces are then ground by semiautogenous grinding (SAG) mills, followed by ball mills. Because crushing balls are consumed in the mill process, the metals contained in the balls are reported in the Toxics Release Inventory. The SAG mills eliminate the need for fine crushing. The lead and zinc concentrates are then ground to 80 percent passing 20 to 25 $\mu$m in high efficiency tower mills. Red Dog uses tank and column cell flotation to recover the metals and separate the zinc and lead concentrates. Process water reports to the tailings impoundment for storage during freeze-up, to be treated and discharged seasonally during months when Red Dog Creek is free-flowing. The impoundment dam itself is constructed as "zero-discharge." Seepage controls were engineered into its design. Wastewater from the tailings impoundment is treated and reused as process feedwater in the flotation circuit. Treated wastewater is also discharged via Outfall 001 to Middle Fork Red Dog

Creek. The National Pollutant Discharge Elimination System (NPDES) permit authorizes discharge of up to 2.4 billion gallons of treated wastewater per year.

The mining rate at Red Dog is approximately 20,000 tons per day. This rate is small in relation to other mining operations because of its high-grade deposit and low-stripping ratio. The original reserves were estimated to be 85 million tons, composed of 17.1 percent zinc, 5 percent lead, and 2.4 oz./ton silver.

Mobile equipment at the mine consists of two 14-cubic-yard loaders and a third loader for stockpiling. There are also three 100 ton and four 85-ton haulage trucks, three bulldozers, two utility loaders, two graders, and a water truck.

At the mine site, the concentrates are stored in a CSB, which can hold an amount of concentrate equivalent to 10 days of production, in the event that bad weather conditions or caribou migrations halt the transportation to the port.

### 2.1.2 Ore Composition (Pre-Processing)

The mill feed for 1989–2000 was 22.45 million tons at an average composition of 20.4 percent zinc and 5.5 percent lead. The mill feed for 2001 was 3.2 million tons at an average composition of 19.8 percent zinc and 5.0 percent lead. Reserves estimates provided in the 2000 annual report were 41.9 million tons at 19.2 percent zinc and 5.2 lead. The zinc and cadmium are contained in the mineral sphalerite (zinc sulfide) and the lead and silver are contained in the mineral galena (lead sulfide). The iron is primarily contained in the mineral pyrite (iron sulfide).

### 2.1.3 Concentrate Composition (Post-Processing)

The zinc and lead concentrates produced at the Red Dog Mine are sulfides, and they include minor amounts of other metal sulfides and impurities. Table 2-1 provides an analysis of the zinc and lead concentrates for the 2001 shipping season. The zinc concentrate contains approximately 55 percent (550,000 ppm) zinc, 0.33 percent (3,300 ppm) cadmium, which is associated with the zinc mineral, and 3.2 percent (32,000 pmm) lead. The lead concentrate contains approximately 58 percent (580,000 ppm) lead, 0.12 percent (1,200 ppm) cadmium, and 10.8 percent (108,000 ppm) zinc. The concentrates are a very fine powder. The zinc concentrate particles are 80 percent smaller than 23 $\mu$m in size. The lead concentrate particles are 80 percent smaller than 20 $\mu$m in size.

The mineral composition of the concentrates is as follows:

- Zinc Concentrate—80 to 85 percent sphalerite, 7 to 9.5 percent pyrite, 2.5 to 5 percent galena, and 2.8 to 3.7 percent quartz
- Lead Concentrate—60 to 70 percent galena, 14 to 21 percent sphalerite, 6 to 15 percent pyrite, and 2 to 4.5 percent quartz.

### 2.1.4 Chemicals Used in Ore Processing

The following chemicals are used in the processing of ores at the Red Dog Mine:

- **Zinc and copper sulfate** are water soluble salts that are used in the flotation process. They are shipped in bulk, 2,205-lb reinforced plastic tote bags. The copper sulfate bags are also boxed. Zinc sulfate is a depressant used to prevent sphalerite flotation in the lead circuit. Copper sulfate is an activator used to coat the sphalerite surface and render it amenable to flotation with xanthate.

- **Sodium cyanide** is a water soluble reagent that is used in the milling process. It is shipped in boxed, 2,205-lb reinforced plastic tote bags. Sodium cyanide is a depressant used to prevent pyrite flotation in the lead and zinc circuit and to prevent sphalerite flotation in the lead circuit.

- **Methyl isobutyl carbinol** (MIBC) is a flammable, aliphatic liquid alcohol that is lighter than water and has only a modest solubility in water. It is used in the milling process as a “frother” to reduce the water surface tension and stabilize air bubbles. MIBC is shipped in 2,000-lb reinforced poly totes.

- **Potassium amyl xanthate** (PAX) and **potassium ethyl xanthate** (PEX) are used in the flotation process. They are both shipped in boxed, 750-kg reinforced plastic tote bags. PAX is an organic collector used to recover copper coated sphalerite by making its surface hydrophobic, whereas PEX is similarly used to recover galena in the lead circuit.

- **Sodium meta bi-sulfite** (SMBS) is used in the flotation process as an oxygen scavenger. It acts as a pyrite depressant in the grinding circuit. SMBS is shipped in 2,205-lb reinforced plastic tote bags.

- **Magnafloc 10** is the flocculent used in the water treatment plants and zinc/lead thickening process. It is an anionic clarification agent used to agglomerate the lead and zinc concentrate particles, as well as the water treatment sludge particles, to improve settling. It is shipped in 1,543-lb reinforced plastic tote bags.

- **Lime** is used as a pH modifier in the flotation process and in the water treatment plants. It is used in the water treatment plants to precipitate metal ions. It is shipped in 4,500-lb reinforced plastic totes bags.

- **Sodium sulfide** is used in the summer water treatment plant to precipitate cadmium ions in order to meet the permit discharge limit. It is shipped in 700-kg reinforced plastic tote bags.

- **Nalco 9353 antiscalent** is an agent used in the process water lines as a dispersant to minimize the growth of calcium and magnesium scale in pipes and heat exchangers. Nalco is shipped in 6,000 U.S. gal ISO containers to the site. When the containers are empty, they are returned to the supplier for refilling.

Copper sulfate and PAX boxes are supplied by Quadra Chemicals and empty containers are recycled back to them. All plastic bags and wooden crates are collected by the surface crew, who ensure they are empty before being landfilled. Empty MIBC totes are stored in a Connex box (or shipping container) and sent back to the supplier for refilling.

Table 2-2 shows the annual consumption rates for these reagents in 2001, as well as use and storage information.

Red Dog has a comprehensive system designed to contain reagent spills. Once delivered from connex boxes by the surface crew, reagents are temporarily stored in the Reagents Building, where they are mixed to the required strength by mill operators according to standard operating procedures. The prepared reagents are stored in day tanks, from where they are piped to various holding tanks in the mill, which supply controlled flow to specific flotation cells. Leaks that occur at seals in piping are immediately corrected. Any discharges of material have been wholly contained within the reagent/mill building perimeter and are completely cleaned up in accordance with standard mill operating procedures, utilizing appropriate safety precautions. On the rare occasion that a reagent spill occurs outside the mill, it is completely cleaned up and the product is returned to the milling process.

The various flotation agents are present in the concentrate and tailings streams in the form of surface complexes bound to the solids. The remainder is dissolved in the process water that makes up the waste slurry stream reporting to the tailings pond. Metals dissolved in the process water that precipitate in the water treatment plants report to the sludge, which is also discharged regularly to the tailings pond. Most of the chemicals (organic chemicals such as xanthates, frother, and flocculent) degrade or break down to elemental constituents (carbon dioxide, water, nitrogen) once in the pond. The inorganic chemicals (zinc and copper sulfate, and antiscalent) dissolve and add to the total dissolved solids load in the pond. Metals ions are removed in the water treatment plant prior to discharge, and other ions such as sodium and potassium are discharged to Red Dog Creek.

## 2.2 DMTS Road Operation

The following sections describe the loading, transport, and unloading process to move the concentrates from the mine to the CSBs at the port.

### 2.2.1 Concentrate Loading Process at the Red Dog Mine (Trucks)

The trucks are first driven inside an attachment to the CSB at the mine. Once inside, the doors are closed and the trailer lids are opened before stopping at the zinc/lead chute. If necessary, a releasing agent (Chemloc) is applied to reduce the adhesion of the concentrate to the trailer tub when it is dumped. Either zinc or lead concentrate is loaded by a loader through a chute into the trailer. This process has been utilized since 1992. Prior to that, the trucks drove into the main building, where the concentrate was stored. However, this loader activity and spillage would contaminate the trucks, resulting in tracking and generation of fugitive dust. In 1992, this problem was resolved by adding a separate enclosure to the CSB for truck loading.

### 2.2.2 Concentrate Transportation Process (Trucks)

Concentrates are trucked over the DMTS road to the DMTS port. A fleet of 130-ton trucks, operated by NANA-Lynden, is used to transport the concentrates from the mine CSB to the port site CSBs. The trucks are specially designed tractor units towing tandem trailers using a B-train assembly. Older side-dump trailers with rolling tarp covers were replaced in the fall of 2001 with new trailers that have hydraulically operated steel covers that seal in the concentrates during transport. The new trailers also have smoother internal and external surfaces for easier cleaning. A total of nine trucks make up the fleet, however, typically 6 to 7 trucks are used on a daily basis, thus allowing for a steady maintenance program. A maximum of three round trips can be made per 12-hour shift, depending upon road and weather conditions. Typically, 33 to 35 trips are made per day to the port site concentrate storage facility.

While in transit on the DMTS road, a safety protocol controls traffic on the road. All vehicles are in radio contact with each other and the operational base. Concentrate haul trucks have right-of-way over other vehicles in the winter. Initially, the road was is marked every 200 ft with reflective delineators, staggered at 100-ft intervals on each side of the road. The number of delineators was doubled in the fall of 2001, to a spacing of one for every 100 ft, staggered at 50-ft intervals on each side of the road.

### 2.2.3 Concentrate Unloading Process at the DMTS Port Site (Trucks)

The original haul trucks were covered with heavy-duty tarps. The trucks would pull into the "racetrack" loop at the port site CSBs, and stop to roll back the tarps covering the trailers. This procedure was a potential source of fugitive dust. Trucks would then proceed into the truck unloading building. The trucks were dumped using a platform that rotated the entire trailer. The sudden displacement of air resulting from the release of the concentrate load into the hopper tended to result in dust being blown back onto the truck and trailers, which resulted in tracking of concentrate dust out of the unloading building and onto the road.

New trucks replaced the old trucks in fall 2001. The new trucks empty the concentrates by opening the front trailer lid halfway, then rotating the trailer body along its long axis to deposit the concentrates into a hopper. If concentrates remain at the bottom of the trailer following dumping, the trailer is rotated back into the cradle position, and is then re-rotated. However, the trailer is not rotated more than twice. Once the trailer body is back in the cradle position, the truck moves forward, and the same process is repeated with the rear trailer.

The hopper that receives the concentrates feeds them into a fully enclosed conveying system that carries them to one of the two CSBs. Stilling curtains were installed in 2001, and have been customized to effectively trap airborne dust during the dumping process, so as to minimize any dust escapement or deposition on the trucks. The gradual manner by which the concentrates are dumped from the self-rotating trailers into the hopper also helps to minimize air displacement and dust generation during unloading.

### 2.2.4 Truck Decontamination

Both the trailer and tractor are cleaned of any concentrates before leaving the loading and unloading facilities. Before the trucks are loaded with concentrate at the mine, the rear tub is rotated, then the front, so that cleaning can be performed inside the CSB. Any buildup of concentrate is first scraped or hammered off. After the zinc or lead concentrates have been loaded, the top of the trailer rails are cleaned before the lids are closed. Before leaving the unloading site, trucks are cleaned to minimize any concentrates remaining on the outside of the truck. Truck washing was initiated in summer 2001. During the summer months, the trucks are washed before they leave the mine site and as they exit the unloading building at the port site. The truck washes are operated only during the summer months, until the temperature drops below freezing in September. During the winter months, washing would create a hazard of freezing brakes.

## 2.3 DMTS Port Operations

Because the shipping season is confined to a few months when the waters are ice-free, the concentrates are usually stored for most of the year. In general, the ice breaks up in early July, and remains free until November. In addition, the local subsistence committee will confirm with Teck Cominco when shipping can start, so that operations will not affect the marine mammal hunting season. The subsistence hunting usually starts early in the ice breakup when marine mammals are closer to shore. When ice starts forming in the Bering Straits and along Chukchi Sea shores, the shipping season is over.

Figure 2-1 shows the port site storage and conveyance features at the DMTS port site. The following sections describe the storage, conveyance, loading, and transfer of concentrates at the DMTS port site.

### 2.3.1 Concentrate Storage

The concentrates are stored in two CSBs. These A-frame buildings are approximately 218-ft wide, 140-ft high and 1,425-ft long (1,200-ft long for Building No. 2). Together, these storage buildings can hold all of the concentrate produced in about 9 months of mine operation, which is approximately 872,000 tons of zinc concentrate and 165,000 tons of lead concentrate. This storage capacity allows mine operations to proceed year-round, between shipping seasons.

### 2.3.2 Concentrate Conveyor System

Concentrates are loaded from the storage buildings with front-end loaders into track-mounted feeder-hoppers on the conveyor system. The fully enclosed conveyors transfer the concentrates from the CSBs to the barge loader, which loads the barges. Initially, this conveyor system was covered but not fully enclosed. In the summer of 1992, the conveyor belt from the CSB to the dock was enclosed with an industrial tent-like structure. During the construction of the second CSB in 1996−1998, all of the associated conveyors were enclosed in a solid steel tube. In 2001, the long conveyor from CSB-1 (the CSB closest to the dock) to the surge bin was enclosed in a steel tube. Figure 2-1 illustrates the conveyor layout relative to the CSBs and the barge loader. The main overland conveyor, P8, transfers the concentrates into a 1,500 ton-capacity surge bin. This surge bin receives a discontinuous flow of concentrate and delivers a steady flow into conveyors P9A and P9B, which are twin variable-speed feeders, underneath the surge bin. Finally, the concentrates are fed onto conveyor P10, and then P11, which is the shiploader conveyor. The conveyor system is approximately 3,250-ft long.

### 2.3.3 Concentrate Loading (Barge)

The fully enclosed P10 conveyor moves the concentrates to a barge loader. This barge loader can rotate to load either the north or south side of the barge berth. The barge berth is composed of three steel sheetpile cells, about 66 ft in diameter. While at rest in the barge berth, Foss Maritime's lightering barges are loaded from the enclosed barge loader conveyor (P11, see Figure 2-1) using a snout-like canvas tube that lowers into the barge, and is slowly raised as the barge is filled, to minimize the free-fall distance of the concentrate. Two front-end loaders work to move the concentrate to the corners of the barge as it is loading. The barge is covered during the entire process by fixed tarps, except for a lengthwise slot, through which the snout is lowered. The loaders work beneath the fixed tarps.

### 2.3.4 Concentrate Transfer (Barge to Deepwater Ship)

Tugs are used to tow the barges from shallow water at the port to the anchored deep-sea vessels, 3 to 4 miles offshore. The barges have a built-in conveyor that is used to transfer the concentrates from the barges to the deepwater ships. Two front-end loaders that reside on each barge are used to feed the built-in conveyor. The loading activity occurs within the covered barge. Concentrates can be transferred from the barge to the vessel holds as long as waves are less than 5 ft high. When the vessel is light (early on in the loading), there is very little clearance between the barge loading boom and the vessel hatch. Once the concentrates are loaded into the ships, they are delivered throughout North America, Europe, and Asia.

# 3 Regulatory History

This section summarizes the regulatory history relating to fugitive dust emissions. Topics covered include permitting of air emissions, enforcement history (including notices of violation, environmental investigations, and inspections), and fugitive dust control measures that have been taken by Teck Cominco on its own initiative to improve emission controls, or to satisfy a requirement in a permit or compliance order by consent issued by DEC.

## 3.1 Permits Applicable to Fugitive Dust

Air permitting has been an ongoing process throughout the history of Red Dog Mine and the DMTS. This process has included regular review by DEC of emissions sources, and modification of the air permits to address changes or additions to emissions sources. Table 3-1 summarizes the chronological history of air permitting for Red Dog Mine and the DMTS port. Figure 1-6 illustrates the ambient air boundaries that are currently permitted at the DMTS port and at the mine. Ambient air is defined in AS 46.14.990 (2) and 40 CFR 50.1(e) as "…that portion of the atmosphere, external to buildings, to which the general public has access." The ambient air boundary extends 300 ft to either side of the centerline of the DMTS road. The proposed reduced-in-size ambient air boundary at the DMTS port facility has not yet been finalized and approved by NANA. Measures taken to restrict access to areas within the ambient air boundary include (Hoefler 2000):

- General public information and notice to the towns and villages, and the public
- Posting of warning signs at points of possible public access, including the winter trails traversing the DMTS road and port.

Trails "A" and "B" are shown on Figure 1-6. An additional trail not shown on Figure 1-6 follows the beach along the shoreline.

## 3.2 Regulatory History Related to Fugitive Dust

This section summarizes the following types of regulatory involvement relating to fugitive dust over the history of the Red Dog operation: notices of violation, environmental investigations, and federal and state inspections.

### 3.2.1 Notices of Violation

The notices of violation most relevant to the fugitive dust issue have included the following:

- May 1991 NOV by DEC—alleged exceedances in 1990 and 1991 of allowable concentrations specified in the air permit for total suspended particulate matter at the mine (Air Quality Construction Permit No. 8832-AA002)

- December 1991 NOV by DEC—alleged exceedances of an ambient air quality standard at the mill
- May 2001 NOV by the U.S. Environmental Protection Agency (EPA)—alleged certain mine operations were not in compliance with conditions of the air permit (Air Quality Construction Permit No. 9932-AC005).

Remedial actions taken by Teck Cominco in response to these notices of violation are reviewed in Section 3.3.1

### 3.2.2 EPA/State Inspections

The Red Dog operation is governed by a number of major permits and other authorizations issued by various federal, state, and local regulatory agencies. There are also other regulatory requirements. Since the beginning of mine operations in 1989, there have been regular compliance inspections by these agencies often lasting several days at a time. These inspections have included at least annual inspections by air and water compliance staff from DEC, periodic compliance inspections by EPA compliance staff (usually once each year), and periodic land use inspections by the Alaska Department of Natural Resources.

In addition, since 1990, ADFG Habitat Division has been doing extensive biomonitoring, primarily of water bodies in the area around and downstream from the mine. Starting in 1991, Teck Cominco has been funding annual fish studies by ADFG relating to Red Dog Creek, Ikalukrok Creek, the Wulik River, and their tributaries. The fish study was expanded in 1995 to include other aquatic biota. A new aquatic community study was initiated in 1997 that includes invertebrates and periphyton. ADFG makes at least three visits (each usually lasting at least 1 week) to Red Dog each summer to do this biomonitoring work.

Teck Cominco is also required to conduct extensive monitoring of ambient air and sample streams for water quality. (See further discussion of ambient air boundaries in Section 1.7.4, *Industrial Land Use.*) The results of this monitoring and sampling are required to be reported monthly to DEC and EPA pursuant to EPA's NPDES permit for the mine and DEC's 401 Certification. These data are regularly reviewed by the agencies for compliance with permit requirements and used as a tool with on-the-ground inspections to assess the compliance of Teck Cominco with applicable permitting and regulatory requirements.

NPS staff periodically visit Cape Krusenstern National Monument and inspect the DMTS road where it traverses the monument. Other inspections are conducted by the U.S. Corps of Engineers, U.S. Geological Survey, U.S. Coast Guard, and the National Marine Fisheries Service. Information from these inspections relating to environmental concerns is provided to EPA and DEC.

EPA, DEC, and other agency inspections and visits conducted during 2001 included the following:

| Date | Inspection Agency and Personnel |
|---|---|
| May 17–May 22 | USGS |
| May 26–June 5 | ADFG (A. Ott and W. Morris) |
| June | DEC (G. Guay) |
| Late June | DEC (W. Sandel, 4 days) |
| June 30–July 3 | USGS |
| July | DEC (J. Anderson) & EPA and (R. Wilson) |
| July 3–July 14 | ADFG (A. Ott, W. Morris, P. Weber-Scannell, and L. Jacobs) |
| July 31–August 9 | ADFG (A. Ott and W. Morris) |
| August 6-7 | DEC (R. Klein, B. Hahn) & DHSS (S. Arnold, E. Christian, and T. Lynn) |
| August 9–August 11 | U.S. Geological Service |
| August | ADFG (A. Ott) |
| September 18–September 20 | EPA (A. Hess) |
| September 25–September 29 | U.S. Geological Service |
| September 25–October 2 | ADFG (P. Weber-Scannell) |
| September–October | ADFG (F. Diceco, twice during the fall) |
| Several occasions | U.S. Coast Guard |

The DMTS port site and mine are located on lands owned by NANA. Teck Cominco conducts the Red Dog operation pursuant to the "Development and Operating Agreement" entered into by Teck Cominco and NANA in 1982. This agreement provides for the appointment of a committee of local residents to a "Subsistence Advisory Committee" to inspect and review mining operations and advise Teck Cominco and NANA regarding any subsistence concerns. The committee has been functioning since the beginning of mining operations and regularly meets to review and discuss mining operations and conduct inspections. Teck Cominco has also hosted visits to the site by local tribal representatives and public interest groups.

## 3.3 Fugitive Dust Control Measures

This section summarizes actions that have been taken to control fugitive dust emissions at the mine, DMTS road, and port. These actions are described separately below as actions that were taken by Teck Cominco in response to an enforcement action to satisfy permit requirements, and those that were taken independently.

### 3.3.1 Compliance Order Actions

Fugitive dust control measures taken in response to an enforcement action are listed in Table 3-2. Additional actions that have been required and are planned or in progress are also listed in

Table 3-2. For specific details and timelines, please refer to the DEC settlement agreement (DEC Compliance Order by Consent #92-320610001).

### 3.3.2 Independent Actions

Many engineering improvements and operational improvements have been voluntarily implemented over the years by Teck Cominco to control fugitive dust emissions. Table 3-3 provides a chronological summary of fugitive dust control measures that have been taken, and some of those that are currently in progress. For reference, Figure 2-1 illustrates features at the port site that are discussed in Table 3-3. Some of the actions listed were taken in anticipation of the 1991–1992 DEC/EPA enforcement action requirements, and some were taken in response to the compliance order by consent that resulted from the enforcement. However, the majority of the actions listed in Table 3-3 were undertaken by Teck Cominco under its own initiative.

# 4 Historical and Current Environmental Data

A number of environmental studies and monitoring programs have been conducted since Red Dog operations began. A summary of these programs by media sampled is provided in Table 4-1. These programs have been designed to evaluate baseline conditions, monitor environmental impacts from the operation, and measure the effectiveness of emissions control measures. The following sections provide an overview of these monitoring programs.

## 4.1 Pre-Mine/Baseline Studies

The following sections describe the baseline studies that were performed prior to the existence of Red Dog operations. Baseline studies were conducted to document the environmental conditions of the study site prior to mining activities. These included studies contracted by Teck Cominco and other mining companies such as General Crude Oil and Minerals (GCO Minerals).

### 4.1.1 Teck Cominco

In 1981−1982, Dames & Moore performed an environmental baseline study to evaluate environmental conditions prior to the start of any mining activities at Red Dog. A supplemental baseline study was performed in 1983 to continue several of the original environmental studies, including an assessment of water quality. These baseline studies included aquatic and terrestrial biology, socioeconomics, subsistence use patterns, archeology, visual resources, and water quality. Water samples were collected from Mainstem Red Dog Creek and tributaries and analyzed for a range of metals and water quality parameters. Fish tissues from Arctic char and grayling in the study area were also analyzed for metals (Dames & Moore 1983).

In 1983 (the most recent baseline data), water samples were collected along Mainstem Red Dog Creek at multiple stations. The total minimum and maximum concentrations of cadmium in water were <0.002 and 0.284 mg/L, respectively. Minimum and maximum concentrations of total lead were 0.0009 and 0.946 mg/L, respectively. Total zinc minimum and maximum concentrations were 0.179 and 23 mg/L, respectively. In Mainstem Red Dog Creek and Ikalukrok Creek, on average, 53 percent of the lead occurring in water was in the dissolved phase. For cadmium and zinc, an average of 86 and 88 percent, respectively, were the dissolved form.

Fish samples taken during the 1983 supplemental baseline study found that various char tissues had cadmium concentrations that ranged from 0.17 to 2.71 mg/kg dry weight in muscle and kidneys, respectively. Cadmium concentrations were higher in grayling organs. Mean concentrations ranged from 0.26 mg/kg dry weight in muscle tissue, to about 38.5 mg/kg dry weight in the kidney. Lead tissues in char and grayling muscle tissues were generally undetected (detection limit of 0.06 mg/kg dry weight). Mean values of lead in grayling kidney, gill, and liver tissue were <0.48, 0.89, and 1.99 mg/kg dry weight, respectively. Zinc concentrations were lowest in muscle tissues at 14.1 mg/kg dry weight, and highest in kidneys at

95 mg/kg dry weight (Dames & Moore 1983). Cadmium concentrations ranged from 0.26 mg/kg dry weight in muscle to 38.5 mg/kg dry weight in kidneys.

### 4.1.2 General Crude Oil and Minerals

In 1978 and 1979, a baseline study was performed by GCO Minerals in the Red Dog study area to determine metal concentrations in water and fish and identify any potential environmental problems related to potential mineral exploration and extraction. Water and fish samples from the Wulik and Kivalina Rivers were sampled (Ward and Olson 1980). Sampling stations are shown in Figure 4-1.

Water samples had maximum cadmium concentrations in Red Dog Creek ranging from 0.001 to 0.554 mg/L (ppm). These values exceeded the Alaska drinking water maximum contaminant level (MCL) of 0.010 mg/L. Lead concentrations ranged from 0.0017 to 3.0 mg/L in Red Dog Creek. Some samples exceeded the MCL of 0.05 mg/L. Zinc concentrations in Red Dog Creek generally varied from 1.08 to 3.28 mg/L, although two samples had concentrations of 90.4 and 47 mg/L (Ward and Olson 1980).

Fish samples taken in Red Dog Creek in 1978 had mean cadmium, lead, and zinc concentrations in grayling muscle tissue of 0.89, 1.25, and 74.1 mg/kg dry weight, respectively. Grayling muscle tissue taken from Grayling Creek had concentrations of 0.93, 2.32, and 32.2 mg/kg dry weight of cadmium, lead, and zinc, respectively (Ward and Olson 1980).

### 4.1.3 Alaska Department of Environmental Conservation

In 1982, DEC contracted EVS Consultants to determine metal concentrations in fish in the Wulik and Kivalina River drainages so that a baseline could be established to assess potential adverse effects to the environment from future mining activities. Arctic char and grayling fish tissues were analyzed for a suite of metals (EVS and Ott Water 1983).

Lead and cadmium were undetected in Arctic char muscle tissue samples taken from Wulik and Kivalina Rivers. Zinc concentrations ranged from 16.2 to 24.0 mg/kg dry weight. Arctic grayling samples in Tutak Creek had only one detected cadmium concentration at 0.044 mg/kg dry weight. Lead and zinc concentrations in muscle tissue samples ranged from undetected to 5.10 mg/kg dry weight, and 25.5 to 41.3 mg/kg dry weight, respectively (EVS and Ott Water 1983).

### 4.1.4 U.S. Fish and Wildlife Service

FWS conducted a baseline assessment for the Selawik National Wildlife Refuge in 1987 and 1988. The refuge is located east of Kotzebue Sound and is bisected by the Arctic Circle. The area is approximately 849,858 ha, of which 97,127 ha is Congressionally designated wilderness, 27,000 ha is private patented land, and 147,000 ha allotted to Alaska Native village corporations. This area is close to the Red Dog study area and the environmental conditions can be used for comparison. The FWS report summarizes the water quality and concentrations of trace elements (dissolved, total recoverable [weak-acid digestion] and total [complete acid digestion] metals and metalloids) in the water, stream sediments, and fish. The FWS water samples were taken from seven sites, five within the refuge (Kugarak River, Selawik River, Tagagawik River, Kobuk River [2 sites]), and two outside of the boundaries (both stations in Klery Creek). In 1987, samples were collected from the first four sites, and the remaining sites in 1988 (Mueller et al. 1993). Sampling stations are shown in Figure 4-1.

Water samples taken from Kugarak River, Selawik River, and Tagagawik River have detectable mean cadmium levels of 0.004, 0.006, and 0.002 mg/L, respectively. In 1988, the mean lead concentration in Klery Creek was 0.028 mg/L (Mueller et. al 1993).

Cadmium was detected at least once in northern pike tissue in each of the Kugarak, Tagagawik, and Kobuk Rivers. Detected levels were 0.34, 0.45, and 0.62 mg/kg dry weight, respectively. Cadmium levels in Arctic grayling tissue from the Selawik River and two of its tributaries ranged from undetected (at 0.30 mg/kg dry weight) to 0.64 mg/kg dry weight in the ventral muscle (Mueller et. al 1993).

Sediment samples taken in 1987 had background levels of zinc in the Kugarak, Selawik, Tagagawik, and Kobuk rivers. Mean concentrations in each of these rivers were 36.6, 50.8, 32.1, and 56.3 mg/kg dry weight, respectively. The minimum and maximum concentrations were 28.1−44.3, 43.6−56, 25.9−37, and 48.5−62 mg/kg dry weight for the Kugarak, Selawik, Tagagawik, and Kubuk rivers, respectively.

## 4.2 Post-Mine Studies and Monitoring Programs

Following start-up of the Red Dog operation in 1989, a variety of studies and monitoring programs were (and are still being) conducted by Teck Cominco and various governmental agencies. The studies and monitoring programs relevant to the fugitive dust issue are summarized below.

### 4.2.1 Teck Cominco

Teck Cominco has developed numerous programs, both required and voluntary, to assess environmental conditions and changes due to mining operations, or for potential expansion opportunities. The following four sections describe each monitoring program and the final results.

#### 4.2.1.1 Port Site Monitoring Program

The initial Port Site Monitoring Program (PSMP) was conducted from June 1990 through August 1996 with the purpose of monitoring lead, zinc, and diesel-range organic concentrations at the port site. ENSR conducted the program in 1990 (ENSR 1990, 1991), 1992 (ENSR 1993), and 1995 (ENSR 1996), and RWJ Consulting conducted the program in 1996 (RWJ 1997). In each year the monitoring was completed, soil, sediment (from lagoons and nearshore marine), and water samples (from the tundra, lagoons, and nearshore marine) were collected from locations and transects established during the 1990 baseline study. Samples were collected from areas near the CSB, conveyor, dock, turnaround loop at the CSB, pipeline, fuel storage tank farm, the four lagoons near the port, and the nearshore marine area of the Chukchi Sea (Figure 4-2). The four lagoons that were sampled included the port lagoon north of the dock (Port Lagoon North), the port lagoon south of the dock (Port Lagoon South), the lagoon farther north of the previous north lagoon (North Lagoon), and a control lagoon one mile southeast of the port (Control Lagoon). The first three of these lagoons are shown on Figure 4-2.

**Soil Sampling Results—**The 1996 PSMP report compares the 1996 sampling results with results from previous years (RWJ 1997). Data from 1996 are the most recent, and therefore the most representative of cumulative effects over the 1990–1996 period. In the 1996 program, 87 soil samples were taken near the CSB, 196 at the conveyor area, 40 at the dock area, 73 in the roadway area, 38 in the unloading area, and 39 in the fuel storage area. "Soil" sample results do not necessarily mean these concentrations are within the soil matrix. For the most part, the higher concentrations result from concentrates on the ground surface. The highest concentrations were observed in samples located close to operational features around the port site, and concentrations rapidly decline with distance. In the vicinity of the one CSB in existence at that time (see Figure 4-2), mean, median, and maximum lead and zinc concentrations were 93.1, 25, and 1,200 ppm, and 323, 85, and 4,500 ppm, respectively. In the vicinity of the south end of that CSB, mean, median, and maximum lead and zinc concentrations were 1,025, 59, and 27,000 ppm, and 2,102, 265, and 22,000 ppm, respectively. In the vicinity of the conveyor (P8), mean, median, and maximum lead and zinc concentrations were 2,563, 645, and 32,000 ppm, and 9,123, 3,600, and 95,000 ppm, respectively. In the roadway area, mean, median, and maximum lead and zinc concentrations were 551, 43, and 5,800 ppm, and 1,977, 160, and 25,000 ppm, respectively. In the dock area, mean, median, and maximum lead and zinc concentrations were 2,436, 370, and 32,000 ppm, and 10,000, 1,350, and 130,000 ppm, respectively. In the unloading area, mean, median, and maximum lead and zinc concentrations were 2,597, 235, and 36,000 ppm, and 10,508, 1,300, and 180,000 ppm, respectively. In the fuel storage area, mean, median, and maximum lead and zinc concentrations were 50.7, 18, and 450 ppm, and 318, 79, and 5,800 ppm, respectively.

**Water Sampling Results—**Water samples collected in 1996 from lagoons showed no increase in lead and zinc levels relative to the 1990 baseline study (mean lead and zinc concentrations were 0.01 and 0.04 mg/L, respectively, in the lagoons) (ENSR 1990). However in years prior to 1996, samples from the lagoon stations had been elevated relative to 1990 baseline levels. For example, water samples collected between June 1991 and September 1992 at the port site showed that lead and zinc increased slightly. Maximum concentrations of lead increased from 0.34 mg/L in 1991 to 0.96 mg/L in 1992. The maximum zinc level was 1.15 mg/L in 1991, and remained unchanged in 1992 at 1.12 mg/L. The maximum lead and zinc concentrations were found in samples collected from the lagoon north of the dock (ENSR 1993).

Samples taken in 1996 had maximum lead and zinc concentrations of 0.017 and 0.19 mg/L, respectively, which were similar to 1990 baseline levels (mean lead and zinc concentrations were 0.01 and 0.04 mg/L, respectively) for all years sampled (ENSR 1990; RWJ 1997). Prior to 1996, lead and zinc concentrations fluctuated in marine water samples. For example, marine water samples collected in the nearshore zone in September 1991 and 1992 had maximum lead concentrations of 0.195 and 0.074 ppm, respectively. The maximum zinc concentration decreased from 0.267 ppm in 1991 to undetected (detection limit of 0.100 ppm) in 1992 (ENSR 1993).

**Sediment Sample Results—**Of the 22 lagoon sediment samples that were collected in 1992, the sediment from the port lagoon north of the dock had the maximum levels of lead and zinc (621 and 4,700 mg/kg, respectively) (ENSR 1993). The lagoon sediment samples taken in 1996 had increased levels of lead and zinc compared with the 1990 baseline concentrations, although most of the increase occurred in the earlier years. Maximum lead and zinc concentrations in the lagoons were 140 and 1,200 mg/kg, respectively. Similarly to 1992, the sediments in the lagoon north of the dock had the highest concentrations out of the four lagoons that were sampled (RWJ 1997).

In 1992, the maximum concentrations of the eight marine sediment samples were 63.9 and 116.3 mg/kg for lead and zinc, respectively (ENSR 1993). Marine sediments in the nearshore area collected in 1996 had maximum lead and zinc concentrations of 74 and 260 mg/kg, respectively (RWJ 1997). Lead and zinc concentrations in sediment showed little change over the years sampled. Only the sample location just off the shallow water dock had consistently elevated concentrations compared with the 1990 baseline.

#### 4.2.1.2 Transportation Corridor Monitoring Program

ENSR conducted a spill and dust monitoring program along the DMTS road that was called the Transportation Corridor Monitoring Program. This program was designed to monitor the extent and concentrations of lead and zinc along the road as a result of the passage of concentrate trucks and other vehicular traffic. To accomplish this, transects along the DMTS road were established in June 1991. Soil samples and opportunistic water samples were taken along the transects in June 1991 and September 1992 (Figure 4-3). Spill sites were also sampled.

Soil samples were collected on transects located approximately 10 miles apart at intervals of 5, 50, and 500 ft from the road in both directions. Soil was collected in the root zone, approximately 2 to 6 in. below the surface in vegetated areas, and at the surface in non-vegetated areas. If vegetation was present, the soil layer of peat or decaying organic matter was sampled. Water samples were collected opportunistically (ENSR 1993).

Soil samples collected along the DMTS road transects in 1991 and 1992 had maximum concentrations of lead and zinc of 510 and 1,330 mg/kg, respectively. The mean values by transect for these two years ranged from 11.7 to 132 mg/kg for lead and from 59.5 to 437 mg/kg for zinc. There was a decreasing trend of metals concentrations with increasing distance from the mine, except for the transect closest to the port with the highest zinc level. Laterally from the road, lead and zinc concentrations decrease with increasing distance from the road.

In addition to the monitoring, ENSR sampled soil and water samples to locate five previous spills of concentrate along the DMTS road. These spills were estimated to have occurred between January 12 and September 18, 1990. To locate these spill sites, a systematic grid was established at each of the suspected sites. Approximately 20 soil samples and two water samples were collected at each spill site. Each grid line was approximately 20 ft apart and soil samples were taken at the intersections of these grid lines.

The range of metals concentrations in soil at the spill sites was 1.5 to 2,580 mg/kg for cadmium, 11.5 to 665 mg/kg for lead, and 21.9 to 558,000 mg/kg for zinc. The range of metals concentrations in water at the spill sites was 0.005 mg/L to 0.040 mg/L for cadmium, 0.007 to 0.210 mg/L for lead, and 0.040 to 7.10 mg/L for zinc (ENSR 1992).

The two water samples collected along the DMTS road dust transects had lead concentrations of 0.11 and 0.09 mg/L, which were higher than the maximum reference lead concentration of 0.007 mg/L. Zinc concentrations were 0.24 and 0.12 mg/L, which were higher than the maximum zinc reference concentration of 0.01 mg/L (ENSR 1992). The concentrations of lead and zinc in water decreased between 1991 and 1992. In 1992, the maximum concentration was 0.029 mg/L for lead and 0.154 mg/L for zinc (ENSR 1993).

#### 4.2.1.3 Port Site Air Monitoring Program

From 1997 through the present, Teck Cominco has conducted an air monitoring program at the port site. This program is intended to monitor fugitive dust emissions and to facilitate operational improvements to reduce fugitive dust emissions. The program has included dustfall collection jars, snow surveys, and air sampling using high-volume air samplers and tapered-element oscillating microbalance (TEOM) samplers. The Port Site Air Monitoring Program was summarized in Exponent (2001b).

Seasonal dustfall sampling was initiated in 1997 and continued through 2000. The dustfall sampling method is based on standard procedures (American Society for Testing and Materials method D1739), using collection jars placed on a post approximately 6 ft above the ground. Collection jars were placed in 37 locations in a 1,000-ft grid pattern around the port site. Measurements included lead, zinc, and total solids deposition. Seasonal samples were collected in summer/fall 1997, spring/summer 1998, summer/fall 1998, winter 1999, summer 1999, and winter 1999/2000. Results indicated that the primary sources of fugitive dust within the port site area were the south end of the CSBs and the roadway where the trucks exit from the TUB. The limited data set and high variability of results in these seasonal data sets prevented identification of any changes or trends over time. In 2001, a more intensive and extensive dustfall sampling program was initiated. Monthly sampling was begun in August at 7 new stations (14 samplers) along the DMTS road and, starting in September, at the 37 existing collectors at the port site. In this expanded and ongoing dustfall sampling program, additional precautions are being taken to minimize effects that increase variability in the results (Exponent 2001a).

Two snow surveys were conducted, one in April 1997, and another in February 1998. Samples were collected by coring the entire snow profile, and were analyzed for lead, zinc, and cadmium. The results showed that probable sources of fugitive dust occurred primarily where trucks exited the original CSB, and along road toward the dock from the CSB. The effectiveness of the snow sampling program was somewhat limited by variable snow cover and topography-dependent drifting and deposition of snow and dust.

High-volume air sampling was conducted at the port site from 1997 through 1999 using five samplers. In 1997 and 1998, the high volume air samples were collected every other day during the months of June through October. In 1999, samples were collected every 6 days. Total suspended particulates were measured at four locations, and $PM_{10}$ (i.e., particles less than 10 $\mu$m in diameter) was measured at the fifth location. A subset of samples were also analyzed for lead and zinc. In 1997 through 1999, samples were generally collected during the shipping season (from June or July through October each year). A preliminary review of the data by Air Sciences Inc. (Air Sciences 2001) indicated that the road between the CSBs and the dock was a major source of fugitive dust, and that the surge bin in the dock area and the ends of the CSBs were secondary sources of fugitive dust. The data were found insufficient to identify trends or changes over time due to multiple variables affecting the results.

Difficulties with analysis of temporal trends are primarily related to the large number of controlling variables affecting results in different time periods. These include meteorological factors such as wind speed and direction, precipitation, concentrate handling activities, and changes in the facility or equipment (e.g., addition of the second CSB, or changing to new haul trucks).

As a result of limitations in other air monitoring methods tested at the port site, a new monitoring method was initiated in September 2000. TEOM sampling was begun September 24, 2000. TEOM sampling allows measurement of ambient air concentrations of particulates in real time, in discrete time intervals. The TEOM samplers are operated every day, year round. These measurements are expected to allow review of data relative to detailed operational and meteorological information, and comparison of data from similar time periods in different years. Evaluation of this data is in progress.

#### 4.2.1.4 Vegetation and Soil Monitoring Program 1992–1997

RWJ Consulting performed monitoring of soil and vegetation around the mine in September 1992, June 1993, and August 1997. The purpose of this program was to assess the environmental conditions in a 2-mile radius around the living and office quarters, known as the personnel accommodation complex (PAC). Soil samples around the PAC were analyzed for lead and zinc fugitive dust emissions from the mine. The vegetation study also determined the percent frequency and percent cover for mountain avens, birch, blueberry, and willow communities. Four vegetation monitoring quadrats were established in each of five study areas. The five study areas were located to the north, east, west, and south of the mine, as well as one reference area farther away to the southeast. Each vegetation monitoring quadrat consisted of a square 10 m on a side. Soil samples were collect within a 5-m distance outside of each of the vegetation quadrats (RWJ 1998).

The soil samples taken in 1997 had mean lead concentrations ranging from 22.7 to 70.6 mg/kg dry weight. The reference site (3.6 miles away from the PAC) had low levels of lead (mean of 19.1 mg/kg) similar to concentrations measured in previous years. Mean concentrations of zinc in the four quadrants ranged between 112 and 213 mg/kg dry weight. Zinc values ranged from 20 to 2,069 mg/kg in the three sampling events.

The vegetation study indicated that the distinct vegetation covers did not change drastically since the baseline in 1992. The vegetation covers were dominated by a mountain aven community, dwarf birch and blueberry community, and a willow community.

#### 4.2.1.5 Mine Site Air Monitoring

The principle sources of particulate matter at the mine are activities related to mining (blasting, road traffic, and material handling) and particulate matter emissions from power-generation exhaust. Permit-required dispersion modeling demonstrates compliance at the ambient air boundary as required by the air permit.

Teck Cominco conducts several types of air monitoring in the mine area to evaluate the effectiveness of operational controls in minimizing emissions, and to ensure compliance with the air permit. This monitoring includes EPA Methods 22 and 9. EPA Method 22 is a visible dust emission evaluation method that measures the absence or presence of dust over a period of time. Method 9 measures the opacity of a source.

EPA Reference Method 22 evaluations are conducted and documented monthly (at a minimum) at five discrete locations to monitor the emissions of particulate matter from bulk materials handling, exposed areas, quarry operations, and stockpiles. Additionally, each day facility roads are not frozen or the road surface does not exhibit visible surface moisture (rain), an EPA Reference Method 22 evaluation is conducted and documented to determine the duration of vehicle particulate matter emissions. Additional particulate matter controls, for each area or road, are taken if the evaluations indicate a need.

EPA Reference Method 9 evaluations are conducted quarterly (at a minimum) on all of the Wartsila main power generators and two solid waste incinerators, to insure compliance with permit limits for opacity (direct relation to particulate matter). All monitoring records for EPA Reference Methods 9 and 22 are submitted semiannually to DEC.

A monitoring program designed to measure the ambient concentration of particulate matter less than 10 microns ($PM_{10}$) at the mine ambient air boundary was initiated June 1, 2000. $PM_{10}$ concentrations are measured near the DMTS haul road, where it crosses the ambient air boundary. Teck Cominco and DEC selected this monitoring location because it was modeled to have the highest $PM_{10}$ impacts. A report summarizing monitoring results is submitted to DEC annually.

Historically, total suspended solids (TSP) and $PM_{10}$ monitoring was conducted at the mine between January 1992 and August 1994. The DEC-approved program consisted of a high-volume TSP sampler and co-located duplicate, as well as a $PM_{10}$ sampler. These monitoring devices were all located on the roof of the mine's PAC. Additionally, during the same period, high-volume TSP samplers were operated along the DMTS haul road at Material Site 10 (MS-10) to measure road impacts, and near Material Site 2 (MS-2) as a "background" location selected by DEC. All samplers were operated for sampling periods of approximately 24 hours every other day, and monitoring data was submitted to DEC monthly.

#### 4.2.1.6 Kivalina Drinking Water/Surface Water Studies

Kivalina residents obtain drinking water from the Wulik River. From the vicinity of the mine, Red Dog Creek drains into Ikulukrok Creek, which in turn is a tributary to the Wulik River (see Figure 4-1). Teck Cominco collects water samples from two stations (Stations 1 and 2) along the Wulik River and seven stations along the Ikulukrok Creek:

- Station 1—on the Wulik River, just upstream of where Kivalina Village withdraws water
- Station 2—downstream of the confluence of the Ikalukrok and the Wulik (downstream of the mixing zone, but upstream of the confluence of Tutak Creek with the Wulik)
- Station 160 (formerly the "new" Station 7)—on the Ikalukrok, approximately 16 miles upstream from the confluence with the Wulik
- Station 73—on the Ikalukrok, approximately 23 miles upstream from the confluence with the Wulik
- Station 150—on the Ikalukrok, approximately 27 miles upstream from the confluence with the Wulik
- Station 9—on the Ikalukrok, approximately 28 miles upstream from the mouth and just upstream of the confluence with the Main Stem of Red Dog Creek (mine discharge)
- Station 207—on the Ikalukrok, approximately 33 miles upstream from the confluence with the Wulik
- Station 208—on the East Fork of Ikalukrok Creek, approximately 33 miles upstream from the confluence with the Wulik
- Station 206—on the Ikalukrok, approximately 35 miles upstream from the mouth.

In 1998–2001, Teck Cominco collected water samples at Station 1 in the Wulik River where Kivalina residents collect water for drinking. Lead concentrations were undetected, except for one sample (0.02 mg/L) that was slightly above the Alaska drinking water action level of 0.015 mg/L. For comparison, of the 108 water samples that were collected between 1981 and 1998, only two results were greater than 0.015 mg/L. One sample taken in 1991 was anomalously high (0.167 mg/L) and most likely an analytical or reporting error, because it was an order of magnitude higher than the next highest measured value. Cadmium was detected (0.0034 mg/L) in one sample slightly above the Agency for Toxic Substances and Disease Registry (ATSDR) child screening level of 0.002 mg/L. All other metal concentrations were below the screening levels (DHSS 2001).

At Station 2 in the Wulik River, Teck Cominco collected 312 water samples between the years of 1981 and 2001. These samples were collected upstream of Tutak Creek, which is 20 miles from Kivalina. Thirty samples (less than 30 percent of samples) had a lead concentration above the EPA screening level of 0.015 mg/L. Only three samples of the 103 samples taken since 1995 had cadmium levels that were greater than the EPA risk-based screening level (0.018 mg/L). None of the cadmium results were above the MCL.

Water samples were collected in 1991–1993 and 1997–1998 at the Kivalina school by Teck Cominco. In July 1997, Teck Cominco also collected one water sample from the Kivalina clinic. The mean concentration of lead in all 27 samples was 0.002 mg/L. All other metals were below the MCL or EPA risk-based screening level (DHSS 2001).

It is likely that the occurrences of elevated metals concentrations at Stations 1 and 2 are related to naturally occurring mineralization in Ikalukrok Creek. Teck Cominco has analyzed thousands of samples from the stations along Ikalukrok Creek. These data show the locations of substantial naturally occurring metals loading in the Ikalukrok. These data also indicate the presence of detectable metal concentrations in Ikalukrok Creek that are released by specific climatological conditions from ubiquitous mineralized surface deposits. Accounting for streamflows and mixing from tributaries, the discharge concentrations allowed by Red Dog Mine's discharge permit limits account for a small fraction of the metals observed in water by the time it reaches Wulik River Stations 1 and 2. A substantial amount of naturally occurring metals are present in the water at those stations.

#### 4.2.1.7 2001 Fugitive Dust Study

Exponent performed a study in 2001 to evaluate the sources and patterns of elevated levels of metals along the DMTS road and at the port site (Exponent 2002). Samples included road surface soil, road soil cores, fine-grained material on the road shoulder, dustfall collected along the road, and vegetation (moss, lichen, willow, and berries) (see Figure 4-4). Soil and water samples were also collected from material sites along the DMTS road, from which construction rock for road grading and water for road watering have been obtained. The Exponent report included surface water samples collected by Teck Cominco from five creeks that the DMTS road crosses between the mine and the port site. The samples were analyzed for a suite of metals, including aluminum, arsenic, cadmium, calcium, iron, lead, magnesium, and zinc.

Soil samples were collected from the surface of the DMTS road at 34 locations over its length. Core samples were collected at nine stations along the DMTS road in order to characterize the vertical distribution of metals within the material that makes up the road. Cores were collected to a depth of 12 in. Three samples were collected from each core in the following depth intervals: 0−4, 4−8, and 8−12 in. Samples of fine soils were collected from the foot of the DMTS road shoulder at nine stations along the road. These nine stations correspond to the stations where core samples were collected from the road. The road shoulder samples were collected to characterize the finest material from the DMTS road that is most likely to be representative of fine source material that may become airborne from the road. Samples of soil and water were collected from several material sites that are used to supply fill for road repair and water for road watering to minimize dust. These samples were collected to determine whether these materials could be sources of the metals observed on the DMTS road. Dustfall samplers were installed on both sides of the DMTS road at seven stations along its length. Locations of road surface, road core, and road shoulder fines samples, as well as vegetation sample transects, corresponded with these dustfall stations (Exponent 2002).

**Soil Results—**Soil samples taken by Exponent (2002) indicated that the elevated metals concentrations occur primarily on the surface of the road and that construction materials are not a significant source of metals to the DMTS road. Lead concentrations along the road surface soil samples ranged from 30.3 to 1,180 mg/kg, with an average of 250 mg/kg. Cadmium concentrations ranged from 1.2 to 39.3 mg/kg, with an average of 5.5 mg/kg, and zinc concentrations ranged from 185 to 6,610 mg/kg, with an average of 940 mg/kg. Note that the average values listed above are not representative of the entire DMTS road. The road core samples that were sampled at nine stations to a depth of 12 in. had lead concentrations that ranged from 3.8 to 200 mg/kg. Cadmium concentrations ranged from 1.2 to 3.8 mg/kg. Zinc concentrations ranged from 90 to 566 mg/kg. Metals concentrations were higher in shallow samples, and decreased with depth. The road shoulder fines samples had lead concentrations that ranged from 116 to 2,440 mg/kg. Cadmium concentrations ranged from 3.75 to 29.3 mg/kg. Zinc concentrations ranged from 565 to 4,910 mg/kg. The most likely primary source appears to be the tracking of metals in the form of powdered concentrates by haul trucks. Truck spills do not appear to be a significant source of metals to the road surface.

**Water Results—**Water samples collected from five creeks at locations along the DMTS road showed no exceedances of hardness-dependent water quality criteria in 4 months of data collection (July through October 2001). Surface water data show little, if any impact from the DMTS road. Most of the results (82, 84, and 97 percent of the results for lead, zinc, and cadmium, respectively) of the 89 water samples were undetected. Detected lead concentrations ranges from 0.05 to 2.37 $\mu$g/L. Detected cadmium concentrations ranged from 0.1 to 0.2 $\mu$g/L. Detected zinc concentrations ranged from 2.07 to 34.4 $\mu$g/L, with an average of 7.5 $\mu$g/L. There were no sample results in exceedance of hardness-dependent water quality criteria (Exponent 2002).

**Vegetation Results—**Cadmium, lead, and zinc concentrations in moss samples collected by Exponent along DMTS road transects located between the mine and port site were comparable to NPS data, indicating that the dustfall pattern was similar along most of the DMTS road and suggesting that metals concentrations in moss samples were approaching background concentrations at approximately 1,000 m from the road. (Note that vegetation sample results provided in this document are for unwashed samples. Therefore, reported concentrations are the total concentration of metals within the plant matrix as well as on the surface of the sample). Cadmium, lead, and zinc concentrations along the DMTS road ranged from 0.502 to 27.2 mg/kg, 9.54 to 875 mg/kg, and 59.2 to 4,180 mg/kg dry weight, respectively. Metals concentrations in moss samples collected at spill sites were similar to levels observed in other moss samples collected near the DMTS road. Concentrations of cadmium, lead, and zinc in spill site moss samples ranged from 6.65 to 15.5 mg/kg, 338 to 995 mg/kg and 822 to 2,580 mg/kg dry weight, respectively. Port site cadmium, lead, and zinc concentrations ranged from 5.53 to 48.4 mg/kg, 323 to 1,670 mg/kg, and 1,260 to 6,480 mg/kg dry weight, respectively (Exponent 2002).

Cadmium, lead, and zinc concentrations in unwashed lichen samples collected from DMTS road transects by Exponent (2002) ranged from 0.259 to 11.9 mg/kg, 6.86 to 660 mg/kg and 82.2 to 1,720 mg/kg dry weight, respectively. Cadmium, lead, and zinc concentrations in port site lichen samples ranged from 5.42 to 5.94 mg/kg, 182 to 218 mg/kg, and 1,010 to 1,050 mg/kg dry weight, respectively.

Unwashed willow leaf samples collected along the DMTS road transects had concentrations of cadmium, lead, and zinc concentrations ranging from 0.499 to 7.75 mg/kg, 0.431 to 45.6 mg/kg, and 122 to 546 mg/kg dry weight, respectively. Cadmium, lead, and zinc concentrations in port site willow leaf samples ranged from 0.753 to 1.66 mg/kg, 4.8 to 15.6 mg/kg, and 196 to

290 mg/kg dry weight, respectively. Cadmium concentrations in willow leaf samples leveled off around 100 m from the DMTS road. Similarly, lead concentrations in willow leaf samples declined at 100 to 1,000 m along DMTS road transects (Exponent 2002).

Concentrations in salmonberry samples along the DMTS road transects by Exponent (2002) had cadmium, lead, and zinc concentrations ranging from 0.0581 to 1.58 mg/kg, 0.462 to 13.5 mg/kg, and 15.8m to 70.5 mg/kg dry weight, respectively. At the port site, cadmium, lead, and zinc concentrations ranged from 0.229 to 0.415 mg/kg, 0.565 to 0.820 mg/kg, and 17.7 to 25.8 mg/kg dry weight, respectively. Relative to concentrations observed in samples from Noatak and Point Hope, salmonberry samples collected at the port site and 3 m from the DMTS road generally had elevated cadmium and lead levels. Zinc concentrations in salmonberry samples collected 3 m from the road were elevated relative to concentrations in samples from Noatak and Point Hope, but samples collected at the port site and 100 m from the DMTS road were within the range of concentrations observed in the Noatak and Point Hope samples (Exponent 2002).

## 4.2.2 Alaska Industrial Development and Export Authority

AIDEA contracted environmental consultants to determine the site conditions and assess the potential of increasing the capacity of the port. This section discusses two studies of sediment and biota at the port site.

### 4.2.2.1 Sediment Quality Survey

Cominco, Alaska, Inc., RWJ Consulting, and Peratrovich, Nottingham & Drage, Inc. conducted a sediment survey for H.A. Simons, Ltd., as part of the port facility expansion feasibility study in June–August 1998. The feasibility study evaluated options for increasing the capacity of the port, including creation of a deepwater port through various dredging alternatives, and alternatives that would allow concentrates to be loaded directly onto deepwater ships without the use of lightering barges. The main objective of the sediment testing was to determine whether contaminants from dredged sediments could adversely affect the water column or benthic biota. Metals, VOCs, SVOCs, pesticides, PCBs, and conventional parameters were analyzed. The samples were taken from four locations in the port site area: 24 stations from the proposed ship channel, 6 stations from the offshore reference sites south of the ship channel; 6 stations from the proposed deep marine dredge disposal area, and the 6 stations from the port site lagoon. A total of 49 sediment samples from these 42 sites were collected, including 41 surface (0−1 in. depth) and 8 subsurface (1−16 in. depth) samples (Cominco, RWJ, and PN&D 1999).

Sediment samples had cadmium concentrations that ranged from 0.04 to 0.72 mg/kg. Lead concentrations ranged from 3.50 to 32.7 mg/kg and zinc concentrations ranged from 14.6 to 179 mg/kg. The concentrations of cadmium, lead, and zinc did not exceed marine sediment quality criteria listed in the State of Washington Sediment Management Standards (Cominco, RWJ, and PN&D 1999).

#### 4.2.2.2 Marine Biota Survey

In 2000, Teck Cominco and AIDEA contracted RWJ Consulting to perform environmental studies at the Red Dog port site, in an effort to assess the potential for relocating the concentrate loading facility and dredging a shipping channel to allow direct access to the marine barges. The purpose of this study was to obtain information, such as relative abundance and characterization of marine fish and shellfish at the port site under ice and open water conditions. In addition to this study, the researchers also developed marine mammal stomach sampling "kits" for subsistence users to sample marine mammals caught in Kivalina and Kotzebue in the spring (RWJ 2001).

After the 2000 spring and summer survey of crabs and shrimp in the Red Dog port site, RWJ (2001) identified 16 species or taxa. Seastars and helmet crabs were the most abundant animals. RJW (2001) found very few adult and larvae-size red king crabs due to the unsuitable habitat on the marine bottom. A survey of stomach contents found in the red king crab included polychaetes (marine worms), amphipods, fishes, and brittle stars, in decreasing order. A total of 20 prey items, excluding sediment and unidentifiable matter, were found in the stomachs of 25 red king crabs. Using bottom trawlers in the summer, shrimps, seastars, and helmet crabs dominated the catch. The dominant fish species collected in the bottom trawls were northern sculpin, yellowfish sole, saffron cod, and snake prickeleback. However, observations by underwater videotaping found that bottom-dwelling fish rarely frequented the port site, although this could vary from year to year (RWJ 2001).

The port study by RWJ (2001) found that the animals that are present in the sediment (i.e., benthic infauna) were dominated by marine worms and that much of the community was homogenous, and well adapted to thrive under various dynamic, physical, environmental conditions (RWJ 2001). Metals concentrations in benthic infauna tissue were not measured.

### 4.2.3 Alaska Department of Environmental Conservation

DEC and its contractor (Ecology and Environment, Inc.), with help from the staff of the Maniilaq Association and the villages of Noatak and Kivalina (including members of the Subsistence Committee), took berry and plant samples in August 2001 for cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, and zinc analyses. This study was designed to provide information about subsistence foods near the Red Dog port site, in response to previous reports (Ford and Hasselbach 2001) that indicated a potential for subsistence food along the DMTS road and port to be affected by the Red Dog operation. Salmonberries were collected at the port, a few miles north and south of the port, and in the vicinity of Noatak and Point Hope. Blackberries and sourdock were collected north of the port facility and in the vicinity of Noatak (see Figure 4-5). Ten samples each of blackberry, salmonberry, and sourdock were collected near the port site. Eight blackberry samples, 10 sourdock samples, and 10 salmonberry samples were collected north of Noatak. Near Point Hope, 10 salmonberry samples were also collected for analysis.

One water sample was taken from the Wulik River in August 2001 and analyzed for a suite of metals. The cadmium, lead, and zinc concentrations were 0.112, 0.648, and 13.6 $\mu$g/L, respectively. One water sample was taken from New Heart Creek. The concentrations of cadmium, lead, and zinc were 0.0241, 0.317, and 2.97 µg/L, respectively (DEC 2001). Summary statistics for berry and sourdock samples are presented in Figure 4-6.

## 4.2.4 Alaska Department of Fish and Game

### 4.2.4.1 National Pollutant Discharge Elimination System Permit

ADFG sampled water and fish from tributaries below Red Dog mine as part of the NPDES permit application. The NPDES permit requires biomonitoring of fish, aquatic invertebrates, and plants (i.e., periphyton) in streams near the mine. From 1991 to 1994, between May and September, a fish distribution monitoring plan was implemented. An expanded scope of work began in 1994 and continued annually through 1998. The objective of this scope was to monitor and document the changes in the Ikalukrok Creek and Red Dog Creek, either naturally or due to mining operations.

In addition to the monitoring required by the permit, Teck Cominco supported a voluntary and supplemental sampling program of fish in other locations along Red Dog Creek, Ikalukrok Creek, Wulik River, Ferric Creek, Anxiety Ridge Creek, Evaingiknuk Creek, Buddy Creek, and Graying Creek in 2000. Sampling stations corresponded to the same stations used by Dames & Moore (1983) during the baseline study (see Figure 4-5). Twelve samples of Dolly Varden tissues were analyzed for metals.

The median cadmium concentrations in Dolly Varden kidney tissue samples were lower in samples taken after 1991 (when the median was 3.62 mg/kg) and have since fluctuated between 2.4 and 0.38 mg/kg. Since the fall of 1997, median cadmium concentrations in kidneys have been below 2 mg/kg. There was no increase in cadmium concentration in other tissues. Median lead concentrations have remained low between the years 1990 to 1998. In the spring of 1999, median lead concentrations rose in liver, muscle, and kidney tissues (maximum of 0.36 mg/kg in liver tissue), but declined in 2000 (maximum of 0.06 mg/kg in liver tissue). Zinc median concentrations were low (median of 78 mg/kg) in liver tissue samples in Dolly Varden caught in 2000.

Water samples were taken in 2000 at Ikalukrok Creek, Mainstem Red Dog Creek, and Middle Fork Red Dog Creek, and were analyzed for water quality parameters and metals (Weber-Scannell and Ott 2001). The highest cadmium concentration was found in Middle Fork Red Dog Creek (15.9 µg/L). The minimum cadmium concentration was 0.20 µg/L in North Fork Red Dog Creek. The maximum zinc concentration was 2,510 µg/L in Middle Fork Red Dog Creek and the minimum zinc concentration was 14 µg/L at Ikalukrok Creek, upstream of Red Dog Creek. Concentrations of lead ranged from a minimum of 0.05 µg/L at Ikalukrok Creek upstream of Red Dog Creek, to a maximum of 207 µg/L at North Fork Red Dog Creek (Weber-Scannell and Ott 2001).

### 4.2.4.2 Juvenile Dolly Varden Tissue Sampling in 2001

ADFG recently reported (Morris and Ott 2001) the results of a sampling program of juvenile Dolly Varden fish, which is a species and age class that can readily indicate environmental metals concentrations in their tissues. Samples were taken in North Fork Red Dog Creek and Anxiety Ridge Creek in the summer of 1998. Mainstem Red Dog Creek and the mainstem of Anxiety Ridge Creek were sampled in 1998, and North Fork Red Dog Creek, Mainstem Red Dog Creek, and Anxiety Ridge were sampled in 1999 and 2000. In July and August 2001, Evaingiknuk Creek, Aufeis Creek, and Omikviorok River were sampled. Approximately 10 fish from each stream were sampled. Fish were caught with minnow traps that were baited with salmon roe and left in the stream for 24 hours.

Dolly Varden juvenile fish samples had mean cadmium, lead, and zinc concentrations of 0.093, 0.415, and 108 mg/kg dry weight, respectively, in the north fork of the Omikviorok River. This river is upstream of the DMTS road. The range of concentrations for cadmium, lead, and zinc were 0.04−0.14, 0.04−3.03, and 71.7−155 mg/kg dry weight, respectively. Mean levels in Aufeis Creek, also upstream of the road, were 0.134, 1.642, and 96.3 mg/kg dry weight for cadmium, lead, and zinc, respectively. Concentration ranges were 0.11−0.17, 0.13−6, and 84.5−121 mg/kg dry weight for cadmium, lead, and zinc, respectively (Morris and Ott 2001). These concentrations may be considered reference values, as they would be uninfluenced by runoff of metals from the DMTS road.

Mean concentrations were 0.073, 0.318, and 111 mg/kg dry weight for cadmium, lead, and zinc, respectively, for tissue samples collected in Omikviorok River and Aufeis Creek. Minimum and maximum values were 0.05−0.1, 0.08−1.05, and 97.7−131 mg/kg dry weight for cadmium, lead, and zinc, respectively. These results indicate that runoff from the DMTS road is not increasing metal concentrations in fish tissue samples compared to upstream samples. Additionally, the researchers found no significant correlation between the metal concentrations and the size of the sampled fish (i.e., the length of the fish from its snout to the fork in its tail) (Morris and Ott 2001).

#### 4.2.4.3 Caribou Monitoring Program

An annual caribou monitoring program was implemented in 1984 and carried out each year through 1997, in conjunction with the Subsistence Committee. The objectives of this study were to observe caribou seasonal activity and herd movements in the Red Dog Mine area, as well as to determine whether mining control measures were effective in protecting the herd. Through reconnaissance aerial surveys in the summer, fall, and winter, the program estimated the caribou population, migration, calving, and feeding patterns (Pollard 1994).

The caribou monitoring effort tabulated approximately 450,000 caribou in the western Arctic caribou herd (WACH). The caribou population had doubled in the previous 10 years, but did not experience growth in the last 3 years. The density of the WACH was estimated to be about 1.4 caribou per square kilometer in 1992. Researchers were concerned about a population crash due to overpopulation, as previously seen in the George River herd in northern Quebec, Canada, which had a drastic decline in population when its density reached 1.9 caribou per square kilometer.

Surveys done in late September through October 1994 showed that caribou were able to successfully cross the DMTS road, aided by a policy for truck traffic to stop for caribou. The fall 1994 survey found that the caribou migrated from the Kivalina River, then went southeastward along the coastal foothills, and finally moved north, past Hotham Inlet. These coastal migrations may reach the DMTS road. Caribou were not found near Red Dog in 1994, but in July the caribou migrated east towards the DeLong Mountains and the Brooks Range (Pollard 1994).

ADFG has also analyzed the liver, kidney, and muscle tissue samples of 15 caribou harvested along the DMTS road in 1996. Lead, zinc, cadmium, and other metals were analyzed. Muscle, liver, and kidney sample mean concentrations of zinc were 33, 22.4, and 16.8 mg/kg wet weight, respectively. Mean cadmium concentrations in muscle, liver, and kidney tissue samples were 0.006, 0.43, and 0.23 mg/kg wet weight, respectively. Average lead concentrations were 0.05, 1.65, and 10 mg/kg in muscle, liver, and kidney tissue samples, respectively. The researchers calculated intake concentrations of the metals and found that the metals in the caribou samples were not a threat to human health, based on ATSDR adult and child risk-based screening concentrations. The calculated intake concentration (assumed to be 96 percent muscle ingestion, and liver and kidney contributing 2 percent each) for cadmium, lead, and zinc were 0.06, 0.28, and 32 mg/kg wet weight, respectively. The non-cancer adult risk-based screening concentrations for cadmium and zinc were 0.4 and 119, respectively. The non-cancer child risk-based screening concentrations for cadmium and zinc are 0.21 and 62 mg/kg wet weight, respectively (DHSS 2001).

### 4.2.5 National Park Service

The DMTS road traverses 24 miles of the Cape Krusenstern National Monument, which is managed by NPS. NPS performed a preliminary study in June–July 2000 to determine whether there were elevated lead, zinc, and cadmium levels near the road. (NPS conducted a larger sampling effort in the summer of 2001 but those data are not yet available.) To achieve this objective, NPS collected soil and moss at transects along the road and compared the data to other studies done in the Arctic and elsewhere. Transects were placed perpendicular to straight stretches of the DMTS road (within National Monument land). Moss samples (recent 3-year growth) were collected within a 2-m radius at 3, 50, 100, 250, and 1,000 m transect points. Samples were also taken at 1,600 m at two transects. Soil samples were taken at the same locations with a hand drill. Soil depths of up to 45 cm were obtained, and dust samples were collected from willow leaves.

This study used an “enrichment factor” ratio to relate the ratio of the contaminants to a conservative soil element (in this study, aluminum was used) in moss to the same ratio in soil. According to NPS, the local geology is represented by ratios less than 10. Ratios that are greater than 10 suggested that additional metals have been deposited on the moss (Ford and Hasselbach 2001).

The average soil (at depth) concentrations of lead, zinc, and cadmium were 19, 88, and 0.32 mg/kg dry weight, respectively. Together with the metal measurements in moss, NPS concluded that ore concentrate was escaping along the DMTS road corridor and, in addition, was contributing airborne heavy metals to the Omikviorok River drainage as a whole.

Lead, zinc, and cadmium concentrations in moss samples collected along DMTS road transects by NPS ranged from 8.6–458, 96–2,860, and 0.34–17 µg/kg dry weight, respectively. Although metals concentrations decreased rapidly with distance from the road, transect endpoints at 1,000–1,600 m from the road had concentrations of lead >30 mg/kg, zinc >165 mg/kg, cadmium >0.6 mg/kg. Moss enrichment factors for cadmium ranged from 40 to 219. Lead and zinc enrichment factors were 21−86 and 21−150, respectively. NPS concluded that the enrichment factors indicated that lead, zinc, and cadmium from airborne sources, other than remobilized parent material (soils, road dust), were apparent. Maximum metals concentrations were detected in samples collected 3 m from the DMTS road, and metals concentrations decreased with increasing distance from the road. Metal concentrations tended to be higher in moss samples collected on the downwind side of the road than in moss samples collected upwind of the road.

### 4.2.6 Kivalina Village

In 1995, 1996, and 2001, water samples were taken by the village of Kivalina from the Kivalina drinking water tanks and/or washeteria and tested for a suite of metals. In 1995 and 1996, all of the analytes were below their respective MCLs. Most were undetected in both years, except for barium, cadmium, and selenium in 1995, and beryllium in 1996. The cadmium concentration in 1995 was 0.0002 mg/L (MCL is 0.005 mg/L). In 2001, five water samples were taken and analyzed for lead and copper. The lead concentration was undetected (<0.004 mg/L), and below MCLs in all samples (DHSS 2001).

### 4.2.7 Alaska Department of Health and Social Services

DHSS completed a public health evaluation of exposure to heavy metals for local residents and employees at Red Dog Mine. The evaluation included a review of blood tests for Red Dog employees that were taken between January 1992 and 2001 and analyzed for heavy metals, especially lead. Red Dog employees included recent hires and contractors from Kivalina and Noorvik. The report also reviewed results of previous monitoring events with samples taken of soil, sediment, fish, caribou, and salmonberries, as well as drinking water from the Kivalina village (DHSS 2001).

Overall, the study found that there is very little threat to human health posed by drinking water, soil, sediment, fish, caribou, and salmonberries. Despite elevated lead and zinc concentrations along the mine, port and DMTS road, the low bioavailability of the ore limited the health threat. The report concluded that local residents of Kivalina, Noatak, and Port Hope can continue to safely eat traditional subsistence foods and drink the water (in Kivalina) (DHSS 2001).

People that were recently hired by Cominco (15 from Noorvik [located approximately 90 miles southeast of Red Dog Mine; see Figure 4-1] and 20 from Kivalina) had mean blood lead concentrations of 4.7 µg/dL. Recent hires from Noorvik and Kivalina had geometric means of 3.4 and 3.7 µg/dL, respectively.

The 10,685 blood tests from 1,805 Teck Cominco employees and contract workers had lead geometric mean levels of 9.02 µg/dL and ranged from 1 to 74 µg/dL. Only 1 percent of the employees had lead levels greater than 40 $\mu$g/dL. The researchers concluded that lead can be adsorbed into the blood of workers that are exposed to lead concentrates, while workers that do not experience excessive exposure to lead have blood lead levels comparable to the general population. In general, most employees at Red Dog had lead levels below the 25 $\mu$g/dL level of concern for adults.

DHSS (2001) assumed that the average char ingestion rate is 252 g/day for a 70-kg adult, and 136 for a 15-kg child. The average adult intake rate for unwashed salmonberries was estimated to be 17.5 g/day, and the same intake rate for children was 17 g/day. By using the mean lead concentration 0.027 $\mu$g/g wet weight and performing a risk calculation, the DHSS concluded that it would still be safe to consume a large amount of berries without any adverse effects to human health (DHSS 2001). For caribou, adults are assumed to ingest 177 g/day, and children 73 g/day. The report concluded that eating fish from the rivers in the mine area, caribou near the mine and DMTS road, and unwashed salmonberries from the study sites did not pose a threat to the health of the local people (DHSS 2001).

# 5 Nature and Extent of Fugitive Dust

The nature and extent of fugitive dust is discussed in the following sections by areas, including the port, DMTS road, mine, and offsite areas, and by types of media sampled, including soil, water, sediment, air, and biological (aquatic and terrestrial species). The nature and extent discussions are limited to general conclusions and summaries of findings by media within each area. Specific information on sampling and monitoring programs, and analytical results, are presented in Section 4. A tabular summary of sampling efforts is presented by media and by study in Table 4-1.

## 5.1 Port Site

The following sections provide a discussion of the nature and extent of metals resulting from fugitive dust in the vicinity of the port site, organized by the types of media sampled.

### 5.1.1 Soil

Metals concentrations in soil at the port site are elevated in several areas near operational parts of the facility, and concentrations decline rapidly with distance away from the operational features.

At the time of the 1996 PSMP, soil sampling results indicated that the areas that were most affected by lead and zinc were the conveyor area, the dock area (near the surge bin), the ends of the CSB (at the time there was just one CSB), the unloading area, and the loop road where trucks pulled in to the CSB. In samples collected between 1990 and 1996, the maximum soil concentrations of lead and zinc were generally elevated by 2−5 times above 1990 levels (RWJ 1997). Section 4.2.1.1 of this report discusses soil concentrations in detail. For the most part, the higher concentrations result from concentrates on the ground surface. The highest concentrations were observed in samples located close to operational features around the port site, and concentrations rapidly declined with distance.

Recent surface and core sampling of the road identified elevated concentrations on the road surface near the exit from the truck unloading building, and near the surge bin in the dock area (Exponent 2002). This pattern is illustrated in Figure 5-1.

### 5.1.2 Water

Surface water sampling was conducted at the port site as part of the PSMP between 1990 and 1996. Samples were collected from lagoons and from the nearshore marine environment, as well as opportunistically from surface water in tundra areas of the site. Surface water concentrations were fairly consistent from year to year, especially toward the latter part of the PSMP. In 1996, none of the lagoon water samples had elevated lead or zinc concentrations relative to the 1990 baseline measurements. In earlier years, elevated concentrations of lead and zinc had been observed in the lagoon just north of the dock (Port Lagoon North; see Figure 4-2) (RWJ 1997).

As an example of potential impacts of the port site on nearby water supplies, DHSS compared lead and zinc concentrations for the 22 lagoon water samples collected in 1996 against MCLs and risk-based screening criteria, and all were lower than these levels (DHSS 2001).

### 5.1.3 Sediment

As part of the PSMP, sediment sampling was conducted between 1990 and 1996 in four lagoons at the port site, and in nearshore marine sediment. Of the four lagoons (see Figure 4-2), sediment concentrations of lead and zinc were consistently highest in the lagoon immediately north of the dock area (Port Lagoon North), and increased over time relative to the baseline 1990 results. Most of the increase occurred in the first few years of the PSMP, and then leveled off. The "North Lagoon" had slightly elevated lead and zinc concentrations in 1996, relative to the 1990 baseline. The Port Lagoon South and the Control Lagoon had concentrations of lead and zinc in 1996 that were comparable to 1990 baseline values (RWJ 1997).

Nearshore marine sediments were generally similar to background concentrations measured in 1990, with the exception of one location between the second and third cells beneath the shiploader, which had consistently elevated lead and zinc concentrations (RWJ 1997). More recently, marine sediments were sampled by RWJ as part of the port expansion feasibility study conducted by AIDEA (Cominco, RWJ, and PN&D 1999). This study found lead and zinc concentration ranges were within the ranges measured during the PSMP (RWJ 1997).

### 5.1.4 Air

Patterns observed based on dustfall collector sampling, snow sampling, and high-volume air sampling indicated that the primary sources of fugitive dust were at the ends of the CSBs, the roadway where trucks exit from the truck unloading building, and the surge bin (at the dock area) that evens out concentrate flow on the conveyors at the dock area. Data were inconclusive as to trends or changes in fugitive dust emissions over time. The monitoring program has been revised, and additional data are being collected to facilitate evaluation of operational improvements designed to reduce fugitive dust emissions (see discussion in Section 4.2.1.3).

### 5.1.5 Biological—Aquatic

No chemistry data were found for metals in aquatic species at the port site.

### 5.1.6 Biological—Terrestrial

Twelve moss samples and three lichen, willow, and salmonberry samples were collected at the port site and analyzed for metals content as part of the fugitive dust study (Exponent 2002). Figures 5-2 through 5-4 show the sampling locations and the sample metals concentrations for these four species. Lichen, willow, and salmonberry were sampled primarily to provide data for an ecological risk assessment, whereas moss was sampled with greater frequency than the other species in order to characterize metals deposition patterns across the port site. Therefore, moss is the most appropriate biological indicator of the distribution of metals at the port.

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 (Figures 5-2 through 5-4). Concentrations decreased away from operational features but remained elevated above levels observed offsite along DMTS road transects (see Section 5.2.6). Aside from "hot spots" near operational features, lead and zinc concentrations were fairly uniform across the port site (Figures 5-2 and 5-3); cadmium concentrations were more variable (Figure 5-4).

As part of the Wild Foods Investigation, DEC collected salmonberry samples at the port facility. Unwashed salmonberry samples collected by both Teck Cominco and DEC at the port (including berries collected along DMTS road transect HR-01) had elevated mean lead, zinc, and cadmium concentrations relative to unwashed salmonberry samples collected in offsite areas. Offsite areas sampled included locations 2.6 miles north and 1.6 miles south of the port, and near the communities of Noatak and Point Hope (Figures 4-3 and 4-4).

## 5.2 DMTS Road

The following sections provide a discussion of the nature and extent of metals resulting from fugitive dust in the vicinity of the DMTS road, organized by the types of media sampled.

### 5.2.1 Soil

Soil samples collected from transects along the DMTS road in 1991 and 1992 show a decreasing concentration of metals with distance away from the DMTS road, typically dropping off significantly within 50 ft of the road, and leveling out between 50 and 500 ft from the road. Concentrations were consistently higher on the north side of the road (ENSR 1993).

Soil sampling conducted in 2001 along the DMTS road included surface soil, core, and shoulder samples. The results of this program indicated that the source of the metals is not the soils making up the road base, but that elevated metals concentrations primarily occur on the road surface and shoulder (Figure 5-5). Soil sample results from material source areas confirmed that the road surface construction and repair materials had low levels of metals relative to concentrations in samples from the road surface. Road surface sample results indicated that tracking of metals (via haul trucks) from the port site and the mine site was most likely the primary source of metals to the DMTS road (Figure 5-1). A secondary source was the former side-dump concentrate haulage trailers (sources and transport mechanisms are discussed further in Section 6.1). Road surface data showed elevated concentrations of metals at either end of the DMTS road, with the highest metals concentrations observed in road surface samples where trucks exit from the truck unloading building (Sample RS-04, Figure 5-1) (Exponent 2002). Metals concentrations in road shoulder samples were generally higher than concentrations in road surface samples (see Figure 5-5).

Soil samples collected by NPS (Ford and Hasselbach 2001) were from deeper soils (35–45 cm below the surface), collected to represent substrate unaffected by surface deposition of metals. Because of their depth, these samples are not particularly relevant for evaluating the extent of fugitive dust deposition. Any metals moving down from the surface are likely to become bound up in the layer of decayed organic matter above the soil horizon.

### 5.2.2 Water

Surface water samples collected from five creeks at locations along the DMTS road had no exceedances of hardness-dependent water quality criteria in 4 months of data collection (July, August, September, and October 2001). Samples collected at each crossing included upstream samples, samples immediately downstream of the road, and samples further downstream where that stream joins another creek. Surface water data show little if any impact from the DMTS road. Most of the results (82, 84, and 97 percent of the results for lead, zinc, and cadmium, respectively, of the 89 water samples) were undetected. The observed detections were quite low in concentration, as illustrated by the ratio of the measured concentration to the hardness-specific water quality criteria, plotted for lead, zinc, and cadmium (Figures 5-6 through 5-8).

### 5.2.3 Sediment

No sediment data were found for the DMTS road area.

### 5.2.4 Air

Dustfall samplers were installed on both sides of the road at 7 stations in late August 2001. The first monthly set of dustfall results (September 2001) indicated that the total dustfall rate was greatest near the port site and relatively consistent along the rest of the road (Figure 5-9). The metals (lead, zinc, cadmium) dustfall deposition rate was also highest in the vicinity of the port site. For the rest of the stations away from the port site, the metals dustfall rate was much lower. The dustfall measurements from the north side of the DMTS road were generally higher than those on the south side, evidently because the wind direction was from the southeast during September. This is consistent with the available data about prevailing wind direction.

### 5.2.5 Biological—Aquatic

ADFG sampled juvenile Dolly Varden tissues from two streams in the vicinity of the DMTS road between 1998 and 2000, Aufeis Creek, and Omikviorok River. Juvenile Dolly Varden was chosen because it is a species and age class that can rapidly reflect the environmental metals concentrations in its tissues, and therefore is a good indicator of metals contamination. The results from Aufeis Creek and Omikviorok River indicate that fugitive dust and/or runoff from the DMTS road did not have an effect on the metals concentrations in juvenile Dolly Varden samples (Morris and Ott 2001).

### 5.2.6 Biological—Terrestrial

As a component of its fugitive dust study (Exponent 2002), Teck Cominco sampled moss, lichen, willow, and salmonberry from transects positioned along the DMTS road from the port facility to the mine. Transect locations and moss sample metals results are shown in Figures 5-10 through 5-12, together with the six NPS transects from 2000 (data from the 2001 NPS moss sampling are not yet available). As at the port facility, moss was sampled more frequently than the other species, and therefore moss data provide the most complete picture of the extent of metals deposition. Transects HR-01 and HR-02 fell within the ambient air boundary of the port facility. Along other transects, sampling points 3 m from the road fell within the DMTS road right-of-way, which includes areas within 300 ft (91 m) on either side of the road centerline. Teck Cominco also collected moss samples from former DMTS road spill sites within the road right-of-way (Figure 5-12). Lead, zinc, and cadmium concentrations were highest in moss samples collected 3 m from the road and decreased with distance from the road, with the exception of transect HR-06, where metals concentrations increased with distance to 1,000 m but then dropped off substantially at 2,000 m (Figures 5-10 through 5-12). Metals concentrations in moss collected at spill sites were similar to levels observed in other moss samples collected near the DMTS road (Figure 5-13). Tracking trucks (and to a lesser degree, escapement from the old trucks) traveling from the mine and port facilities, and windblown dust from truck and road surfaces, were the likely sources of elevated lead, zinc, and cadmium in moss sampled near the DMTS road.

Among transects, metals concentrations were higher along transects HR-01 and HR-02, near the port facility, and transects HR-06 and HR-07, near the mine, than along transects located in the central portion of the DMTS road (Figures 5-10 through 5-12). This trend suggests that transects near the port and mine received metals contributions from windblown dust tracked from the facilities by vehicles. Data from NPS transects inside the national monument and from Teck Cominco transects HR-03, HR-04, and HR-05 were comparable, indicating that the dustfall pattern was similar along the central portion of the DMTS road. The data also suggest that metals concentrations in moss were leveling out around 1,000 m from the road (Figures 5-10 through 5-12). NPS observed a trend towards higher metals concentrations in moss collected downwind (north) of the DMTS road than in moss collected upwind (south) of the road (Ford and Hasselbach 2001). Teck Cominco only sampled one upwind and two downwind transects in the central portion of the DMTS road, away from the influence of the mine and port, and thus comparisons between upwind and downwind metals concentrations in moss sampled by Teck Cominco were inconclusive.

## 5.3 Mine

The following sections provide a discussion of the nature and extent of fugitive dust in the vicinity of the mine, organized by the types of media sampled.

### 5.3.1 Soil

Soil sampling conducted in 1992, 1993, and 1997 within a 2-mile (3,200 m) radius around the mine (centered around the PAC) found the highest lead and zinc concentrations in areas sampled to the west of the mine, but these were not greatly different from reference area samples collected 3.6 miles to the southeast of the PAC. Median lead concentrations in the east, west, north, and south sampling areas in 1997 ranged from 21 to 47.5 mg/kg as compared with the reference area concentration of 17.5 mg/kg. Median zinc concentrations in for these areas in 1997 ranged from 75 to 195 mg/kg as compared with the reference area concentration of 160 mg/kg (RWJ 1997).

### 5.3.2 Water

Teck Cominco routinely collects thousands of water samples as part of their NPDES permit requirement. Water samples were collected from tributaries upstream and downstream of the mine in 2000 at locations where fish tissue samples were collected by ADFG. Results from sampling in 2000 were compared to sample results from 1996. Median concentrations of cadmium, lead, and zinc were lowest in North Fork Red Dog Creek and were highest in Middle Fork Red Dog Creek. Metals concentrations in Dudd Creek were relatively unchanged compared with 1996 results. Median cadmium concentrations were generally low in Ikalukrok Creek. Zinc concentrations in Mainstem Red Dog Creek increased in 2000 compared with 1996 results (Weber-Scannell and Ott 2001). Lead concentrations ranged from 0.05 $\mu$g/L at Ikalukrok Creek upstream of Red Dog Creek to 207 $\mu$g/L at North Fork Red Dog Creek. Zinc concentrations ranged from 14 $\mu$g/L at Ikalukrok Creek upstream of Red Dog Creek to 2,510 $\mu$g/L in Middle Fork Red Dog Creek. Cadmium concentrations ranged from 0.20 $\mu$g/L in North Fork Red Dog Creek to 15.9 $\mu$g/L in Middle Fork Red Dog Creek (Weber-Scannell and Ott 2001).

### 5.3.3 Sediment

No sediment sampling results were found for the mine area.

### 5.3.4 Air

The principal sources of particulate matter at the mine are activities related to mining (blasting, road traffic, and material handling) and particulate matter emissions from fuel combustion related exhausts. Permit-required dispersion modeling demonstrates compliance at the ambient air boundary as required by the air permit. Permit-required monitoring of particulate generating sources, including EPA Method 9 and Method 22 evaluations, and stack testing, indicate that permit and regulatory requirements are being met. Additionally, ambient air monitoring for TSP and $PM_{10}$ has shown that NAAQS are being met.

### 5.3.5 Biological—Aquatic

ADFG has collected fish samples in tributaries upstream and downstream of the mine from 1991 through 2001 as part of the NPDES permit for biomonitoring, and has conducted supplemental fish sampling in 1999–2001. Dolly Varden tissues sampled in the Red Dog Mine area had consistent metal concentrations throughout those years, compared to baseline concentrations in 1978 and 1983. Juvenile Dolly Varden samples had increased maximum concentrations of cadmium and lead from Mainstem Red Dog Creek downstream of the mine in 2000, compared to samples taken in 1999. However, the median metals concentrations did not change. The population of juvenile Dolly Varden decreased in streams both downstream and upstream of the mine, due to mortalities caused by early freezing (Weber-Scannell and Ott 2001). However, a large population of young-of-the-year graylings indicated that Arctic grayling spawning has been more successful in recent years than the early 1990s, when the sampling program began (Weber-Scannell and Ott 2001).

Median lead concentrations in 1998 were consistent with concentrations in 1990 (below 0.1 mg/kg). In the spring of 1999, median lead concentrations rose in liver, muscle, and kidney tissue samples (maximum of 0.36 mg/kg in liver tissue), but declined in 2000 (maximum of 0.06 mg/kg in liver tissue). Zinc median concentrations were low (median of 78 mg/kg in liver tissue samples in Dolly Varden caught in 2000. The median cadmium concentrations in Dolly Varden kidney tissue samples were lower in samples taken after 1991 (when the median was 3.62 mg/kg) and have since fluctuated between 2.4 and 0.38 mg/kg. Since the fall of 1997, median cadmium concentrations in kidney samples have been below 2 mg/kg. There was no increase in cadmium concentration in other tissue samples.

### 5.3.6 Biological—Terrestrial

Metal concentrations in moss collected by Teck Cominco along DMTS road transects HR-06 and HR-07, near the mine, were higher than concentrations measured in moss collected by Teck Cominco and NPS along transects located on the central portion of the DMTS road, away from the influence of mine activities (Figures 5-10 through 5-12). Further discussion of the terrestrial vegetation results from the Teck Cominco fugitive dust study (Exponent 2002) and NPS study (Ford and Hasselbach 2001) can be found in Section 5.2.6.

## 5.4 Offsite Areas

Offsite areas are defined as areas outside the ambient air boundaries for the port site (see Figure 1-6), and outside the DMTS road right-of-way. Between the port and Cape Krusenstern National Monument, the road falls within the port site ambient air boundary. Between the port and the mine, the ambient air boundary is 600 ft in width, with 300 ft on either side of the as-built centerline.

The following sections provide a discussion of the nature and extent of metals resulting from fugitive dust in offsite areas, organized by the types of media sampled.

### 5.4.1 Soil

Most of the soil samples collected were from onsite areas of the port, DMTS road, and mine. The transect sampling conducted along the DMTS road in 1991 and 1992 (ENSR 1993) showed some limited offsite impacts (see Section 5.2.1). NPS also collected soil samples on transects along the DMTS road (Ford and Hasselbach 2001). These samples were from deeper soils

(35–45 cm below the surface), and were intended to represent substrate unaffected by surface deposition of metals. Because of their depth, these samples are not particularly relevant for evaluating the extent of fugitive dust deposition. Any metals moving down from the surface are likely to become bound up in the layer of decayed organic matter above the soil horizon.

### 5.4.2 Water

Many of the surface water sampling stations related to the DMTS road and the mine are located in offsite areas. There do not appear to be any significant impacts to offsite water quality along the length of the DMTS road (see Section 5.2.2). Water sampling in the area of the mine, including stations that are offsite, is discussed in Section 5.3.2.

Water quality in the Wulik River, where Kivalina village gets its water supply, is monitored regularly. Most sample concentrations have been below state and federal drinking water standards over the years, with the exception of a few slight exceedances (one sample for lead, and one for cadmium; see Section 4.2.1.5). There is a possibility that the occurrences of elevated metals concentrations are related to naturally occurring mineralization in Ikalukrok Creek.

### 5.4.3 Sediment

Most of the marine sediment sampling is offsite, outside the ambient air boundary for the port site. Monitoring between 1990 and 1998 indicates that there has been little impact on the nearshore marine sediments, except at one station located between the second and third cells beneath the shiploader, which had consistently elevated lead and zinc concentrations (RWJ 1997; Cominco, RWJ, and PN&D 1999). See Section 5.1.3 for further discussion.

### 5.4.4 Air

No previous air monitoring has been conducted in the offsite areas surrounding the Red Dog Mine. As discussed in Section 3.3.1, a 1-year air sampling project is planned for Kivalina and Noatak starting in the summer of 2002. Locally initiated and managed air monitoring is planned to start in several communities in the region this summer. This monitoring is part of a monitoring strategies partnership between the regional health organization, Maniilaq Association, and DEC.

### 5.4.5 Biological—Aquatic

Fish tissues were analyzed for metal concentrations in several offsite areas in baseline studies. Several of the fish samples collected by ADFG were located in offsite areas and are described in Sections 5.2.5 and 5.3.5. Metals analyses of fish tissue samples upstream and downstream of the mine and DMTS road indicate that there has been little impact by fugitive dust to the fish population (Weber-Scannell and Ott 2001). For further discussion of invertebrates and periphyton, see Section 5.3.5.

### 5.4.6 Biological—Terrestrial

The Teck Cominco fugitive dust study and NPS study both measured lead, zinc, and cadmium levels in moss samples collected outside of the right-of-way along the DMTS road (Exponent 2002; Ford and Hasselbach 2001). Metals concentrations in moss samples decreased with distance from sources at the mine, along the DMTS road, and at the port facility, and tended to level off around 1,000 m from the road along transects located on the central portion of the DMTS road (Figures 5-10 through 5-12). A more detailed discussion of these studies is presented in Section 5.2.6.

In addition to salmonberry samples collected at the port facility, DEC sampled salmonberries at offsite locations, including sites 2.6 miles north and 1.6 miles south of the port, and sites near the communities of Noatak and Point Hope. DEC also collected blackberry and sourdock samples at locations about 2 to 6 miles north of the port and at the Noatak site (Figure 4-3). Mean lead concentrations in unwashed salmonberry, blackberry, and sourdock samples collected north and south of the port were elevated above levels measured in samples from Noatak and Point Hope (Figure 4-4). However, mean zinc and cadmium concentrations in unwashed salmonberry, blackberry, and sourdock samples were generally comparable among offsite sampling locations (Figure 4-4). Noatak blackberry and sourdock samples had a higher mean zinc and cadmium concentration, respectively, than those samples collected north of the port (Figure 4-4) (DEC 2002).

In 1996, ADFG collected 15 caribou in the vicinity of the DMTS road, in response to a large die-off of caribou in the Cape Thompson area. These animal samples were analyzed for metals and radionuclides. Cadmium and lead levels in caribou muscle samples were amongst the lowest, in comparison to caribou muscle samples collected from Anaktuvuk Pass, Barrow, Cape Thompson, Point Hope, and Teshekpuk Lake. Zinc concentrations in caribou muscle samples were within the range of concentrations found at the comparison sites. ADFG concluded that the mortality was due to starvation. DHSS estimated, with human health risk-based calculations, that cadmium and zinc concentrations in caribou muscle, liver, and kidney tissue samples were not hazardous, and that local residents should continue to utilize caribou as a food source (DHSS 2001).

## 5.5 Relationship of Road Transect Data for Road Surface, Road Shoulder Dust, Dustfall Collectors, and Moss Samples

A comparison of road surface, road shoulder, dustfall deposition, and moss transect concentrations for lead, zinc, cadmium, and calcium (Figure 5-14) illustrates a fairly good correlation at each road station and corresponding vegetation transect. These sample results portray a consistent pattern of elevated concentrations near each end of the DMTS road, and lower concentrations through the middle section of the road (Exponent 2002).

# 6 Preliminary Conceptual Site Model

The preliminary CSM is a planning tool for identifying chemical sources, complete exposure pathways, and potential receptors on which to focus any further human health or ecological risk assessment. The CSM describes the network of relationships between chemicals released from a site and the human or ecological receptors that may be exposed to the chemicals through pathways such as ingestion of food or water. The model identifies potential sources, transport mechanisms, exposure media, exposure routes, and human and ecological receptors. The CSM examines the range of potential exposure pathways and identifies those that are present and may be important for human receptors or for vegetation or wildlife, and eliminates those pathways that are incomplete and therefore cannot pose significant risk. This preliminary CSM was developed based on site history, site conditions, and the results of available site sample analyses.

The CSM for the Red Dog operation describes possible transport mechanisms of metals from sources at the mine, along the DMTS road, and at the DMTS port facility into surrounding terrestrial and aquatic ecosystems, and the pathways by which human (Figure 6-1) or ecological receptors (Figure 6-2) may be exposed to these metals.

## 6.1 Sources and Transport Mechanisms

Sources of metals associated with the Red Dog operation include the mine, the DMTS road (including trucks carrying concentrate along the road), and the DMTS port facility. The primary mechanisms by which metals escape from these sources are through fugitive dust and concentrate spillage. In addition, runoff from precipitation and snowmelt could also transport metals from the DMTS road, mine, and port operations into surrounding ecosystems. Once released to the environment, some of the metals may become dissolved or suspended in surface water, adsorbed to sediments, incorporated into soil, and potentially enter the food web through uptake into plants, animals, and humans. The following sections provide a more detailed review of the sources of fugitive dust and the mechanisms by which it is transported into the environment.

### 6.1.1 Mine

Sources of metals from the mine include air transport of dust and surface water runoff. These sources are strictly managed through permitting processes managed by DEC. Air emissions from the mine have been modeled as part of the air permitting process. Air modeling demonstrates that the air permit requirements are met at the ambient air boundary (DEC 1999, 2001). The ambient air boundary is illustrated in Figure 1-6.

All surface water from the mine area is collected behind the tailings dam and is treated prior to release to Red Dog Creek. Metals concentrations in the surface water discharge from the tailings dam are subject to limits defined in the NPDES permit AK-003865-2.

## 6.1.2 DMTS Road

The following sections describe sources and mechanisms of fugitive dust transport along the DMTS road. Note that these sources and transport mechanisms also apply to road areas within the port site.

### 6.1.2.1 Road Construction and Maintenance Materials

Road construction and maintenance materials include the materials originally used to construct the road, gravel used for ongoing road repair, and surface water applied regularly to help keep down dust on the road. Core samples collected in 2001, to a 12-in. depth in the roadway, show that the elevated metals occurrence is a surface phenomenon, and is not likely associated with the materials originally used to construct the road or regularly added to the crushed base during maintenance. The sources of the gravel and road water were also sampled in 2001, and were shown to be insignificant sources of metals to the DMTS road (Exponent 2002).

### 6.1.2.2 Tracking from Mine and Port

The term “tracking” as used here refers to the transport of metals-containing concentrates on the haul trucks and subsequent deposition onto the road. Tracking refers to the transport of the concentrates on all surfaces of the trucks, not just the tires. Road surface sample data showed that tracking from the mine and from the port is the primary mechanism by which metals are transported onto the surface of the DMTS road (Exponent 2002).

### 6.1.2.3 Concentrate Spillage and Escapement from Trucks

Metals can also be released to the road and into the nearby environment by spillage of concentrates from the haul trucks. This can occur by accidents where a trailer is overturned and the concentrates spill onto or adjacent to the road, or by concentrate leakage from the trailers. However, the new trailers put into operation in the fall of 2001 have hydraulically operated steel covers that are not subject to leakage under normal driving conditions. In addition, the new truck trailers are more stable and less likely to overturn. Concentrate spills are reported to DEC, and are cleaned up immediately, followed by sampling to confirm removal to concentrations below the state’s “Arctic Zone” cleanup standards for lead, zinc, and cadmium (1,000, 41,000, and 140 mg/kg, respectively) (18 Alaska Administrative Code [AAC] 75:340). Teck Cominco uses 500 mg/kg for lead and 1,000 mg/kg for zinc as its internal goals for clean up of spillage of concentrates from haul trucks. Concentrate spillage appears to be a minor source of concentrates in comparison to tracking (described above). Concentrations measured in road surface samples showed no obvious correlation with spill locations (Exponent 2002).

Historically, the older haul truck trailers had additional sources of concentrate loss and escapement. The old trailers had side dump doors, whereas the new truck trailers do not. Additionally, the tarps that covered the old truck trailers allowed some windblown escapement of concentrate while the trucks were in transit. When these older trucks arrived at the port site, the tarps were rolled back to uncover the trailers prior to entering the truck unloading building. This process provided another possible mechanism for fugitive dust escapement.

#### 6.1.2.4 Windblown Dust from Road Surface

One mechanism by which metals are transported into the environment is in dust that is blown by wind from the surface of the road. This transport mechanism appears to be one of the more important means by which metals are deposited onto the tundra adjacent to the road. Factors affecting this transport mechanism include road maintenance and watering frequencies, and the application of calcium chloride to the road surface, which helps make a harder surface and helps retain moisture so that the surface does not dry out as easily.

#### 6.1.2.5 Windblown Dust from Truck Surfaces

Some metals-containing dust is carried on the surfaces of the trucks traveling up and down the road. Dust on truck surfaces may either originate from the concentrate loading or unloading processes at the mine and port, or from mud or dust from the road surface getting picked up as the truck travels along the road. As the trucks travel the road, wind may blow dust from the truck surfaces and carry it onto the road or into the surrounding environment. This, along with windblown dust from the road surface (described above), are likely the primary mechanisms for fugitive dust transport onto the adjacent tundra.

#### 6.1.2.6 Surface Water Runoff from the Road Surface

Surface water runoff from the road can carry metals-containing dust from the surface of the road to the tundra just off the road shoulder. This transport mechanism may be important in the immediate shoulder area of the road, but is not likely to carry dust very far, as compared to airborne transport of dust. However, surface water runoff is also a potential mechanism for transport of dust into streams at road crossings.

### 6.1.3 Port

This section describes fugitive dust sources and transport mechanisms that occur at the port site. Note that in addition to the sources and transport mechanisms described below, those described above for the DMTS road also apply to road areas within the port site. See Figure 2-1 for an illustration of port site storage and conveyance features.

#### 6.1.3.1 Windblown Dust from TUB and CSBs

Concentrate dusts can become airborne during the unloading process at the TUB, and during handling of the concentrates in the CSBs, where they are manually loaded onto conveyor belts using front-end loader buckets. When doors to these buildings are opened, wind can carry these dusts from the buildings and into the environment.

#### 6.1.3.2 Concentrate Spillage and Escapement from Conveyors and Surge Bin

Conveyors carry the concentrates nearly 1 mile from the CSBs to a surge bin, and from there to the dock, where the shiploader fills the barges. These conveyors are now fully enclosed, and do not provide an avenue for spillage of concentrate. Historically, before the system was fully enclosed, some spillage of concentrate from the conveyors occurred. This provided a source of concentrate that could be picked up by wind, water, or by vehicle tracking and then spread to other nearby areas. When the old conveyors were replaced with fully enclosed conveyors, the soil containing concentrate beneath the old conveyors was removed and reprocessed at the mine. There may be additional areas that remain with elevated soil metals concentrations. Further characterization is planned to identify areas of elevated metals concentrations in soil at the port site, particularly soils beneath the conveyors. The surge bin has historically been a source of fugitive emissions, and is in the process of being upgraded. Additional characterization work is planned for the summer of 2002.

#### 6.1.3.3 Residual Concentrate from Older Conveyor System

When the conveyor systems were upgraded, the older systems were temporarily stored at several locations within the port site prior to final shipment to the mine for storage. These units were thoroughly washed before storage. It is possible that this equipment may have retained some residual concentrates on it.

#### 6.1.3.4 Spillage and Windblown Dust during Barge Loading

Barges are loaded from the shiploader conveyor using a snout-like canvas tube that lowers into the barge, and is slowly raised as the barge is filled, to minimize the free-fall distance of the concentrate. Two front-end loaders work to move the concentrate to the corners of the barge as it is loading. The barge is covered during the entire process by fixed tarps, except for a lengthwise slot, through which the snout is lowered. There is some potential for concentrate dust emerging from the covered barge to be carried into the surrounding environment by the wind. In addition, there is a potential for fugitive dust release from the transfer point between the P10 and P11 conveyors.

Between barge loading events, the shiploader snout is retracted, and the apparatus is placed into a “shiploader neutral position” above the third caisson (“Cell 3”). There may be residual concentrate in the snout of the shiploader after loading is complete, despite efforts to clear it. There is potential for concentrate dust to be left on the third caisson, which may be carried into the surrounding environment by the wind.

#### 6.1.3.5 Spillage or Windblown Dust from Barges during Transport

During transport between the shiploader and the deepwater ship, the barges remain covered by the fixed tarps. During this time, the concentrate is not being disturbed, and there is a low potential for spillage or generation of windblown dust.

#### 6.1.3.6 Spillage or Windblown Dust during Transfer from Barge to Deepwater Ship

The barges have a built-in conveyor that is used to transfer the concentrates from the barges to the deepwater ships. Two front-end loaders that reside on each barge are used to feed the built-in conveyor. The loading activity occurs within the covered barge; however, there is some potential for concentrate dust to emerge from the slot in the fixed tarp cover and to be carried into the surrounding environment by the wind. Similarly, there is a potential for some dust to emerge from the hold of the deepwater ship during loading and be carried away by the wind.

#### 6.1.3.7 Spillage or Windblown Dust from Deepwater Ship

Once the concentrate is within the hold of the deepwater ship, the hatches are sealed shut, and the potential is low for spillage or generation of windblown fugitive dust.

### 6.1.4 Animal Tracking

Various animals move in and around or pass through the vicinity of Red Dog Mine and the DMTS road and port site. While these animals may track a small amount of dust in their movement from one place to another, this is an insignificant transport mechanism relative to airborne transport of fugitive dust. For a discussion of direct contact and ingestion of metals by animals from media such as plants, soil, or water, refer to the Ecological Conceptual Site Model in Section 6.3 below.

## 6.2 Human Health

The following sections provide a description of the CSM for human health, including potential receptors and exposure pathways.

### 6.2.1 Potential Human Receptors

The potential for people to be exposed to metals related to the DMTS road and the port area is limited, due to the remote nature of the affected area. Worker exposure is controlled through a closely monitored industrial hygiene program and will not be considered further in this report. Section 1.7 provides a detailed description of site use and identifies several populations other than workers who could potentially be exposed to metals related to the DMTS road or the port site. The subsistence group that fishes, hunts, and gathers plants and berries can also be exposed through consumption of food items. Although there is some regional recreational use, any exposure for recreational visitors would be much more limited than that related to subsistence hunting and gathering in the area. The closest villages to the mine are Kivalina and Noatak and thus, residents of these villages are hypothetical receptors (both directly and through the subsistence pathway). Given the distance between the villages and the DMTS road or port site, however, migration to media within the villages (e.g., soils, indoor dust, or drinking water) is not expected. As described in Section 3.3.1, one year of air sampling is planned for the Kivalina and Noatak villages. If air concentrations at Kivalina or Noatak are found to be elevated, additional consideration of exposure within the villages may be warranted. Additional water sampling is also planned for the Kivalina drinking water supply (see Section 3.3.1).

## 6.2.2 Potential Human Exposure Pathways

An exposure pathway is the course a contaminant takes from a source to an exposed receptor. Exposure pathways consist of the following four elements: 1) a source; 2) a mechanism of release, retention, or transport of a contaminant to a given medium (e.g., air, water, soil); 3) a point of human contact with the medium (i.e., exposure point); and 4) a route of exposure at the point of contact (e.g., incidental ingestion, dermal contact). If any of these elements are missing, the pathway is considered incomplete (i.e., it does not present a means of exposure). Only those exposure pathways judged to be potentially complete are of concern for human exposure and are quantified in a human health risk assessment. Figure 6-1 summarizes the exposure pathways identified at the site.

Potential exposure pathways can be categorized under three environments: marine, terrestrial, and freshwater. In each of these environments, there may be some potential for exposure to metals through consumption of food (e.g., plants, fish, and/or other animals) and incidental ingestion or dermal contact with soil/sediment. In addition, in the freshwater environment people may be exposed to metals through ingestion or dermal contact with affected water. These exposure pathways are described in more detail below, along with a discussion of the relative importance of each pathway.

### 6.2.2.1 Subsistence Use in the Marine Environment

Metals could be transported to the marine environment through surface water runoff, fugitive dust deposition, or spillage in the barge transfer operation, and could subsequently be taken up by marine animals that are consumed by people. Containment of surface water runoff at the port site limits the potential for migration.

### 6.2.2.2 Subsistence Use in the Terrestrial Environment

Local residents could be exposed to metals taken up by plants or animals downwind of the DMTS road or port site through consumption of subsistence harvest foods. Metals from the DMTS road or port facility that have been transported onto plants or tundra soils could be consumed by animals (e.g., ptarmigan and caribou) that are in turn consumed by people. People could also consume plants and berries that have taken up metals from the soil or onto which dust has been deposited. People could also be exposed to metals through incidental ingestion and dermal contact with soil. Inhalation of airborne particulates from soil is another potential exposure pathway, although it is likely to be limited relative to other pathways.

Preliminary risk calculations conducted by DHSS, based on the first set of DEC salmonberry metals data, did not suggest elevated risks associated with consumption of berries (DHSS 2001). From this initial evaluation of salmonberries collected north and south of the port site, DHSS concluded that salmonberry metals concentrations “are consistent with typical background levels and do not pose a public health concern” (DHSS 2001). Further berry sampling conducted by DEC and Exponent suggested elevated concentrations of some metals at the port site relative to reference conditions. Fish, birds, and mammals consumed by subsistence populations (e.g., Arctic char, ptarmigan, and caribou) may be sampled (fish and caribou have been sampled previously) to determine whether metals concentrations are elevated.

#### 6.2.2.3 Subsistence and Residential Use in the Freshwater Environment

Although current data indicate minimal effects, surface water quality could potentially be impacted by metals from the DMTS road, port, or the mine. If surface water quality is affected, fish in the streams may accumulate metals, which could then be consumed by subsistence users. If freshwater sediments are affected by metals, exposure could theoretically occur through incidental ingestion or dermal contact with the sediments.

Surface water runoff from the mine is collected behind the tailings dam, treated, and discharged to Red Dog Creek (subject to discharge limits in the NPDES permit described previously), which ultimately flows into the Wulik River. The Wulik River is a source of drinking water for Kivalina residents. Sampling of Kivalina drinking water has been conducted on an ongoing basis and has not shown elevated metals concentrations. As described in Section 3.3.1, Teck Cominco will be funding additional study of Kivalina drinking water.

## 6.3 Ecological

The following sections provide a description of the CSM for ecological endpoints, including a discussion of potential exposure pathways and receptors.

### 6.3.1 Potential Ecological Exposure Pathways

Pathways by which ecological receptors may be exposed to metals associated with Red Dog mining activities exist for both aquatic and terrestrial communities in the vicinity of the mine, DMTS road, and port facility. Primary exposure pathways for aquatic receptors include the ingestion or uptake of surface water, consumption of plant material or prey, incidental ingestion of sediment during foraging, and direct contact with surface water (Figure 6-2). Some aquatic receptors may also be exposed through the uptake of metals from sediments. Primary exposure pathways for terrestrial receptors include the consumption of plant material or prey and the incidental ingestion of soil. For plants, the primary pathways are the uptake of metals incorporated into soil and the uptake of metals deposited onto plant surfaces in fugitive dust (Figure 6-2). For most receptors, direct contact with affected sediment or soil would be brief, and thus constitutes only a minor exposure pathway. Additionally, exposure to naturally occurring metals is likely throughout the area, both beyond and within the area of the Red Dog operation, through the pathways described above. Exposure to fugitive dust releases represents an incremental exposure above that due to naturally occurring metals.

### 6.3.2 Potential Ecological Receptors

Ecological receptors that may be exposed to metals from the Red Dog operation occur in aquatic systems such as creeks, tundra ponds, marshes, bogs and other wetlands, coastal lagoons, and the marine ecosystem. Receptors also occur in terrestrial systems such as shrub and tussock tundra and coastal sand dunes. The receptors comprise a wide range of life histories, from small herbivorous mammals that could complete their entire life cycles in small home ranges near the DMTS road, to migratory waterfowl that forage and breed on coastal lagoons during summer months and then migrate. Large-bodied herbivorous and carnivorous mammals that roam widely in search of food may be exposed in multiple areas near the mine, DMTS road, and port, but would also forage outside areas affected by metals from these operations. Forage areas both within and beyond the affected area include naturally occurring metals that contribute to exposure of various receptors.

Categories of ecological receptors that are potentially affected include aquatic and terrestrial plants, benthic macroinvertebrates, fish, birds, and mammals (Figure 6-2). Each category encompasses a range of functional groups, such as terrestrial plant-eaters (herbivores) or freshwater fish-eaters (piscivores), which differ by habitat utilization and preferred foods. The particular species composition of aquatic and terrestrial communities varies among habitats near the mine, DMTS road, and port, as previously reported in Section 1. Thus, some receptor categories are not represented in all communities near the Red Dog operation area.

Potential receptors to be used in risk assessment would be identified in consultation with local subsistence users. Receptors to be used in the assessment may include large-bodied herbivorous mammals such as caribou and musk oxen that forage on moss, lichen, and willow in the vicinity of the Red Dog operation, as well as terrestrial birds such as ptarmigan that feed on berries and willow catkins in the area. The risk evaluation would also likely examine potential trophic (food web) transfer of metals by modeling exposure for arctic fox, which feeds on small herbivorous mammals. The risk assessment work will be further defined in a risk assessment scoping meeting with DEC.

# Part C

# Regulatory Review and Data Gaps

# 1 Regulatory Framework

This section provides a preliminary identification of potentially applicable state and federal regulations regarding fugitive dust at the Red Dog Mine.

## 1.1 Hazardous Substances and Hazardous and Solid Waste

Hazardous substances and hazardous and solid waste are defined differently in state and federal laws and regulations; therefore, they are discussed separately below.

### 1.1.1 Federal

The Federal Resource Conservation and Recovery Act (RCRA) 42 U.S.C. § 6901 *et seq*. and its regulations apply to the management and disposal of hazardous and solid wastes. Generally, a solid waste is any "discarded material" that is not covered by an exemption or exclusion. A solid waste is a hazardous waste if it is not excluded from regulation as a hazardous waste under 40 CFR § 261.4(b) and it either exhibits hazardous characteristics (including toxicity) or is explicitly listed as "hazardous" in the regulations. Among the exclusions and exemptions is the Bevill Amendment ((42 U.S.C. § 6921(b)(3)(A)(ii) and 40 CFR § 261.3(a)(2)(i)), which creates an exemption such that "solid wastes from the extraction, beneficiation and processing of ores and minerals…[are not hazardous wastes]." This exemption has been narrowed since originally passed by Congress in 1980.

#### 1.1.1.1 Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (a.k.a. Superfund 42 U.S.C. § 9601 *et seq*.) is a regulatory program that applies, again with certain exclusions, to releases of "hazardous substances." CERCLA has many definitions as to what constitutes a hazardous substance, including "elements, compounds, mixtures, solutions, and substances which, when released into the environment may present substantial danger to the public health or welfare or the environment (42 U.S.C. 9602 (a))." Risk assessments will be used in determining whether CERCLA may be applicable. CERCLA also defines "hazardous substances" by reference to listings of materials under other statutes, including the list of hazardous air pollutants under Section 112 of the Clean Air Act, as amended. Lead and cadmium compounds are included in this list.

### 1.1.2 State Statutes and Regulations

Under AS 46.03.826(5), a hazardous substance is defined as:

> …(A) an element or compound which, when it enters into the atmosphere or in or upon the water or surface or subsurface land of the state, presents an imminent and substantial danger to the public health or welfare, including but not limited to

fish, animals, vegetation, or any part of the natural habitat in which they are found;

(B) oil; or

(C) a substance defined as a hazardous substance under 42 U.S.C. 9601(14);…

The Site Cleanup Rules in the Alaska Oil and Hazardous Substances Pollution Control Regulations list hazardous substances and cleanup levels. Otherwise, the Alaska Solid Waste Management Regulations are potentially applicable.

#### 1.1.2.1 Alaska Oil and Hazardous Substances Pollution Control Regulations (18 AAC 75)

These regulations set out requirements for the reporting and clean up of discharges of hazardous substances to land or waters of the State of Alaska. These regulations provide four methods of determining what the cleanup standards would be and therefore whether a cleanup is necessary for a specific site. The regulations also require that a contaminated site must be characterized and DEC approve the work plan for this work. Method One addresses petroleum-contaminated soil. Method Two addresses soil contaminated with substances other than petroleum hydrocarbons. In Method Two, cleanup levels are provided for the most common hazardous substances, including petroleum, solvents, and metals found at sites in Alaska where hazardous substance spills have occurred. The following table provides the soil cleanup levels for the chemicals of concern to the Red Dog Mine.

**Method Two soil cleanup levels for the chemicals of concern (mg/kg)**

| | Arctic Zone | | Under 40-in. Zone | |
|---|---|---|---|---|
| | Ingestion | Migration to Groundwater | Ingestion | Migration to Groundwater |
| Cadmium | 140 | N/A | 100 | 5 |
| Lead[a] | | N/A | | |
| Zinc | 41,000 | N/A | 30,000 | 9,100 |

[a] “Lead cleanup levels must be determined on a site-specific basis, based on land use; for residential land use, the soil cleanup level is 400 mg/kg, and for commercial or industrial land use, that level is 1,000 mg/kg… (18 AAC 75.341 Table B1. Method Two—Soil Cleanup Levels Table Note 11).”

One-tenth of the value provided for each chemical is the level used to screen data to account for issues of cumulative risk. The other two methods in 18 AAC 75 provide procedures to calculate site-specific cleanup levels based on standard equations provided in guidelines or by risk assessment. If concentrations exceed the cleanup levels, then action (e.g., cleanup and monitoring) may be warranted.

The applicable cleanup level determined must be protective of human health and the environment.

#### 1.1.2.2 Alaska Solid Waste Management Regulations

Alaska's Solid Waste Management Regulations (18 AAC 60) may apply to wastes that do not meet the federal definition of a hazardous waste under RCRA, but that contain contaminants that exceed cleanup levels.

## 1.2 Air

Air quality in Alaska is regulated under both state and federal regulations; however, air emissions permits are issued by the state.

### 1.2.1 Federal Regulations

Federal air regulations address both air quality and emissions standards. Potentially relevant regulations are discussed below.

#### 1.2.1.1 National Emission Standards for Hazardous Air Pollutants 40 CFR 61

The National Emission Standards for Hazardous Air Pollutants delegates to the State of Alaska enforcement of many of the requirements of the Clean Air Act. Although the regulation lists cadmium and zinc as substances that could cause serious health effects from ambient air exposure, it does not provide specific regulatory guidelines on the emissions of these substances.

#### 1.2.1.2 National Ambient Air Quality Standards for Criteria Pollutants 40 CFR Part 50

These standards set national limitations on ambient concentrations of specific pollutants, including lead and particulate matter, to protect public health and welfare. Attainment and maintenance of NAAQS is the responsibility of the state, and is achieved through state Implementation Plans and through regulation of major sources. The potentially applicable standards are the following:

- Lead—1.5 $\mu g/m^3$, and
- $PM_{10}$—150 $\mu g/m^3$ (maximum 24-hour average).

However, these regulations apply to regions as defined by 40 CFR 81 as designated areas for air quality planning purposes. According to 40 CFR 81.302, the Red Dog Mine is part of the Northern Alaska Intrastate Air Quality Control Region. In general, the Northern Alaska Intrastate Air Quality Control Region is in compliance with all the air quality standards.

## 1.2.2 State Regulations

As with federal air regulations, the state air regulations address both air quality and emissions standards. In addition, the state has the authority to issue air quality control permits. The Red Dog Mine has operated under a series of air quality control permits since it began operations.

### 1.2.2.1 State Ambient Air Quality Standards (AS46.03, AS46.14, and 18 AAC 50)

The State of Alaska regulates air quality and issues permits to operators who emit particulates and chemicals into the atmosphere. The regulations provide ambient air quality standards. Those that are applicable to fugitive dust include regulations for $PM_{10}$ and lead. $PM_{10}$ levels cannot exceed an average of 50 $\mu g/m^3$ annually and a 24-hour average of 150 $\mu g/m^3$. The lead standard is a quarterly arithmetic mean of 100 $\mu g/m^3$. In addition, these regulations describe how federal air quality regulations have been incorporated into the state regulations and how these will be implemented. In addition, there is a portion of the State of Alaska's Ambient Air Quality Standards that discusses fugitive dust in 18 AAC 50.045 (d):

> A person who causes or permits bulk materials to be handled, transported, or stored, or who engages in an industrial activity or construction project shall take reasonable precautions to prevent particulate matter from being emitted into the ambient air.

These regulations are applicable to the Red Dog Mine, and the State of Alaska administers these regulations with respect to the Red Dog Mine through its air quality control permits. The Red Dog Mine has had multiple air quality control permits under 18 AAC 50. All emission sources at the Red Dog Mine are permitted, including truck roads and truck loadouts. Included within the permits are fugitive dust control plans. The following paragraphs describe the provisions in the air quality control permits that address fugitive dust control.

In the 1994 Permit No. 8832-AA0002, the permit specifies the following measures for fugitive dust control:

- "All crushed ore and ore concentrates handling and storing activities, including… materials handling with truck loadout station must be fully enclosed to assure compliance with 18 AAC 50.050(f). The ore truck dump station shall be partly enclosed to avoid suspension of particulate matter under windy conditions.
- "Permittee shall apply chemical or physical dust suppressants or any other equally effective means of surface stabilization to control fugitive dust emissions on all materials haul roads. Permittee shall take reasonable precautions at material piles, exposed areas, and roadways to prevent release of particulate matter beyond the facility boundary."

In the 1996 Permit No. 9632-AA001, the following measures were stipulated:

> The [p]ermittee shall take reasonable precautions at material piles, exposed areas, and roadways to prevent release of particulate matter beyond the facility boundary (DEC Permit No. 9632-AA001).
>
> All ore concentrates handling and storing activities, including stockpiling and truck loading/unloading stations, must be fully enclosed to prevent violations of the ambient air quality standards and increments set out in 18 AAC 50.020(a)(1) and (b)(2)(A).

In the 1999 Air Quality Construction Permit No. 9931-AC005, the permit stipulates that "the allowable emissions from the facility and the surrounding growth not cause ambient concentrations that exceed standards in Table 6 (18 AAC 50.310(d)(2)) at any location or would not meet the ambient air quality standard or maximum allowable ambient concentration." None of the standards addresses metals, but standards are specified for $PM_{10}$ (maximum annual average of 1.0 $\mu g/m^3$ and maximum 24-hour average of 5 $\mu g/m^3$).

This permit imposes stricter controls on particulate matter emissions than the previous permits. It specifies that the Red Dog Mine control particulate matter emissions from the all facility roads through the application of calcium chloride at least once per year and the application of additional calcium chloride if particulate emissions last longer than 2 minutes. In addition, the Red Dog Mine is required to operate an ambient particulate emissions monitoring station at the area of the anticipated highest particulate emissions.

## 1.3 Water

Like air, both federal and state water quality statutes and regulations apply to the Red Dog Mine.

### 1.3.1 Federal Regulations

Applicable federal water regulations to the Red Dog Mine include those that address discharge limitations and water quality. The Red Dog Mine has a federal permit to discharge effluent.

#### 1.3.1.1 Clean Water Act, National Pollutant Discharge Elimination Permit (Sections 101, 301(b), 304, 308, 401, 402, and 405) and 40 CFR 122

Teck Cominco has an NPDES permit to discharge effluent to the Chuckchi Sea and to tundra at the port site. Permitted effluents are effluent from the sewage treatment plant facilities, desalination plant, and treated mine drainage from the two CSBs. The NPDES permit establishes effluent limitations and restrictions, monitoring, and other requirements. DEC has certified the permit under Section 401 of the Federal Clean Water Act and the NPDES permit also serves as the state waste discharge permit.

#### 1.3.1.2 Clean Water Act, Section 404 (40 CFR 230, 33 CFR 320-330, 40 CFR Part 6 Appendix J)

Section 404 of the Clean Water Act, which is implemented by EPA and the U.S. Army Corps of Engineers through regulations in 40 CFR 230 and 33 CFR 320 to 330, prohibits the discharge of dredged or fill material into waters of the United States without a permit. This is potentially applicable to any remedial action where dredged or fill material may be placed in a stream or on wetlands.

### 1.3.2 State Regulations

State water regulations address water quality and drinking water standards. These regulations are applicable to the water quality of the water bodies that are crossed by the DMTS.

#### 1.3.2.1 Alaska Water Quality Standards and Alaska Drinking Water Standards (18 AAC 70 and 18 AAC 80)

The Alaska Water Quality Standards provide ambient water quality standards for the fresh and marine waters in the State of Alaska. 18 AAC 70.015(a) specifies that actions may not degrade water that is higher in quality than Alaska Water Quality Criteria unless approval from DEC is obtained. With respect to specific standards for the chemicals of concern, 18 AAC 70.020(b)(1)(C)(1)—toxic and deleterious substances—provides the most conservative protection for the potential freshwater uses in the area. This regulation specifies the following:

> Individual substances may not exceed criteria in the EPA Quality Criteria for Water… or, if those criteria do not exist, may not exceed the Primary Maximum Contaminant Levels of the Alaska Drinking Water Standards (18 AAC 80). If those criteria are absent, or if the department finds that the criteria are not appropriate for sensitive resident Alaskan species, the department will, in its discretion, establish in regulation chronic and acute criteria to protect sensitive and biologically important life stages of resident Alaskan species, using methods approved by the EPA or alternate methods approved by the department (18 AAC 70[1][c]).

The following table lists the EPA water quality criteria for freshwater and salt water.

**EPA water quality criteria for contaminants of concern (μg/L)**

| | Freshwater | | Saltwater | |
|---|---|---|---|---|
| | Criteria Maximum Concentration | Criteria Continuous Concentration | Criteria Maximum Concentration | Criteria Continuous Concentration |
| Cadmium | 4.3 | 2.2 | 42 | 9.3 |
| Lead | 65 | 2.5 | 210 | 8.1 |
| Zinc | 120 | 120 | 90 | 81 |

**Source:** U.S. EPA. 1999. National recommended water quality criteria—Correction. EPA 822-Z-99-001. U.S. Environmental Protection Agency, Office of Water 4304.

The standards referred to in 18 AAC 80 are the State of Alaska drinking water standards. These are similar standards as those provided in 18 AAC 75.345, groundwater and surface water cleanup levels. The potentially applicable standards relevant to the constituents of concern are:

**MCLs and Method Two groundwater cleanup levels for the chemicals of concern (mg/L)**

| | |
|---|---|
| Cadmium | 0.005 (Primary MCL and Method Two) |
| Lead | 0.015 (Method Two) |
| Zinc | 5 (Secondary MCL); 11 (Method Two) |

The other portion of 18 AAC 70 that is potentially applicable is the regulation of residues both in fresh and salt water. Alaska's water quality criteria for residues in marine waters (18 AAC 70[2]) to support the designated use of "growth and propagation of fish, shellfish, other aquatic life, and wildlife" are as follows:

> May not, along or in combination with other substances or wastes, make the water unfit or unsafe, for the use, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. May not, alone or in combination with other substances, cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited, beneath or upon the surface of the water, within the water column, or upon adjoining shorelines.

The criterion for fresh water is similar. The applicability of this regulation can only be determined after the evaluation of site-specific surface water and sediment data. These regulations are potentially applicable at the port and where the road crosses streams.

## 1.4 Historic and Archeological

Since the DTMS crosses the Cape Krusenstern National Monument, a national historic landmark since 1974, the following regulations are potentially applicable.

### 1.4.1 Federal Laws and Regulations

Federal laws and regulations potentially apply because Cape Krusenstern is a National Monument.

#### 1.4.1.1 National Historic Preservation Act (16 United States Code 470, 36 CFR 800)

The National Historic Preservation Act (NHPA) requires that federal agencies consider the effects of a federally assisted undertaking or licensing on any district, site building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. Cape Krusenstern National Monument is on the National Register of Historic Places. If an eligible site or structure will be adversely affected, the procedures for protection of historic properties are in Executive Order 11,593 titled *Protection and Enhancement of the Cultural Environment* and in 36 CFR 800, 36 CFR 63, and 40 CFR 6.301(c).

Any actions, including remedial actions that are proposed to occur within Cape Krusenstern National Monument, would require a Section 106 consultation process of the National Historic Preservation Act.

**Archeological and Historical Preservation Act (16 United States Code 469, 40 CFR 6.301)—**This act and its implementing regulations provide for the preservation of historical and archeological data that might otherwise be lost as a result of terrain alteration. If any actions could cause irreparable loss to significant scientific, prehistoric, or archeological data, the act requires the agency undertaking the project to preserve the data or request the U.S. Department of Interior to do so. This act differs from NHPA in that it encompasses a broader range of resources than those listed on the National Register and mandates only the preservation of data.

**Archeological Resource and Recovery Action (16 United States Code 470, 43 CFR 7)—** This federal law establishes steps to protect archeological resources and sites. These requirements may be applicable given that remediation or reclamation may occur near archeological resources.

## 1.4.2 State Regulations

State laws and regulations applicable to historic resources potentially apply because there are known and suspected historic resources near the DMTS.

### 1.4.2.1 Alaska Department of Natural Resource State Historic Preservation Office

The State Historic Preservation Office (SHPO) is a branch of the Alaska Office of History and Archaeology under the Alaska Department of Natural Resources. The National Historic Preservation Act of 1966 established SHPO for each state, and a SHPO officer is appointed by each state's governor (Public Law 89665; 80 Stat. 915; 16 U.S.C. 470). The SHPO officer advises and assists in all federal, state, and local historic projects within each state.

The Alaska Historic Preservation Act (AHPA; Alaska Statute 41.35) promulgated a review process for projects that impact significant state historic properties. Under the rules of AHPA, SHPO staff review projects to determine if project activities or objectives may affect historical, archaeological, or paleontological resources of the state, and how these cultural resources will be protected and preserved during development.

SHPO has a database of locations that are reported to have prehistoric and historic significance. There are locations along the DMTS road that are reported to have historic or prehistoric significance. SHPO is reviewing other locations of potential prehistoric or historic significance in the vicinity of the mine, DMTS road, and port site to determine if they are eligible.

## 1.5 Endangered Species

Endangered species are protected under federal law. There are known threatened and endangered species in the vicinity of the Red Dog Mine; therefore, this federal law is potentially applicable. There are no comparable state laws or regulations.

### 1.5.1 Endangered Species Act 50 CFR 402

The Endangered Species Act (ESA) provides a means for conserving various species of fish, wildlife, and plants that are threatened with extinction. ESA defines an endangered species as "…any species which is in danger of extinction throughout all or a significant portion of its range." In addition, ESA defines a threatened species as "… any species which is likely to become an endangered species within the foreseeable future." Furthermore, ESA provides for the designation of critical habitats that are "… specific areas within the geographical area occupied by the (endangered or threatened) species … on which are found those species …."

Section 7(a) of ESA requires federal agencies, in consultation with the U.S. Department of the Interior and National Marine Fisheries Service, as appropriate, to ensure that the actions that they authorize, fund, or carry out are unlikely to jeopardize the continued existence of a threatened or endangered species, or adversely modify or destroy their critical habitat. Actions that might jeopardize listed species include direct and indirect effects, and the cumulative effects of other actions that are interrelated or interdependent with the proposed action. If the lead agency determines that a threatened or endangered species or its critical habitat will be affected by the proposed action, then it must avoid the action or take appropriate mitigation measures.

EPA, in their issuance of the NPDES permit for the port site, appears to have conducted a Section 7 consultation. According to the fact sheet for Teck Cominco's NPDES permit for the Red Dog port site (NPDES permit # AK-004064-9), the spectacled eider (*Somateria fischeri*) and the Steller's eider (*Polysticta stelleri*) are threatened species that may occur in the area of discharge. Another species that may occur in the area is the arctic peregrine falcon (*Falco peregrinum tundrius*), which is a species of concern. The eiders migrate through the area in the spring and fall. The port site is not a designated critical habitat. FWS determined that no endangered species were likely to occur within the project area of the port site's discharges; however, the endangered bowhead whale and the Steller or northern seal lion seasonally occur in the Chukchi Sea. EPA determined that discharges would not affect these species (NPDES permit # AK-004064-9).

## 1.6 State Mining Statutes and Regulations

Additional potentially applicable state laws and regulations include the State of Alaska's Mining Statutes (AS 27) and the Mining Claims Regulations (11 AAC 97). According to AS 27.19.020:

> A mining operation shall be conducted in a manner that prevents unnecessary and undue degradation of land and water resources, and the mining operation shall be

> reclaimed as contemporaneously as practicable with the mining operation to leave the site in a stable condition.

AS 27.19.100 includes all areas, facilities, and roads used in connection with the development, extraction, and processing of mineral deposits as part of a mining operation. Therefore, the DMTS road, port site, and mine appear to be subject to the reclamation standard. Under this statute, reclamation to a stable condition means the rehabilitation to a condition that allows for the reestablishment of renewable resources in a reasonable period of time by natural processes. This implies that waterborne soil erosion will return to pre-mining levels within 1 year after the reclamation is completed, and revegetation can occur within 5 years.

Unnecessary and undue degradation is defined in AS 27.19.100 as:

> (A) means surface disturbance greater than would normally result when an activity is being accomplished by a prudent operator in usual, customary, and proficient operations of similar character and considering site specific conditions;
>
> (B) includes the failure to initiate and complete reasonable reclamation under the reclamation standard of AS 27.19.020 or an approved reclamation plan under AS 27.19.030 (a).

To date, it has not been determined if the surface disturbance is greater than normally would occur for this type of activity. Teck Cominco has a reclamation plan required under AS 27.19.030(a). Reclamation has not been initiated because it is an active mine.

**Easement and Other Agreements**. In addition to the above regulatory provisions, there are other agreements between Teck Cominco, NANA, and government entities that may apply to certain aspects of the fugitive dust issue. 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. Other parts of the DMTS road and port facility are on lands owned by NANA or the state. 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.

# 2 Identification of Data Gaps

This section provides a preliminary list of additional information that may be needed to understand the effects of fugitive dust on the environment (referred to as data gaps).

The following list of data gaps emerges from a review of the various background information and analytical data, as well as the site conceptual model reviewed and described in this document. Public participation and input into the process is important, and that input may result in the identification of additional data gaps. As these potential data gaps are evaluated, and available data reviewed, some of the items may be removed from the list, if sufficient information is already available.

These data gaps are organized into the following categories:

- Background information
- Nature and extent characterization
- Monitoring.

The data gaps related to nature and extent characterization and to monitoring are further categorized by the following environmental media:

- Soil
- Water
- Sediment
- Air
- Biological-aquatic
- Biological-terrestrial.

The data gaps listed below should be viewed as a starting point for public review, and may not be a complete list of needed information. Additional data gaps will be identified through the public review process.

## 2.1 Background Information Data Gaps

Additional background information that may be needed to evaluate fugitive dust transport, deposition, and effects includes:

- Current subsistence information (e.g., percentages of villagers relying on subsistence activities, most important subsistence foods, consumption rates)

- Regional metals occurrences and background concentrations of metals (in order to distinguish between naturally occurring metals concentrations and metals concentrations resulting from dust emissions from the mining and transport operations).

## 2.2 Nature and Extent Characterization Data Gaps

Data gaps related to the characterization of the nature and extent of metal releases from fugitive dust deposition are listed below.

### 2.2.1 Soil

- Extent of concentrate deposition around operational features at the port site (e.g., conveyor storage area, P8 conveyor, etc.)
- Soil data (versus moss data) for evaluating extent of deposition.

### 2.2.2 Water

- Tundra ponds in vicinity of DMTS.

### 2.2.3 Sediment

- Nearshore areas
- Deepwater ship area
- DMTS road (stream sediment and/or tundra pond sediment).

### 2.2.4 Biological-Aquatic

- Aquatic organism sampling in tundra ponds.

### 2.2.5 Biological-Terrestrial

- Extent of metals in moss around the DMTS port and along the DMTS road (unclear where elevated numbers approach background)
- Metals uptake into subsistence harvest plants—metals within versus on plant (potentially for addressing human health concerns)
- Ecological impacts of fugitive dust (ecological risk screening evaluation)

- Small animal tissue data to support ecological risk screening evaluation.

## 2.3 Monitoring Data Gaps

Data needs related to monitoring fugitive dust emissions and the effects of fugitive dust deposition are listed below.

### 2.3.1 Soil

- Periodic soil sampling (road, port).

### 2.3.2 Water

- Periodic water sampling (lagoons, streams at road crossings).

### 2.3.3 Sediment

- Periodic sediment sampling (lagoon and offshore sediment).

### 2.3.4 Air

- Air monitoring (ambient air boundary of road, port, and mine)
- Air monitoring in villages (already planned).

### 2.3.5 Biological-Aquatic

- Juvenile Dolly Varden tissue (additional monitoring near road already planned).

### 2.3.6 Biological-Terrestrial

- Periodic moss sampling
- Caribou sampling (field work completed in April 2002, analyses in progress)
- Other species (e.g., ptarmigan, receptors in risk assessment process).

# 3 Decision Making Framework

This section describes the decision-making process used by the DEC Contaminated Sites group. Areas that qualify as "contaminated sites" will be 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 general decision framework shown in Figure 3-1 will be used to make cleanup decisions at contaminated sites associated with the Red Dog Mine operations between the CSB at the mine and the deep sea vessels off the coast. Taken together, paragraphs 21, 22, 23, 49, and 115 of 18 AAC 75.990 define a contaminated site as an area containing hazardous substances at concentrations exceeding applicable cleanup levels. Cleanup levels are defined as concentrations of hazardous substances that may be present in environmental media under specified exposure conditions without posing a threat to human health, safety, or welfare, or to the environment. Environmental monitoring options to evaluate and determine dust control measures at the Red Dog Mine CSB, and the DMTS road and port facilities will be evaluated throughout the project.

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