

**DMTS Fugitive Dust
Risk Assessment
Conceptual Site Model**

Prepared for

Teck Cominco Alaska Inc.
Anchorage, Alaska

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Risk Assessment
Conceptual Site Model**

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January 2003

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Acronyms and Abbreviations

CoPC	chemical of potential concern
CSB	concentrate storage building
CSM	conceptual site model
DEC	Alaska Department of Environmental Conservation
DHSS	Department of Health and Social Services
DMTS	DeLong Mountain Regional Transportation System
ERA	ecological risk assessment
HHRA	human health risk assessment
MSHA	Mine Safety and Health Administration
NAAQS	national ambient air quality standards
OSHA	Occupational Safety and Health Administration

1 Introduction

This document provides a revised¹ conceptual site model (CSM) for the DeLong Mountain Regional Transportation System (DMTS) fugitive dust risk assessment. The purpose of the DMTS fugitive dust risk assessment is to assess whether adverse impacts to human health or the environment could occur as a result of direct or indirect exposure to metals from fugitive dust from the DMTS transportation corridor. The results of the risk assessment will help risk managers to determine what actions, if any, are necessary to reduce those impacts. The study area for the risk assessment is defined by the extent of fugitive dust deposition related to the DMTS transportation corridor. This risk assessment will be focused on evaluating the incremental risk from fugitive dust deposition associated with the DMTS. The area around the mine will be evaluated in a separate risk assessment at a later date.

1.1 Setting

The Red Dog Mine is located approximately 50 miles east of the Chukchi Sea, in the western end of the Brooks Range of Northern Alaska (Figure 1). Base metal mineralization occurs naturally throughout much of the western Brooks Range, and strongly elevated zinc, lead, and silver concentrations have been identified in many areas (Exponent 2002b).

The Red Dog deposit is a zinc and lead sulfide ore body. 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 concentrate storage building (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 (Figure 2). At the DMTS 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 two CSBs (Figure 3). The storage capacity allows mine operations to

¹ The CSM has been revised based on comments from the Alaska Department of Environmental Conservation (Sundet 2002, pers. comm).

proceed year-round. During the shipping season, 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. In this document, “the DMTS” or “the DMTS transportation corridor” is used to refer to the entire transportation corridor from the mine to the deepwater ships, including the road, the port facilities, and the barges (Figure 4).

Although fugitive dust control has been a high priority along the DMTS transportation corridor over the years, a moss study performed in 2000 by the National Park Service (Ford and Hasselbach 2001) indicated that there were some impacts from fugitive dust along the DMTS road and near the port. Fugitive dust is defined here as any dust or particulate matter that is emitted to the ambient air from operational activities. Along the DMTS transportation corridor, fugitive dust may be ore concentrate, road dust, or a combination of both. A fugitive dust study completed by Teck Cominco in 2001 (Exponent 2002a) characterized the nature and extent of fugitive dust releases from the DMTS corridor and provided baseline data from which to monitor the performance of new equipment and dust management practices.

1.2 Organization of the Document

The following sections of this document provide the elements of the CSM, including chemicals of potential concern (CoPCs), sources and transport mechanisms, human health exposure pathways and receptors, and ecological exposure pathways and receptors. The human health and ecological risk assessment (ERA) work plan provides further details on the methodology to evaluate the degree to which migration has influenced various media and the potential risks related to fugitive dust migration.

2 Conceptual Site Model

A CSM is a planning tool used for identifying chemical sources, complete exposure pathways, and potential receptors on which to focus the risk assessment. The CSM describes the network of relationships between chemicals released from a site and the receptors that may be exposed to the chemicals through pathways such as ingestion of food or water. The CSM examines the range of potential exposure pathways and identifies those that are present and may be important for human and ecological receptors, and eliminates those pathways that are incomplete and therefore do not pose a risk.

The CSM for the Red Dog fugitive dust risk assessment describes possible sources and transport mechanisms of metals from the DMTS transportation corridor into surrounding terrestrial and aquatic ecosystems, and the pathways by which receptors may be exposed to those metals. It was developed based on site history, site conditions, and the results of available site sample analyses.

The following sections identify sources and transport mechanisms, exposure media, exposure routes, and receptors. Flow chart illustrations of the human health and ecological CSMs are shown in Figures 5 and 6, respectively, and are also discussed in further detail in later sections.

2.1 Sources and Transport Mechanisms

The sources of metals associated with the DMTS are the lead and zinc ore concentrates that are produced at the mine; transported over the DMTS road in trucks; and stored, handled, and loaded at the DMTS port facility. Historically, the primary mechanisms by which metals have escaped from these sources are via windblown dust from the port facilities (buildings, conveyors, etc.), by truck tracking (i.e., tracking of concentrate out of loading and unloading facilities on haul truck tires and other truck surfaces and subsequent deposition onto the road), and by concentrate spillage or escapement from haul trucks, followed by windblown transport as fugitive dust. Additionally, runoff from precipitation and snowmelt could also transport metals from the DMTS road and port operations into surrounding ecosystems. Once released to

the environment, some of the metals may become dissolved or suspended in surface water, co-deposited with or adsorbed to sediments, incorporated into soil, and potentially enter the food web through uptake into plants and animals, which then are consumed by people or upper-trophic level ecological receptors. The following sections briefly describe fugitive dust metal sources and current and past primary transport mechanisms related to these sources.

2.1.1 Road

A number of potential sources of metals and current and past transport mechanisms associated with the DMTS road have been identified. These include:

- **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 keep down dust on the road. Core samples have shown that elevated metals occurrences on the road are a surface phenomenon, and are not likely associated with the materials originally used to construct the road or regularly added to the crushed base during maintenance. Samples from the gravel and road water source sites confirmed that these materials are an insignificant source of metals to the DMTS road (Exponent 2002a).
- **Tracking along the DMTS road**—Ore concentrate can be tracked out of loading and unloading facilities on haul truck tires and other truck surfaces and subsequently deposited onto the road. This appears to have been one of the primary sources and release mechanisms over the life of the operation. Recent measures, described below in *Fugitive Dust Control Measures*, have lessened this transport mechanism.
- **Concentrate spillage and escapement from haul trucks**—Historically this has included leakage from side doors or blowing from under the tarp covers on the old trucks during normal transit, or spillage from overturned trailers

following accidents. Recent measures, described below in *Fugitive Dust Control Measures*, have lessened these sources and transport mechanisms.

Transport mechanisms for metals that have been deposited onto the DMTS road or tundra include:

- **Mechanical or wind generated dust from road or tundra surfaces**—Airborne transport of dust generated from road surfaces is likely one of the primary mechanisms by which metals have historically been deposited onto the tundra adjacent to the road. Recent measures, described below in *Fugitive Dust Control Measures*, have lessened this transport mechanism. In addition, dust could be blown from tundra surfaces along the road.
- **Surface water runoff from road and tundra surfaces**—Surface water runoff from precipitation and from use of water on the road to help keep dust down may transport metals off of the road bed. This mechanism may be important in the immediate shoulder area of the road, but it is not likely to carry dust a long distance compared to airborne transport of dust. In addition, dust may be transported by runoff into streams at road crossings or from the tundra into streams, and could subsequently be carried downstream in water or sediment.

2.1.2 Port

The following list includes a number of potential sources of metals and current and past transport mechanisms associated with port operations. Recent measures, described below in *Fugitive Dust Control Measures*, have lessened many of these sources and transport mechanisms.

- **Windblown dust from the truck unloading building and CSBs**—When doors to these buildings are opened, wind can carry dust from the buildings into the environment around the port site.

- **Concentrate spillage and dust leakage from conveyers and surge bin**—Likely a primary source in the past but less significant now due to facility upgrades.
- **Spillage and windblown dust during barge loading**—Although efforts are made to minimize emissions, some may occur.
- **Spillage and windblown dust from barges during transport**—Not likely a significant source either historically or at present because the concentrate is covered by fixed tarps and undisturbed.
- **Spillage and windblown dust during transfer from barges to deepwater ship**—This may emanate either from the open slot in the fixed tarp or from the open hold of the ship.
- **Spillage and windblown dust from the 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.

Transport mechanisms for metals that have been deposited onto road surfaces at the port site are similar to those mechanisms described above for the DMTS road. In addition, transport mechanisms for metals-containing dust that has been deposited on soil or tundra at the port site include:

- **Mechanical or wind generated dust from soil or tundra surfaces**—This mechanism is similar to the transport of dust from the DMTS road surface.
- **Surface water runoff from soil or tundra surfaces**—May be important in the immediate area of the port facilities, but is not likely to carry dust a long distance compared to airborne transport of dust. This mechanism is partly limited, because surface water from the CSB area is collected and treated prior to discharge to the Chukchi Sea, under a National Pollutant Discharge Elimination System permit.

2.1.3 Changes Resulting from Fugitive Dust Control Measures

The fugitive dust transport mechanisms described above have been subject to change resulting from ongoing efforts to reduce emissions. These changes include the use of newer trucks, implementation of truck washing, test paving of the road near the port, significant upgrades to the surge bin and truck unloading facilities, and full enclosure of the conveyers between the surge bins and the CSBs. Tracking is now being limited by improved dust control in the unloading building, and by truck washing in the summer. Concentrate spillage is now limited by newer trucks, which produce less dust when dumping, have better handling characteristics which reduce the likelihood of roll over, and have hydraulically closed steel covers and solid sides to prevent dust escaping during normal transit or in the event of an accident. Efforts to minimize transport mechanisms from the DMTS road surface include controls implemented to limit tracking, as well as recovery and recycling of metals-containing road material, and placement of hard surface (pavement) at the port and the first 5 miles of DMTS road. Improved dust control procedures within the CSBs have been instituted to reduce fugitive dust emissions during unloading and handling of the concentrates, and the conveyors and surge bin have been upgraded to reduce concentrate spillage and dust leakage from these facilities. Ongoing efforts to reduce fugitive dust emissions are described in more detail in the background document (Exponent 2002b).

2.2 Human Health Exposure Pathways and Receptors

This section identifies the portions of the CSM specific to the human health portion of the risk assessment, including potential exposure pathways and receptors.

2.2.1 Potential Human Exposure Pathways

An exposure pathway is the course a CoPC 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 CoPC 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.

The potentially complete exposure pathways can be further described as “primary” or “secondary” pathways. Primary pathways are those expected to be major contributors to risk estimates, or pathways of particular community concern. Risks from these pathways will be quantified in the human health risk assessment (HHRA). Secondary exposure pathways are those not expected to contribute significantly to risk estimates. Secondary pathways will be assessed qualitatively or semi-quantitatively in the risk assessment. Figure 5 summarizes the exposure pathways identified at the site.

The potential exposure pathways can be categorized under three environments: terrestrial, marine, and freshwater. In each of these environments, there may be some potential for exposure to metals through consumption of subsistence foods (e.g., plants, fish, and/or other animals), incidental ingestion or dermal contact with soil/sediment, and 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.

2.2.1.1 Subsistence Use in the Terrestrial Environment

Subsistence hunters and gatherers 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. Subsistence use of animals is considered a primary pathway and will be quantified in the risk assessment.

People could also consume plants and berries that have taken up metals from the soil or onto which dust has been deposited. Preliminary risk calculations conducted by the Department of Health and Social Services (DHSS), based on the first set of Alaska Department of

Environmental Conservation (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. Subsistence use of plants (e.g., berries and sourdock) will be included in the risk assessment as a primary pathway.

In addition, people could be exposed to metals more directly through incidental ingestion and dermal contact with soil, or inhalation of airborne particulates from soil. There is a public access plan associated with the ambient air permits for the DMTS road and port, which is intended to prevent access to areas within ambient air boundaries.² The plan controls access to these areas by providing public information and education, and posting signage at points of possible public access. Despite the public access controls, hypothetical usage of these areas will be assumed for the risk assessment work. Both dermal contact and inhalation exposure are likely to be limited relative to soil ingestion and other pathways and thus are considered to be secondary pathways. Incidental soil ingestion will, however, be included as a primary pathway for subsistence hunters and gatherers.

The large distance between the dust sources and the villages likely precludes transport of fugitive dust to the villages of Kivalina and Noatak (i.e., minimum of 15 miles from DMTS operations). Ambient air modeling performed during the air permitting process has demonstrated that air concentrations beyond the ambient air boundaries (see Figure 4) do not exceed NAAQS. However, one year of air monitoring is planned for each of these villages, partly in response to community concern. Lead data will be collected and air concentrations of

² 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 ambient air boundaries for the port and mine are shown along with the land ownership and usage in Figure 4. The ambient air boundary for the road is located 300 ft on either side of the road centerline.

lead will be compared with NAAQS (Hall 2002, pers. comm.). This work will be conducted separately from the risk assessment.

2.2.1.2 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 and treatment of surface water runoff at the port site limits the potential for metals migration via surface water. Recent data for marine sediment and water near the port will be evaluated to determine whether there are any elevated concentrations in these media near the port. If concentrations are elevated above sediment quality criteria (e.g., Washington State sediment quality standards; Ecology 2002), further analyses will be conducted to evaluate risks related to consumption of marine foods.

2.2.1.3 Subsistence and Residential Use in the Freshwater Environment

Although current water and fish data indicate minimal effects, surface water quality could potentially be impacted by metals from the DMTS road or the port. If surface water quality is affected, fish in the streams may accumulate metals, which could then be consumed by subsistence users. Subsistence fish consumption will be addressed in the HHRA as a primary pathway.

Surface water drainages in the vicinity of the road ultimately flow into the Wulik River or into the Chukchi Sea near the port site (south of Kivalina). 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. Data will be compiled for surface water and will be compared with water quality criteria. If concentrations are elevated over the water quality criteria, exposure to CoPCs in residential water through ingestion or dermal contact will be quantified in the risk assessment.

2.2.2 Receptors

There is potential for people to come into contact with metals transported by fugitive dust, either directly or indirectly. Three groups of human receptors have been identified for the site: workers in the DMTS road and port, subsistence hunters and gatherers who may use areas in the vicinity of the road as part of their harvest area, and residents of Kivalina and Noatak to the extent that these villages may be affected by airborne deposition. Although there is some regional recreational use, any exposure for recreational visitors would be much more limited than for subsistence hunting and gathering in the area.

2.2.2.1 Workers

Workers have the potential for exposure to metals from fugitive dust associated with the DMTS transportation corridor. The risk assessment will include an estimate of cumulative risk to workers through the evaluation of a hypothetical worker exposed to fugitive dust along the DMTS transportation corridor, as well as exposure through the subsistence pathway (i.e., consumption of subsistence foods and contact with environmental media during hunting and harvesting).

2.2.2.2 Subsistence Hunters and Gatherers

The subsistence group includes people who fish, hunt, and gather plants and berries, *and* other family or community members who share those foods. As described above in *Potential Human Exposure Pathways*, most of the primary exposure pathways evaluated in the risk assessment will focus on this group.

2.2.2.3 Residents

The closest villages to the DMTS road and port are Kivalina and Noatak, and thus the residents of these villages are potential receptors. Given the distance between the villages and the DMTS road and port site, migration of metals to soil, dust, or drinking water within the villages is not expected. As described previously, ambient air modeling performed during the air permitting

process has demonstrated that air concentrations beyond the ambient air boundaries (see Figure 4) do not exceed NAAQS. However, one year of air monitoring is planned for each of these villages, partly in response to community concern. Lead data will be collected and air concentrations of lead will be compared with NAAQS (Hall 2002, pers. comm.). This work will be conducted separately from the risk assessment.

2.3 Ecological Exposure Pathways and Receptors

This section identifies the portions of the CSM specific to the ecological portion of the risk assessment, including potential exposure pathways and receptors.

2.3.1 Potential Exposure Pathways

An exposure pathway is the course a CoPC 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 CoPC to a given medium (e.g., air, water, soil); 3) a point of 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 ecological receptors.

Pathways by which ecological receptors may be exposed to metals associated with the DMTS exist for both aquatic and terrestrial communities in the vicinity of the DMTS road and port facility, as illustrated in the CSM for the DMTS ERA (Figure 6). 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). 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 as fugitive dust (Figure 6). For most receptors, direct contact with

affected sediment or soil would be a minor exposure pathway compared with the ingestion pathway. Additionally, exposure to naturally occurring metals is likely throughout the area, both beyond and within the area of the DMTS, through the pathways described above. Exposure to fugitive dust releases represents an incremental exposure above the exposure to naturally occurring metals.

2.3.1.1 Exposure Pathways in Terrestrial Environments

Ecological receptors could be exposed to metals taken up by plants or animals downwind of the DMTS road or port site through consumption of these prey items. Receptors can also be exposed to metals via incidental ingestion of soil that may occur while consuming food. Exposures via ingestion of surface water and dermal contact are minor exposure pathways relative to ingestion rates through prey consumption or soil intake. Metals may accumulate in the tissues of small herbivorous mammals, and consumption of these prey by carnivorous mammals, such as the arctic fox, represents a potential exposure pathway to higher trophic levels.

2.3.1.2 Exposure Pathways in Freshwater Aquatic Environments

Freshwater habitats, such as rivers and tundra ponds, may receive metals via deposition of metal-bearing fugitive dusts or runoff from the DMTS. Metals may be present either dissolved in the water column or bound to sediments. Benthic invertebrates and fish may be exposed to metals via uptake from or direct contact with sediment or water, and fish may also be exposed via ingestion of prey items, such as aquatic invertebrates. Higher trophic-level species that feed on aquatic invertebrates and fish, such as piscivorous birds and mammals, may be exposed to metals via consumption of these prey items or via incidental ingestion of sediment while foraging. Contact with sediments and surface water and ingestion of surface water represent minor exposure pathways for piscivorous birds and mammals.

2.3.1.3 Exposure Pathways in Marine Environments

Marine environments adjacent to the port facility may receive metals via aerial deposition, runoff from terrestrial habitats, or spillage occurring during barge transfer operations. Metals may be present either dissolved in the water column or bound to sediments. Marine invertebrates and fish may be exposed to metals via uptake from or direct contact with sediment or water, and fish may also be exposed via ingestion of prey items, such as aquatic invertebrates. Higher trophic-level species that feed on invertebrates or fish, such as marine mammals or birds, may be exposed to metals via consumption of prey or via incidental ingestion of sediment while foraging. While exposure pathways are potentially complete for marine mammals, exposure is likely minimized due to their large home ranges and the relatively small fraction of time spent in the port area. Contact with sediments and surface water and ingestion of surface water represent minor exposure pathways for piscivorous birds and mammals.

2.3.2 Potential Ecological Receptors

Ecological receptors that may be exposed to metals from the DMTS occur in aquatic systems such as creeks near or crossing the DMTS road, 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 DMTS road and port, but could potentially forage outside areas affected by metals from these operations. Forage areas both within and beyond the affected area have naturally occurring metals that contribute to exposure of various receptors.

Categories of ecological receptors that are potentially affected include aquatic and terrestrial plants, benthic invertebrates, soil fauna, fish, birds, and mammals (Figure 6). 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 DMTS road and port. Thus, some receptor categories are not present in all communities near the DMTS road corridor.

Species to be evaluated in the DMTS risk assessment are discussed in the risk assessment work plan. The relationship of these species to the categories of subsistence resources, and the representative (i.e., “indicator”) species that will be evaluated in each of those categories, are also discussed in the risk assessment work plan.

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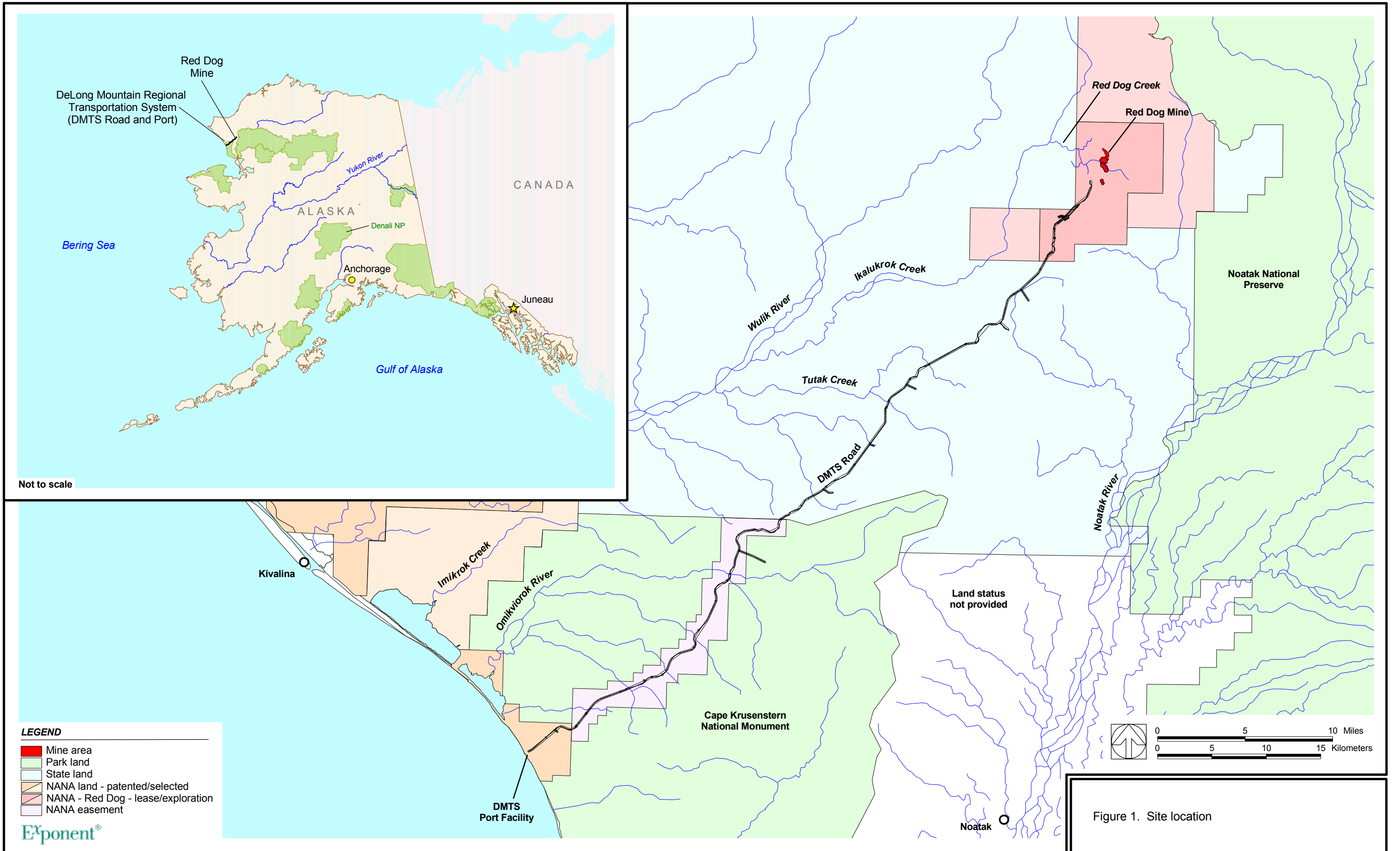
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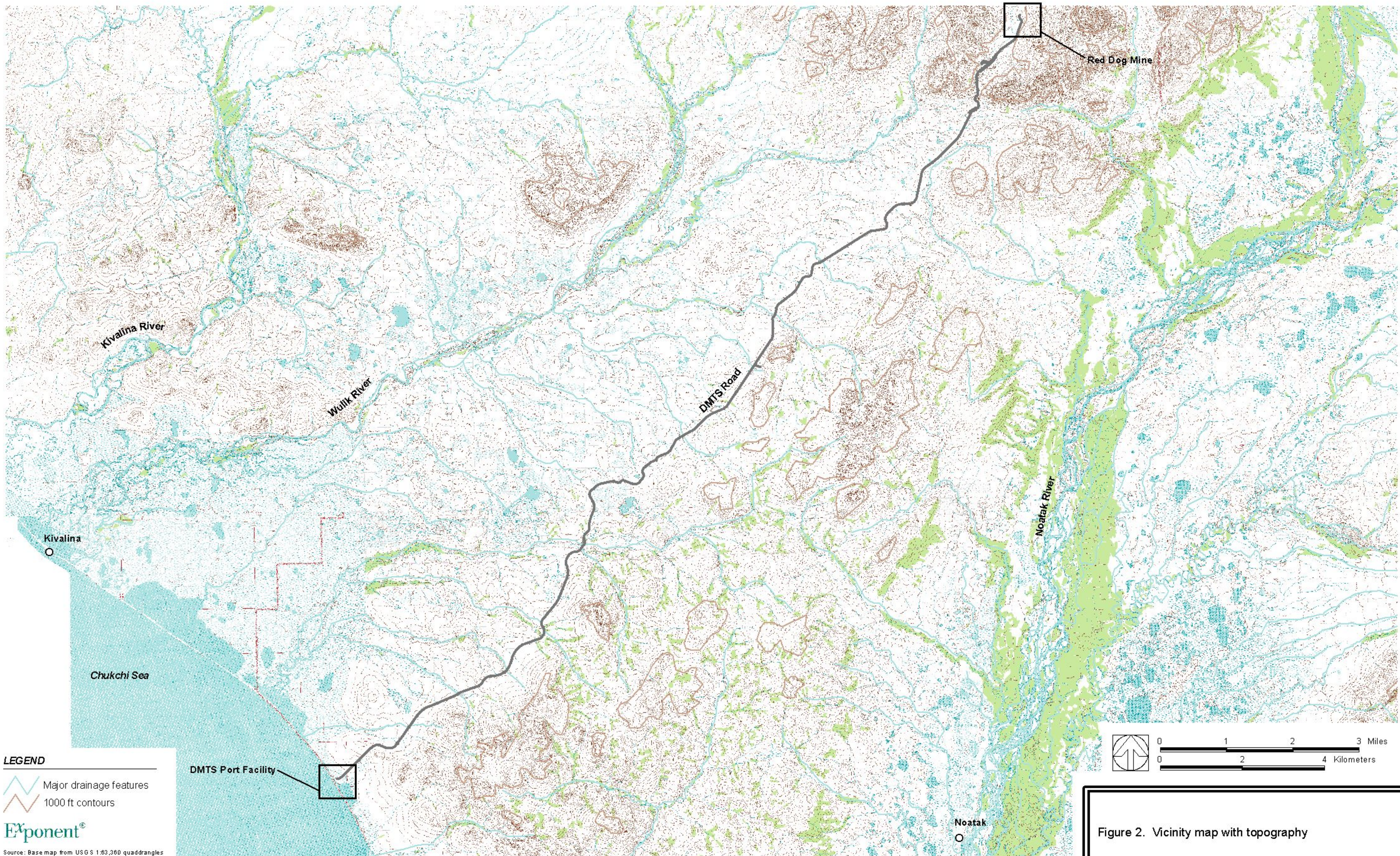
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Figures





LEGEND

- Major drainage features
- 1000 ft contours

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Source: Base map from USGS 1:63,360 quadrangles

0 1 2 3 Miles
0 2 4 Kilometers

Figure 2. Vicinity map with topography

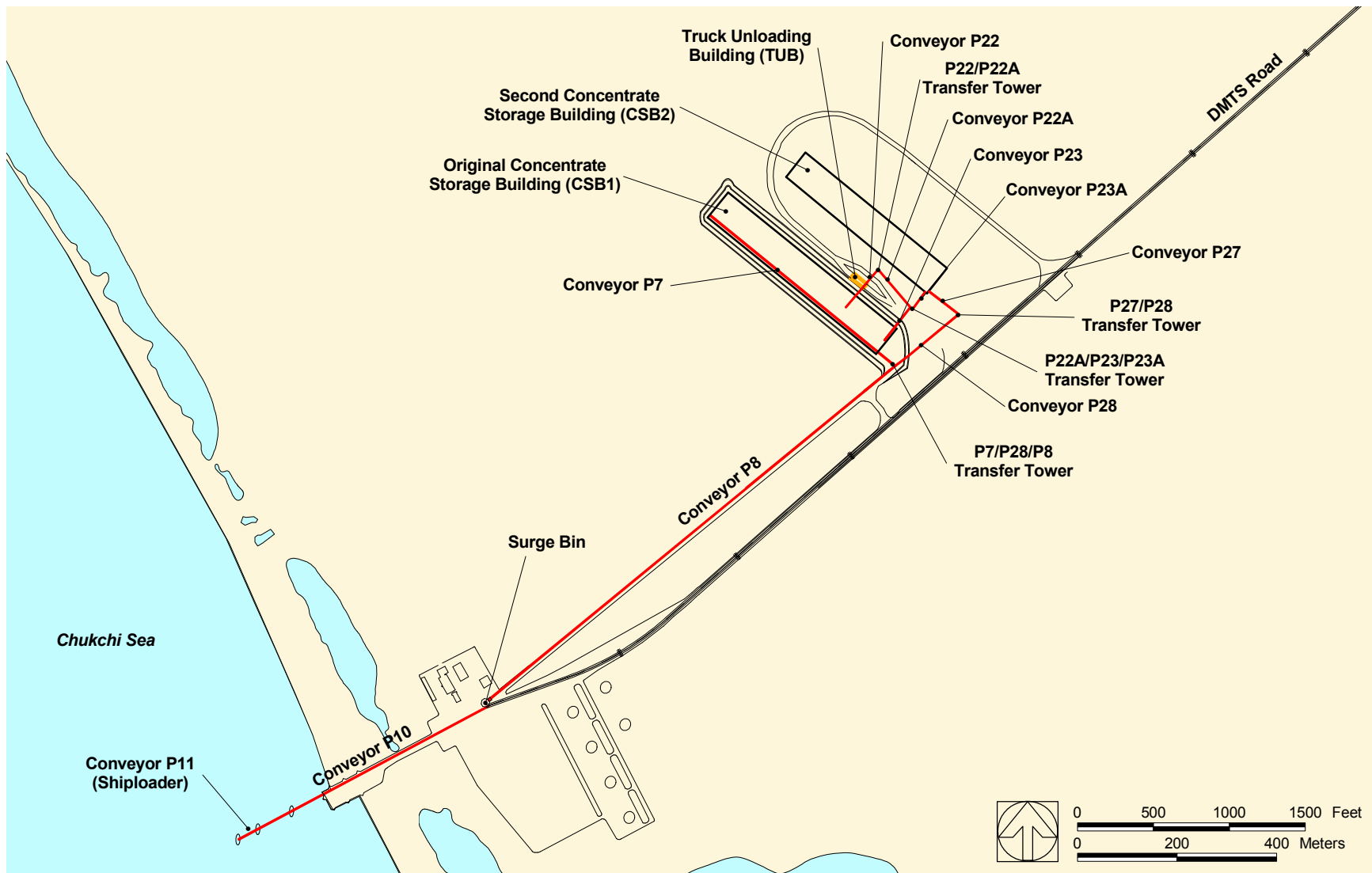


Figure 3. Port site storage and conveyance features map

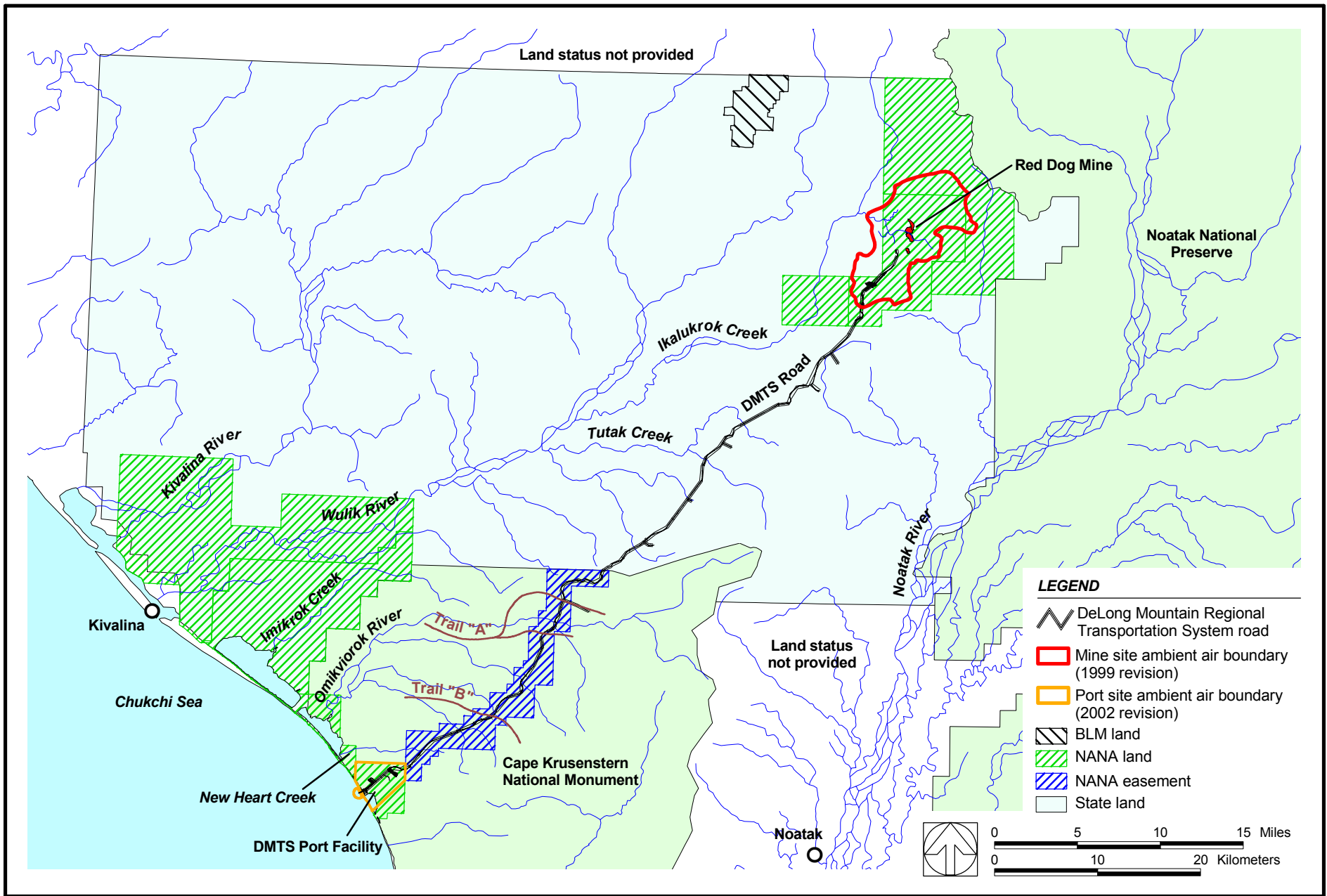


Figure 4. Land ownership and use map

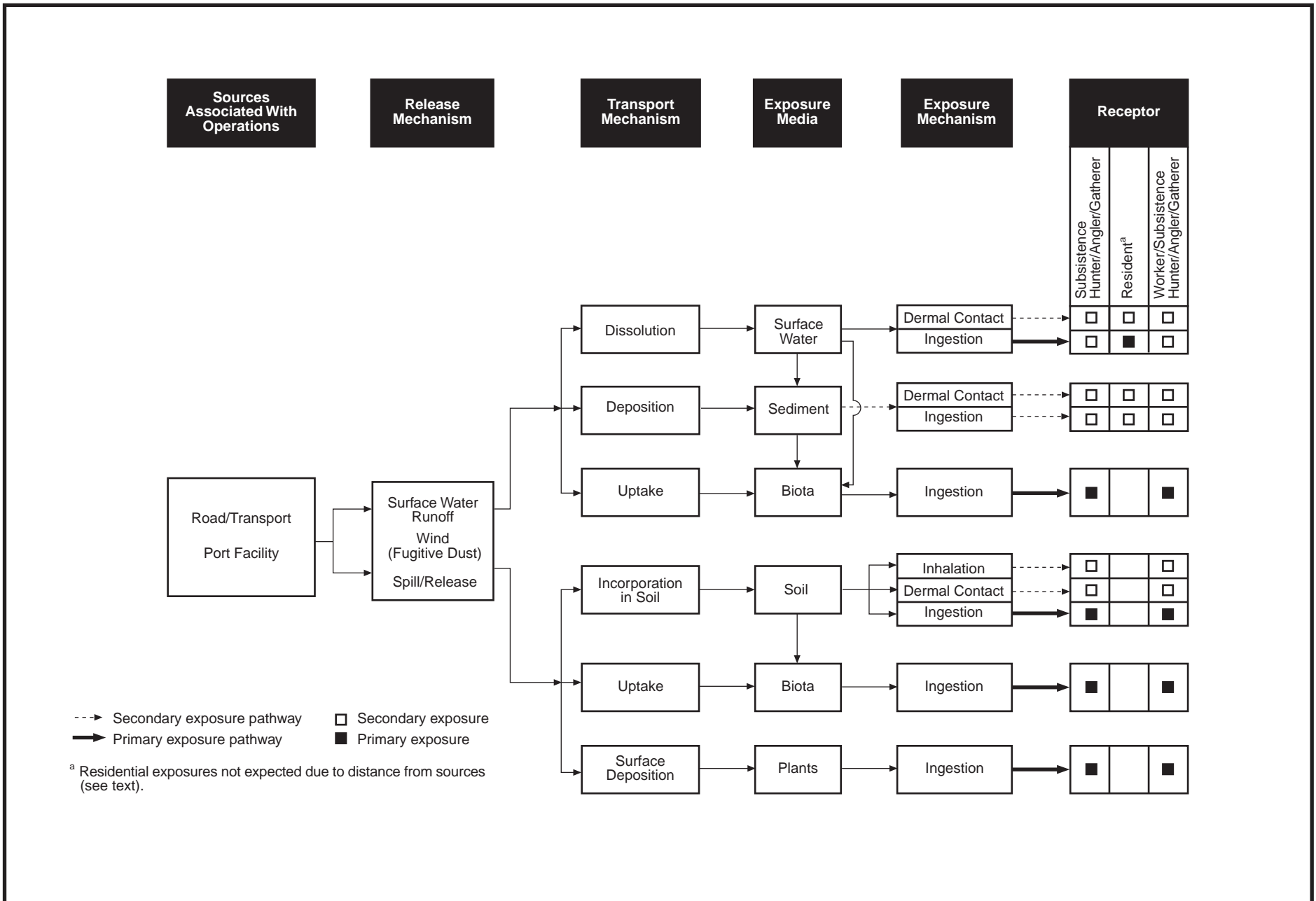


Figure 5. Conceptual site model for the DMTS human health risk assessment

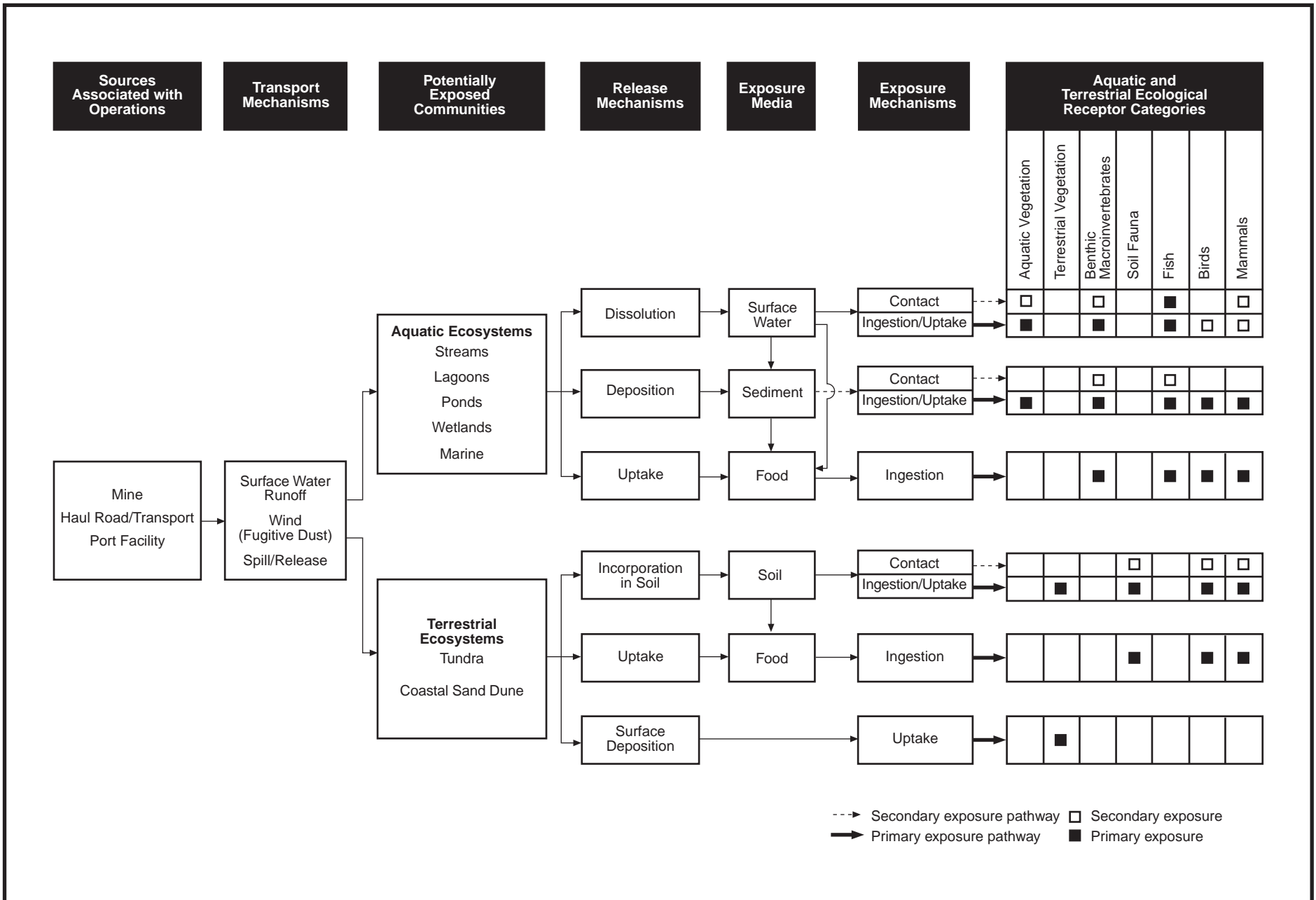


Figure 6. Conceptual site model for the DMTS ecological risk assessment