Executive Summary

In response to public concerns raised about possible contamination by heavy metals in Cape Krusenstern National Monument, the National Park Service (NPS) conducted a study in 2001 along the 52-mile transportation corridor that crosses the monument. The corridor connects Red Dog Mine, the world's largest zinc mining operation, to Delong Mountain port on the Chukchi Sea. At the port, lead and zinc ore is shipped to market.

The NPS research team chose to analyze levels of heavy metals in *Hylocomium splendens*, a species of moss, because moss does not take up minerals from soil and groundwater as rapidly as vascular plants. Therefore, researchers were able to delineate between concentrations of heavy metals that occur naturally in the soil and levels that result from deposition of airborne particles.

The study's findings revealed that a portion of the moss samples contained levels of lead and cadmium equivalent to levels found in some of the most polluted former Soviet bloc nations of Eastern Europe. The source of the contamination, the NPS study determined, was dust thrown from massive ore trucks that travel between the mine and the port along a haul road in the transportation corridor.

Release of the NPS study prompted two additional studies, the first by the consulting firm Ecology and Environment, Inc. (E&E) under contract to the Alaska Department of Environmental Conservation. The E&E study team collected vegetation samples — including three species of plants harvested for subsistence by local Inupiat — from a site at the port and from traditional subsistence harvest areas for the villages of Point Hope, Kivalina and Noatak, all three within an 80-mile radius of the mine.

This study found that cadmium concentrations were highest in vegetation samples collected at the port and that lead concentrations in subsistence foods collected in the Kivalina harvest areas were greater than concentrations found in samples from the Noatak and Point Hope harvest areas.

The second study was completed by Exponent, a consulting firm under contract to Teck Cominco Ltd. (Cominco), the operator of Red Dog Mine. The Exponent team studied moss and vascular plant samples collected along the haul road and at the port. The results were consistent with the NPS study, showing elevated levels of lead and cadmium in plants along the haul road.

The Exponent team also documented higher levels of lead in their salmonberry samples collected at the port and within 100 meters of the haul road than the E&E study found in salmonberry samples at Noatak and Point Hope. Similarly, the Exponent team found higher

National Park Service researchers found that vegetation sampled in the northwestern Alaska study area contained levels of lead and cadmium equivalent to levels in some of the most polluted former Soviet bloc nations of Eastern Europe.

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levels of cadmium in salmonberry samples collected at two of their three port sample sites and within 100 meters of the road than were reported by the E&E team for Point Hope and Noatak.

After reviewing all three studies, the Alaska Department of Health and Social Services' Environmental Public Health Program (EPHP) concluded that the lead found in the sampled vegetation did not pose a health threat to wildlife or people because the lead occurred in a form with low bioavailability, meaning that it can not be readily absorbed by living beings. EPHP cited studies that used rats as models from which to extrapolate the health effects on humans.

Other studies, however, suggest that rats are poor models for humans in studies of the effects of lead because rodents, unlike humans, excrete lead through bile at a high rate and because of the significant anatomical and physiological differences between rodents and humans that may influence the venous uptake of lead. Studies using young swine as models have been deemed more appropriate for determining the bioavailability of heavy metals in humans because the digestive tracts of young swine are anatomically similar to those in human children.

EPHP also claimed that the low bioavailability of lead in Red Dog ore accounted for the low levels of lead in the blood of Kivalina and Noatak residents. The blood lead levels reported by EPHP were taken from tests the agency conducted in 1990, less than a year after Red Dog mine operations began in December 1989. EPHP indicated that additional testing was conducted in children from Kivalina in 1993, but was limited to 21 children, less than 20 percent of the 1990 sample size. EPHP has not conducted additional comprehensive blood lead level tests in villagers since 1990, and most notably not since mining activities expanded in 1998 and again in 2001. The agency's 2001 review concluded that "blood lead testing is not medically indicated at this time."

Fred Youngs, Ph.D., an occupational and environmental research chemist with the University of Massachusetts, conducted an independent review of the Exponent and E&E studies and the results of the EPHP investigation. He compared the levels of lead and cadmium found in the vegetation samples collected in both studies to the recommended allowances for human consumption set by the *Codex Alimentarius* Commission, a commission established by the United Nations' Food and Agriculture Organization and World Health Organization to develop food standards and guidelines to protect human health. Dr. Youngs also compared the levels of lead and cadmium found in the two studies' samples to levels reported by the U.S. Food and Drug Administration (FDA) in two raw fruits analyzed as part of FDA's ongoing Total Diet Study.

This independent review found that approximately 16 percent of the berry samples collected by E&E contained levels of lead in excess of the maximum levels (MLs) for small fruits and berries set in the *Codex Alimentarius* General Standards for

Contaminants and Toxins in Foods, and 16 percent contained levels of cadmium in excess of the draft *Codex* ML for fruits and vegetables. Approximately 30 percent of the sourdock samples collected by E&E exceeded the *Codex* ML for lead in fruits and vegetables, and 10 percent exceeded the *Codex* ML for lead in leafy vegetables.

Of the salmonberry samples collected by Exponent, approximately 29 percent contained levels of lead that exceeded the *Codex* ML for small fruits and berries, and 43 percent contained levels of cadmium in excess of the draft *Codex* ML for fruits and vegetables.

Dr. Youngs used two raw fruits — apples and strawberries — to compare the FDA study with the other two studies because wild foods (subsistence foods) are not included in the FDA study. He calculated mean values for levels of lead and cadmium in all samples from the E&E and Exponent studies and found that they equaled or exceeded mean values for strawberries and apples from the FDA Study.

Dr. Youngs' analysis also found an anomaly in the E&E data, and after investigating the anomaly, he discovered that the data revealed lead levels in salmonberries collected at Point Hope were nearly an order of magnitude higher than indicated in the E&E report.

Data collected in the NPS, E&E and Exponent studies strongly indicate that vegetation in the region of Red Dog Mine, including plant species harvested for subsistence by local residents, contains elevated levels of lead and cadmium. Evidence points to mine operations as the source of observed elevated levels of heavy metals. In an effort to reduce the release of heavy metal contaminants in the transportation corridor, Cominco replaced its truck fleet in 2001 with side-dumping vehicles that have hydraulically sealed cargo covers. However, more must be done to control pollution sources and prevent contamination.

Additional vegetation sampling is needed — in previously sampled areas and in areas that have not been sampled, especially places where people gather berries and plants for subsistence. This will provide more knowledge of where contamination exists. It will also contribute information needed for strategies to limit further contamination and protect human health and the environment.

The state should make new tests for blood lead levels immediately available to residents of Kivalina, Noatak and Point Hope and to the mine's employees. EPHP's recommendation that "residents of Kivalina, Noatak and Point Hope should continue to eat their traditional foods without restriction" seems ill-advised at best, given the lack of recent data on blood lead levels for the villagers.

Local and state health officials should conduct a health education program to make local residents aware of the findings of the studies performed to date, of the need for further testing of plants and, in the interim, of the need to limit or restrict the areas in which they collect subsistence foods.

The state should make new tests for blood lead levels immediately available to residents of Kivalina, Noatak and Point Hope and to Red Dog Mine employees.

Villagers must be given the opportunity for active, meaningful involvement in monitoring programs related to contamination by heavy metals and in public policy decisions regarding operations at Red Dog Mine.

Villagers must be given the opportunity for active and meaningful involvement in the design and review of ongoing monitoring programs related to contamination by heavy metals and in public policy decisions regarding operations at Red Dog Mine.

I. Background

Red Dog Mine, the world's largest producer of zinc, is located in northwestern Alaska on the western edge of the Brooks Range between Noatak National Preserve to the east and Cape Krusenstern National Monument to the west (see map next page). The mine is approximately 55 miles inland from Chukchi Sea.

Teck Cominco Ltd. (Cominco), a Canadian mining company based in Vancouver, British Columbia, operates the mine. Red Dog ore deposits lie within a 120-mile[2] block of land owned by the Northwest Alaska Native Association (NANA), a Native for-profit corporation created pursuant to the 1973 Alaska Native Claims Settlement Act. In 1982, Cominco entered into an agreement with NANA to develop the ore deposit at Red Dog.[1] Mine development began in 1986 and construction was completed in 1989, the same year that operations and production began.[2]

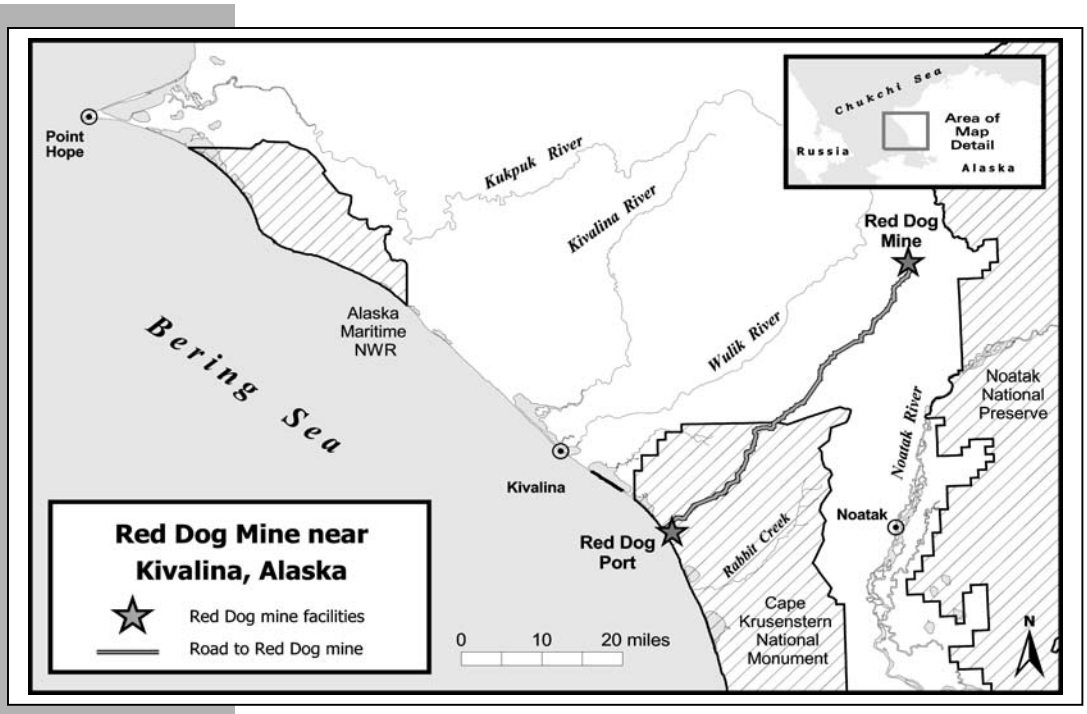
In 1985, Congress granted NANA a 100-year easement for a transportation corridor that bisects the northern portion of Cape Krusenstern National Monument and includes land for a port site inside monument boundaries. The grant exempted the corridor from review under provisions of Title XI of the Alaska National Interest Lands Conservation Act, which require an environmental impact assessment and full public review of proposed transportation and utility corridors across federal lands protected under the Act.[3]

Within the transportation corridor, the State of Alaska financed the construction of a 30-foot wide, 52-mile long all-weather haul road extending from the mine west to the Chukchi Sea, where a shallow-water dock, offshore ore loading facility, fuel distribution and storage systems and other port facilities were built.

Collectively, the corridor and port are known as the DeLong Mountain Regional Transportation System, which is managed by the Alaska Industrial Development and Export Authority (AIDEA).[4] Cominco entered into a contract with AIDEA for a priority, non-exclusive right for use of the system until 2040 to transport ore concentrates over the haul road, store ore concentrates in buildings at the port and load concentrates onto ore ships.[5]

The mine itself encompasses a number of ore bodies that total more than 160 million tons of reserves and resources. The deposit is 15.9 percent zinc and 4.4 percent lead and contains nearly 2.9 ounces of silver per ton.[6] The ore lies close to the surface in a relatively flat area, making open pit mining the method of choice for extraction.[7] After ore is removed from the pit, the rock is crushed. Zinc and lead concentrates, the mine's primary products, are separated in a milling process that utilizes a range of chemicals, including 60-

The transportation corridor, including the heavily traveled haul road and port, is traditionally used by local residents for the gathering of subsistence foods.



70 grams of cyanide per ton of ore. Red Dog produces nearly 20,000 tons of ore concentrates and waste each day.[8] Trucks weighing 100 tons each when loaded leave the mine site every 15 minutes around the clock, taking ore along the 52-mile haul road to DeLong Mountain port, where the ore is stored in two quarter-mile-long buildings that can hold 1.1 million tons of ore concentrates until the product can be shipped.[9] (The port is accessible to ore ships for only about 100 ice-free days per year.[10]) The water at the port is so shallow that the concentrates must be loaded onto small barges for transport to large ore ships anchored approximately three miles offshore.[11]

The nearly continuous heavy traffic along the haul road generates a significant amount of dust from the roadbed and from loss of loaded concentrates as the trucks move up and down the road.[12] To minimize the loss of concentrate and reduce dust emissions, Cominco replaced its older trucks with their open-top containers on tandem tractor-trailers in 2001. The new trucks have hydraulically sealed cargo covers and a side-dumping feature.[13] Cominco also installed washing stations for the trucks at both the mine and the port, but freezing weather conditions soon proved them useless.

Cominco states it is developing other strategies to prevent contamination,[14] but serious concerns have been raised about the release of heavy metals, specifically lead and cadmium, from industrial activities at the mine and from ore truck traffic dust along the haul road and at the port. The transportation corridor, including the haul road and port site, is an area traditionally used by local residents for the gathering of subsistence foods, including berries and plants.

II. Mine Wastes and the Toxics Release Inventory

Under provisions of the federal Emergency Planning and Community Right-to-Know Act of 1986 (Community Right-to-Know Act), industries that manufacture, process or otherwise use toxic substances are required to report each year the locations and quantities of toxic substances released during their operations to the U.S. Environmental Protection Agency (EPA) and the state government in the state(s) where they operate.[15]

The term "release" means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment of any hazardous chemical, extremely hazardous substance or toxic chemical.[16]

Pursuant to the Community Right-to-Know Act, the EPA maintains a list of the substances and quantities of each that industries must report. The Act grants EPA the authority to expand the list of substances, as well as expand the list of industries that must report, and requires the agency to maintain and annually update a database of the release reports it receives.[17] EPA's Toxics Release Inventory (TRI) is the annual compilation of nearly 650 chemicals and chemical categories released by various industries in the United States.

In 1997, EPA expanded the list of industries that must report releases of toxic substances to include the coal and metal mining industries.[18] Effective January 1, 1998, for the first time since mining operations began at Red Dog, Cominco was required to report toxic substances released in the course of operations at the mine. EPA's decision to require reports of mining industry releases for inclusion in the TRI prompted the National Mining Association (NMA) to file a lawsuit in 1998, challenging EPA's authority to extend TRI reporting requirements to the mining industry, EPA's interpretation of TRI reporting requirements to include toxic chemicals placed in containment units at mines and the agency's interpretation that mining companies were required to report toxics produced from the extraction and beneficiation[19] of metal ores. In relation to the latter point, the lawsuit claimed that the toxics contained in the ores were naturally occurring and had not been "manufactured" as defined in the Community Right-to-Know Act.[20]

In January 2001, the federal District Court presiding over the NMA case issued an order and opinion and then a revised order in March 2001 that upheld EPA's authority to extend TRI reporting requirements to the mining industry and EPA's determination that mining facilities must report their releases to land, including into landfills and onsite containment areas. The Court also determined that extraction and beneficiation of undisturbed

Effective January 1, 1998, for the first time since mining began at Red Dog, Cominco was required to report toxic substances released during operations at the mine.

Mine Wastes and the Toxics Release Inventory

ores does not fit the Community Right-to-Know Act's definition of "manufacturing." But the Court made clear in its revised order that its decision did not set aside EPA's determination that mining facilities must report any toxic chemicals generated during extraction and beneficiation that are not present in naturally occurring undisturbed ores (for example, the creation of sulfates from sulfides as a result of the unearthing and processing of metal ores).[21]

TRI reports for Red Dog Mine include toxic releases to land, water and air from waste rock and tailings solids, metal loads from water sources in tailings impoundments, water treatment plant sludge, emissions from power generators and incinerators, fugitive dust emissions, and discharges from sewage treatment facilities. By far, most releases are from waste rock and tailings solids.[22]

In 1998, its first year of reporting, Red Dog Mine's releases totaled nearly 250 million pounds of toxics, the fifth highest total of all metal mines in the nation.[23] The inclusion of the mining industry in the TRI for 2000 pushed Alaska from forty-seventh to fourth place in state rankings for highest total toxic releases. Red Dog Mine's releases accounted for 83 percent of the total releases of toxic substances within Alaska's boundaries.[24] The 2000 TRI shows Red Dog Mine released nearly 445 million pounds of toxics, including 308 million pounds of zinc compounds, 123 million pounds of lead compounds and 2 million pounds of cadmium compounds.

In 2001, Alaska again ranked fourth in the nation for the amount of toxic substance releases that occurred within its borders. More than 522 million pounds of toxic chemicals were released as a result of industrial operations in the state.[25] Of that total, Red Dog Mine was responsible for 432 million pounds, or approximately 83 percent.

In addition, the mine surpassed all other Alaskan mining operations and industries in the total of persistent bioaccumulative toxins reported,[26] releasing more than 128 million pounds of lead compounds and 2.2 million pounds of cadmium compounds.

Table 1 details the releases from Red Dog Mine as reported in EPA's TRI for 2001 and 2002. An onsite release is one that occurs at the reporting facility, while an off-site release refers to a transfer of toxic substances away from the site for disposal. [27]

TRI data clearly show that enormous amounts of toxic substances are generated in the course of mining activities at Red Dog Mine. It is the potential environmental and human health impacts of these releases that have, in turn, generated concern among residents in the region, as well as among federal land managers and state resource agency personnel.

Potential impacts on village drinking water supplies and regional air quality are prominent issues. So are the potential impacts of dust from transportation of ore and other mining activities — the problems that are the focus of this report.

Table 1. Toxic releases (in pounds) from Red Dog Mine, reporting years 2000 and 2001

Total Air Emissions

	2000	2001
Lead	8,290	8,303
Zinc	32,850	32,063
Cadmium	229	225
PBT[a]		9,379
All Chemicals	521,973	524,146

Total Land Releases

	2000	2001
Lead	123,000,000	128,298,825
Zinc	308,000,000	290,902,426
Cadmium	2,080,000	2,214,951
PBT[a]		128,298,825
All Chemicals	444,800,000	431,487,880

Total Water Discharge

	2000	2001
Lead	13	8
Zinc	330	488
Cadmium	12	15
PBT[a]		8
All Chemicals	555	819

Total On-and-Off Site Releases

	2000	2001
Lead	123,008,303	128,307,136
Zinc	308,000,000	290,902,426
Cadmium	2,080,000	2,214,951
PBT[a]		128,308,212
All Chemicals	445,322,528	432,012,845

[a] PBT = Persistent Bioaccumulative and Toxic Chemicals. At Red Dog Mine, these include lead releases. There are no PBT data for 2000.

Since reporting began, data show that Red Dog Mine consistently accounts for the overwhelming majority of toxic chemicals released by *all* industrial operations in Alaska.

III. Living in the Shadow of an Industrial Complex

Red Dog Mine's location (see Figure 1) places it squarely between Noatak National Preserve to the east and Cape Krusenstern National Monument to the west, both units of the America's National Park System and both of which are protected under provisions of the 1980 Alaska National Interest Lands Conservation Act. The road connecting the mine to its port on the Chukchi Sea cuts directly across the northern portion of Cape Krusenstern monument, and the port is located within the monument's boundaries.

The purposes for which the 560,000-acre monument was established include preservation of evidence of prehistoric and historic Native cultures, protection of habitat for marine mammals and populations of fish, birds and other wildlife, and protection of the viability of subsistence resources.[28]

Just about 8 miles east of the mine is Noatak National Preserve, encompassing one of the largest wilderness ecosystems in the National Parks System. The 6.4 million-acre preserve was established to protect the integrity of the Noatak River watershed and "assure the continuation of geological and biological processes unimpaired by adverse human activity," to protect habitat for, and populations of, fish and wildlife, and to protect archaeological resources.[29]

Three Inupiaq Eskimo villages lie within the region that encompasses Red Dog Mine. Nearly all of the residents of two of the villages, Noatak and Kivalina, are shareholders of NANA, the corporate partner of Cominco in the operation of the mine,[30] and a number of villagers are employed as workers at the mine. By virtue of their proximity to the mine and the fact that the economies of their villages are principally based on subsistence, the residents of the three villages also comprise the population most at risk from the potential human health effects of the mine's toxic releases.

The village of Noatak is located on the Noatak River about 45 miles south of the mine and just west of Noatak National Preserve. It was established in the 1800s as a fishing and hunting camp, and because of the abundance of fish and wildlife resources in the region, this village of 428 became a permanent settlement.[31] Red Dog Mine employs many of the village's residents, but subsistence activities are still the central focus of the village's economy and culture.[32] Many of the families living in Noatak travel to fish camps during the summer. Salmon, whitefish, caribou, moose and waterfowl are the primary animal species harvested for subsistence.

Kivalina is 50 miles southwest of Red Dog Mine at the end of an 8-mile long barrier island between the Chukchi Sea and the mouth of the Wulik River. The village

Three Inupiaq Eskimo villages — Noatak, Kivalina and Point Hope — are located in the region that encompasses Red Dog Mine and its operations.

Living in the Shadow of an Industrial Complex

has long been a stopping place for seasonal travel between arctic coastal areas and Kotzebue Sound. (In 1847, a Russian Navy officer's report identified it as "Kivualinagmut."[33]) The economy of this village of 377 people is based primarily on subsistence activities, although Red Dog Mine employs some of its residents.[34] In addition to bowhead and beluga whales, Kivalina residents use seals, walrus, salmon, whitefish, caribou, berries and greens for subsistence. Two of the village's main hunting trails follow the Wulik and Kivalina Rivers.[35] Given the village's proximity to Red Dog Mine and the fact that the village's water supply and many of the species on which villagers rely for subsistence are found within the watershed of the mine and near the DeLong Mountain port, the residents of Kivalina are arguably among the people in the region most at risk from the potential environmental impacts of toxic releases from the mine. Consequently, they have for many years expressed concerns about potential impacts of mining activities on village air and water quality and on resources they harvest for subsistence.[36]

The village of Point Hope is located approximately 80 miles west northwest of Red Dog Mine near the tip of Point Hope, which juts out into the Chukchi Sea and forms the western-most extension of the Northwest Alaska coast. This peninsula is one of the oldest continuously occupied Inupiaq areas in Alaska. Settlements have existed there for at least 2,500 years.[37] The Tikeraqmiut Inupiat of Point Hope depend on marine fish and wildlife species for subsistence. They have been able to retain strong cultural traditions, after more than a century of outside influences, because of the abundance of marine resources in the waters around the peninsula.[38]

There is easy access to marine mammals along the peninsula, with ice conditions that allow boats to be launched into open leads early in spring for the hunting of migrating whales. Historically, inhabitants of the peninsula ranged over an extensive area, south to the Kivalina River and far inland. The current 757 residents of Point Hope use seals, bowhead whales, beluga whales, caribou, polar bears, birds, fish and berries for subsistence.[39]

The impacts of mining activities on the region's water quality are perhaps of greatest concern to local residents. The drinking water supply for the village of Kivalina is drawn from the Wulik River via a 3-mile surface transmission line and is then treated and stored in tanks from which villagers draw water to haul to their homes.[40] Red Dog Mine is located in the watershed of the Wulik River, and Red Dog Creek, which flows through the mine site, is a tributary of the Wulik.

For several years, villagers expressed concerns to Cominco that discharges from the mine were polluting the village's drinking water and impacting fish populations on which villagers depend for subsistence, but they received little or no response from the company.[41] On March 8, 2004, villagers filed a lawsuit against Cominco, asserting nearly 4,000 violations of permits issued under the federal Clean Water Act.

EPA issued two wastewater discharge permits, one for the mine and one for the port, pursuant to Section 401 of the Clean Water Act. The mine's permit allows Cominco to discharge approximately 2.4 *billion* gallons of effluent into the middle fork of Red Dog Creek every year. The permit also sets maximum daily limits for the levels of total dissolved solids, heavy metals and other toxins contained in the effluent. The villagers' citizen lawsuit alleged that between August 1998 and May 2003, Cominco committed 2,322 violations of the provisions of the wastewater permit for the mine, including exceeding the discharge levels for total dissolved solids (in some instances by more than 1500 percent), cyanide and cadmium.[42]

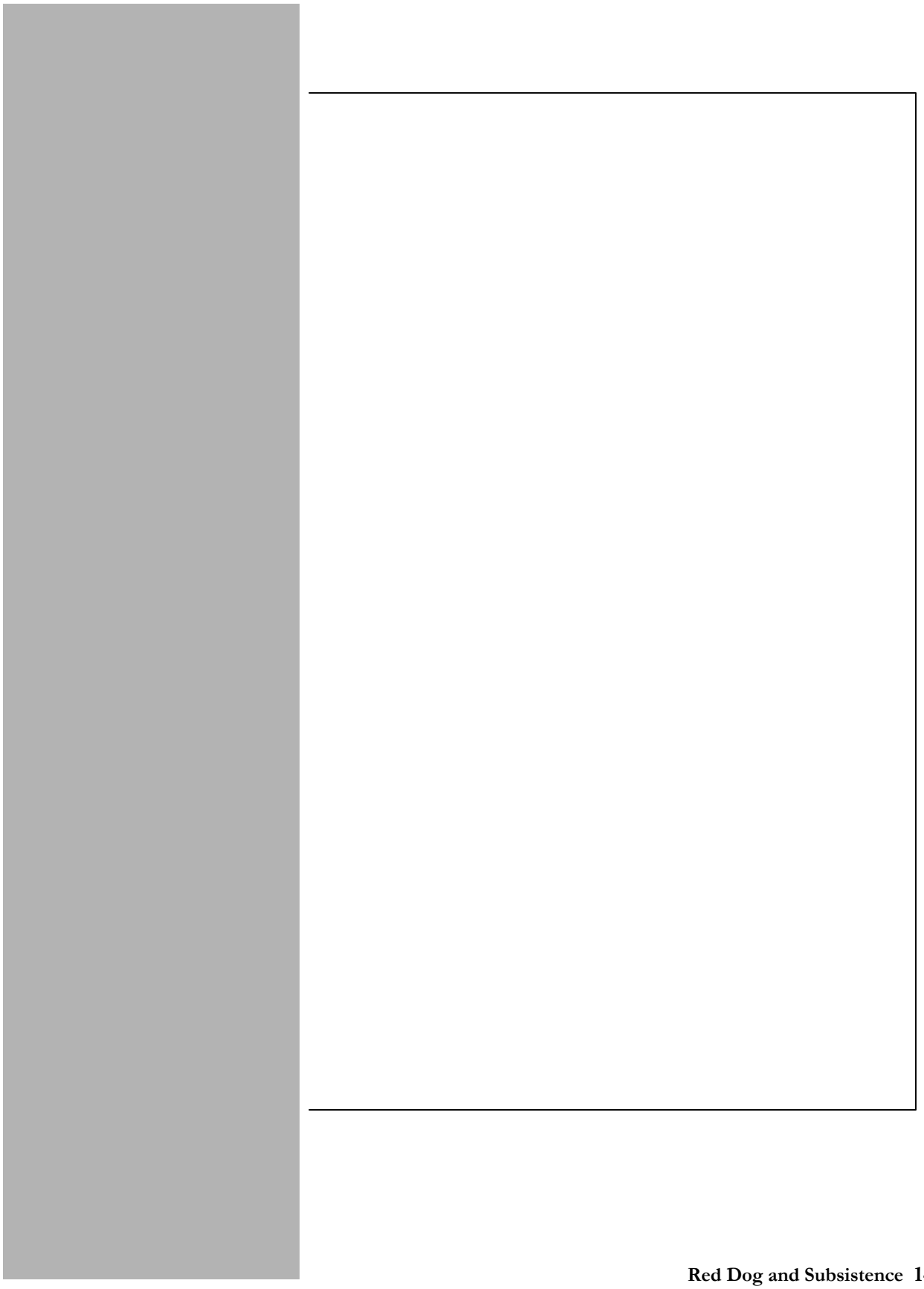
The wastewater permit for the port lets Cominco discharge drainage water from the ore storage buildings directly into the Chukchi Sea or onto the tundra near the port. As with the mine permit, maximum daily limits are set in the port's wastewater permit for levels of heavy metals allowed in the discharges. The lawsuit stated that Cominco violated the provisions of the port permit 1,654 times between May 1999 and May 2003, including the unpermitted discharging of untreated water to the tundra, exceeding the levels of total suspended solids in discharges to the Chukchi Sea and failing to contain a pipeline spill.[43]

Kivalina residents felt compelled to take action to protect resources on which they depend for their lives and livelihoods because of what they determined was a clear lack of action on the part of state and federal agencies charged with protecting their interests.[44] Neither EPA nor the Alaska Department of Environmental Conservation has taken action to enforce the provisions of the mine and port permits. Instead, EPA issued "Compliance Orders by Consent" to Cominco, which extended the deadlines for the company to comply with the permit provisions and relaxed the limits for certain discharge parameters. The agency subsequently modified the Consent Orders to extend the deadlines over an even longer period of time.[45] Even with the relaxation of permit conditions represented by these Consent Orders, Kivalina residents documented in their lawsuit that Cominco committed 64 violations of the mine Consent Orders and 53 violations of the port Consent Order. The lawsuit was pending before the federal District Court in Anchorage, Alaska, as of this writing.

Meanwhile, Kivalina's residents and other residents in the region face another pollution problem arising from Red Dog Mine operations — contamination from dust laden with lead, cadmium and other heavy metals that is generated by the nearly constant movement of ore trucks on the haul road, by loading and unloading of ore trucks and barges at the port and by other mining activities. The area in question includes sites where villagers have traditionally harvested berries, other vegetation, caribou and other animals for subsistence.

Living in the Shadow of an Industrial Complex

On March 8, 2004, villagers from Kivalina filed a lawsuit against Cominco, asserting nearly 4,000 violations of the federal Clean Water Act resulting from operations at Red Dog Mine.



IV. Effects of Lead and Cadmium on Human Health

The concerns of residents regarding the potential effects on human health from pollution generated by mining operations at Red Dog are far from frivolous. A wealth of research indicates that the health effects of at least two of the heavy metals — lead and cadmium —are significant.

Historically, lead has been and continues to be mined for a variety of uses. It was added to gasoline until the mid-1980s and is still used in the manufacture of batteries, industrial paints, ammunitions, aviation parts, medical instruments and computer equipment.[46] Lead particles can come from these products, before and after their disposal, and from mining industry operations. After lead particles are liberated, they easily travel through the atmosphere, settle and readily stick to soil particles.[47] Over time and especially in areas of constant lead-related activity, lead levels can build up in soil, plants and animals. Lead has no characteristic taste or smell, so humans can unknowingly breathe in, eat and drink lead particles.

Once ingested, lead can affect almost every organ of the body. Although it is usually excreted from the body within a couple of weeks after ingestion, continuous exposure can result in accumulation.[48] Lead is typically stored in the bones and teeth. However, it can be liberated throughout the human life cycle and become mobile in the blood.

The kidneys, reproductive organs and neurological systems of the body are particularly sensitive to lead, which can also affect the central nervous system, cause irreversible brain damage and impair the blood-forming system, causing anemia.[49]

People of all ages are susceptible to lead toxicity, but children and developing fetuses are especially vulnerable because they tend to be at a higher risk of exposure and because harmful effects appear at lower blood lead levels.[50] Before 1979, scientists believed blood lead levels of less than 25 micrograms per deciliter (*u*g/dl) did not cause human health problems. Since then, both the Centers for Disease Control (CDC) and the World Health Organization (WHO) agreed that anything above 10 *u*g/dl constituted a "level of concern."[51] As a result, the acceptable blood lead level for children was lowered to ≤10 *u*g/dl, while the acceptable blood lead level for adults remains at ≤25 *u*g/dl.

At the time the change was made, few definitive studies of the effects of blood lead levels below 10 *u*g/dl in children had been completed. The CDC and WHO established the 10 *u*g/dl maximum while simultaneously recognizng that no actual threshold of lead-associated effects may exist.[52] Recent studies indicate that there is no acceptable blood lead concentration thresholds, particularly for children, and that lead-associated impairments may

People of all ages are susceptible to lead toxicity, but children and developing fetuses are especially vulnerable because they tend to be at a higher risk of exposure and because harmful effects appear at lower blood lead levels.

Effects of Lead and Cadmium on Human Health

be both persistent and irreversible.[53] The studies showed that in children with blood lead levels at and above 10 *u*g/dl, IQ scores dropped 4.6 points for each 10 *u*g/dl lead increase.[54] An average 7.4-point decrease in IQ scores was observed in children with blood lead levels ranging up to 10 *u*g/dl.[55] This implies that significant impairment may occur in children at blood lead levels less than 10 *u*g/dl and suggests that, for children at least, there may not be a "safe" exposure level.

Cadmium is often found in association with other heavy metals in the earth's crust, and is released during ore extraction and processing. Once cadmium particles are released, they can drift long distances in the atmosphere; upon settling, they bind strongly to the soil.[56] Plants, animals and fish readily take up cadmium from their environment. Cadmium bioaccumulates (builds up) in tissues and to high levels from years of constant low exposure.[57] People are exposed through breathing in cadmium particles or by eating and drinking substances contaminated with cadmium.

Cadmium causes many short- and long-term detrimental health effects. Acute exposure can result in nausea, vomiting, diarrhea, muscle cramps, excess salivation, sensory disturbances, liver injury, convulsions, shock, renal failure and even death.[58] Long-term exposure to lower levels can cause kidney disease, lung damage, fragile bones and damage to the liver and blood.[59] In addition, preliminary studies indicate that children exposed to cadmium can become hyperactive and have reduced verbal skills and IQ scores.[60]

Preliminary studies indicate that children exposed to cadmium can become hyperactive and have reduced verbal skills and IQ scores.

V. Studies Examine the Impacts of Fugitive Dust from Red Dog Operations

The environmental toxicity of lead and cadmium was the primary reason for concerns about the possible release of heavy metals in airborne dust particles generated by mining activities at Red Dog. Three studies that examined the extent of contamination from dust generated by traffic along the haul road and operations at the port are summarized below.

National Park Service Study

In 2000, the National Park Service (NPS) initiated a study of vegetation in the transportation corridor and port. NPS researchers collected the moss *Hylocomium splendens* and soil samples along six transects in the corridor between the mine and the port. The moss was selected as the sample plant species because it does not take up minerals from soil and groundwater as rapidly as vascular plants; thus, the NPS team was able to distinguish between heavy metals concentrations that occur naturally in the soil and levels that are the result of the deposition of airborne particles.[61]

Keeping in mind that the prevailing winds in the region blow from the south, the researchers drew their transect lines perpendicular to the road, with three on the north side and three on the south side. Samples were collected along the transect lines at sites that ranged from 3-1,600 meters from the road.

Analysis of the samples revealed a gradient of heavy metal deposition, with the highest levels occurring closest to the road and decreasing levels occurring with increasing distances from the road.[62] Specifically, the team found lead levels as high as 430 milligram/kilogram (mg/kg) dry weight of moss samples collected three meters from the road and cadmium levels as high as 12 mg/kg dry weight in the samples collected at this distance.[63]

In their report, the researchers concluded that concentrations of lead and cadmium in the moss samples they collected even at 1,000 and 1,600 meters from the road "…exceed medians (and in most cases maxima) from all 28 countries in the Nordic moss monitoring program, including many of the most polluted countries in Central and Eastern Europe, and all areas of western Russia." [64]

After the release of the NPS report, two additional studies were undertaken in the summer of 2001. The first was done by the consulting firm Ecology and Environment, Inc. (E&E) under contract to the Alaska Department of Environmental Conservation (ADEC). The second was completed by the consulting firm Exponent under contract to Cominco.

In both studies, researchers collected samples of vascular plants, including plants used for

The National Park Service study found heavy metal deposition was highest near the haul road, with decreasing levels occurring as distance from the road increased.

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subsistence. And both studies were expanded to include samples collected beyond the haul road.

E&E Study

ADEC commissioned the E&E study upon the request of villagers in northwestern Alaska to investigate the subsistence foods harvested in areas potentially affected by dust from activities along the haul road and at the port.[65] The E&E study team chose three species of plants used for subsistence to analyze for heavy metals content: sourdock (*Rumex arcticus*), salmonberry (*Rubus chamaemorus*) and blackberry (*Empetrum nigrum*).[66]

The team selected four sites from which to collect samples: an area immediately south of the port next to the port's tank farm (the "Terminal" site); an area that included lands north and south of the port, which are traditional subsistence harvest sites for villagers from Kivalina (the "Port Site"); an area northwest and upriver from the village of Noatak, which is used for subsistence; and a subsistence harvest area west of the village of Point Hope,[67] included at the request of Point Hope residents.[68]

The Noatak site was chosen for statistical control purposes; that is, a site at which heavy metals levels were expected to reflect levels in natural conditions not impacted by mining activities at Red Dog. However, E&E researchers subsequently abandoned use of the Noatak site as a control because the differences in geological conditions and plant community composition between the coastal regions near the port and the inland riverine area of Noatak precluded a valid comparison.[69]

E&E researchers noted that their study was not designed to determine whether dust from port and haul road operations was affecting and accumulating in nearby subsistence foods. Rather, the goal was to determine the similarities and differences in metal concentrations among sampled data sets collected at and near the port, at Noatak and at Point Hope.[70] Because no control data set was available for comparison, the data collected in the study were not compared to background levels; that is, levels found in areas not impacted by Red Dog mining activities. Comparisons were made only among the data collected at each sample site.[71]

At the onset of the study, the state's Environmental Public Health Program was asked to include the study results in its investigation of the risks to human health from the consumption of subsistence foods potentially contaminated by mining activities at Red Dog (see next chapter).[72]

The results of the E&E study showed that the greatest concentration of cadmium in all subsistence food samples was in salmonberries at the Terminal sample site. The greatest concentrations of lead and zinc were found in the sour dock samples collected at the Port sample site, which included the traditional subsistence harvest areas of the residents of Kivalina. And lead concentrations in all subsistence foods sampled at the Port Site were greater than concentrations found in samples from Noatak

and Point Hope.[73] The study also revealed that washing the vegetation samples in the field appeared to have no effect on the concentrations of metals. The research team surmised that a more thorough washing process might have been more effective, but indicated that a simple rinse of subsistence foods would not lower exposure of subsistence users to heavy metals.[74]

Exponent Study

The Exponent research team, contracted by Cominco, collected vegetation samples from sites near the mine, along the haul road and at the port. Berry samples were gathered at varying distances along transect lines perpendicular to the haul road from locations not sampled in the National Park Service study and from four locations close to port facilities near E&E's "Terminal" sample site.[75]

The team chose four species of plants to analyze for heavy metals content: *Hylocomium splendens,* the same moss sampled in the NPS study; the lichen *Peltigera aphthosa*; diamond-leaf willow (*Salix pulchra)*; and salmonberry. The moss was selected because it has been used in long-term atmospheric deposition monitoring programs, and therefore its inclusion allows comparisons of results with the NPS study. The lichen, willow and berry species were selected because they are part of the diet of resident and migratory wildlife in the region.[76] The samples were submitted unwashed for analysis of a range of metals, including aluminum, arsenic, cadmium, calcium, lead, magnesium and zinc.

The results of the Exponent study showed a similar pattern to the findings of the NPS study: the highest levels of metals were found in samples collected closest to the road and port, and decreasing levels occurred with increasing distances from the road and port. This supported the conclusion that the source of the metals contaminants was likely mine traffic and activity at the port. Lead and cadmium concentrations in moss collected along the haul road and at the port were higher than background levels recorded for northern Alaska.[77]

The Exponent team did not compare levels of heavy metals found in moss samples collected closer than 300 meters from the haul road to levels found in Europe, claiming that it was inappropriate to do so since the European study did not include samples closer than 300 meters from any road.[78] In making this judgment, the Exponent team apparently failed to appreciate that the haul road and its impacts on the surrounding area were the *focus* of the NPS study, and it was therefore entirely appropriate to make comparisons of all samples collected to the results of the European study. The Exponent team also noted that dust was shaken from the moss samples prior to analysis in the European study but not from samples collected in the NPS and Exponent studies, concluding that metals concentrations reported in the European study were likely lower than would have been found in undusted samples.[79]

In comparing levels of heavy metals they found in salmonberries to levels found in the

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The study by Ecology and Environment, Inc. revealed that washing the vegetation samples in the field appeared to have no effect on the concentrations of metals.

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E&E study, the Exponent research team asserted that the E&E study team had selected Noatak and Point Hope as control or reference sites,[80] making heavy metal levels in samples collected at these sites normal background or reference levels.

This assertion was contrary to the E&E report (see above). Nonetheless, the Exponent team reported that lead levels in all the salmonberry samples they collected at the port exceeded levels the E&E study found in salmonberry samples at Noatak and Point Hope. And the E&E cadmium levels in salmonberry samples collected at two of their three port sample sites exceeded levels reported by the E&E team for Point Hope and Noatak.

Lead concentrations found in all salmonberry samples collected on the haul road exceeded levels for Point Hope and Noatak, and cadmium levels in salmonberry samples collected within 100 meters of the road were greater than levels for Noatak and Point Hope.[81]

VI. State Environmental Public Health Investigation

After the release of the NPS study, the Alaska Department of Health and Social Services' Environmental Public Health Program (EPHP) initiated an investigation to determine if mining operations at Red Dog Mine were exposing local residents to risks from heavy metal contaminants.[82] EPHP reviewed the data from the NPS, E&E and Exponent studies and compared levels of heavy metals found in salmonberry samples in the E&E and Exponent studies to levels found in berries collected in 1998 in the Yukon and Northwest Territories as part of the Arctic Monitoring and Assessment Programme (AMAP).[83]

EPHP reviewed Cominco data regarding blood lead levels of mine workers and heavy metals in water samples the company collected from the Wulik River and Kivalina's village water tanks. The agency also examined data gathered by the Alaska Department of Fish and Game on levels of heavy metals in the tissues of caribou and fish.[84]

In addition to the data review, EPHP evaluated whether "exposure pathways" existed that would cause residents to be exposed to heavy metal contaminants from Red Dog mining activities. EPHP's definition of exposure pathway included the following elements: (1) a source of contaminants, (2) an environmental medium such as air or water that contains or moves contamination, (3) a point such as a river where people contact contaminated media, (4) an exposure route such as eating contaminated berries or drinking contaminated water and (5) people who come in contact with the contaminants. An exposure pathway is not complete if any one or more of these elements is missing.[85]

EPHP concluded that the levels of heavy metals in the drinking water of the village of Kivalina were low and did not pose a health threat, that the heavy metals levels found in fish from the Red Dog mine area and surrounding watershed were low and did not pose a public health threat, that heavy metals levels in caribou tissue samples were low and did not constitute a public health threat and that levels of heavy metals found in berries sampled from the area were low and did not constitute a public health threat.[86]

Most significantly, EPHP asserted that the form of lead found in the ore at Red Dog had a low bioavailability, meaning it occurs in a form not easily absorbed by living organisms. This assertion was based on studies where rats were used to examine absorption rates of lead from Skagway, Alaska, and Red Dog Mine.

In its report, EPHP stated that because levels were low in all sources of contaminants examined, that because the agency determined the lead in the ore at Red Dog had a low bioavailability and that because public access to

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Red Dog Mine, the haul road and the port was limited, "There are no identified exposure pathways from Red Dog Mine to the residents of Noatak and Kivalina. Exposure monitoring by blood level testing is not medically warranted at this time."[87]

The agency ended its report with a recommendation that "residents of Kivalina and Noatak should continue unrestricted harvest and consumption of subsistence resources in the area."[88]

Alaska's state Environmental Public Health Program reviewed the data from studies completed for Cominco and the Alaska Department of Environmental Conservation and, despite the evidence of elevated levels of toxic chemicals in traditional subsistence areas, declared that "residents of Kivalina and Noatak should continue unrestricted harvest and consumption of subsistence resources in the area."

VII. Independent Analysis

Reviews of the EPHP report revealed a number of insufficiencies and inconsistencies in the data presented and the assumptions made, casting doubt on some of the agency's conclusions. This prompted Alaska Community Action on Toxics (ACAT) to sponsor an independent review of the E&E and Exponent studies and an independent evaluation of the conclusions of the EPHP investigation. ACAT asked Fred Youngs, Ph.D., an occupational and environmental research chemist at the University of Massachusetts Lowell, to conduct the analysis. His findings are summarized below and presented in more detail in the Appendix.

For purposes of comparing data from the two studies in his analysis, Dr. Youngs referred to samples collected from E&E's "Port Site" sample area (the area that includes Kivalina's subsistence harvest sites) as "Kivalina" samples and samples collected from E&E's "Terminal" sample area and Exponent's "port site" sample area as "Port" samples. Dr. Youngs determined that the vegetation samples collected in both the E&E and Exponent studies had higher than normal levels of lead and cadmium. He reached this conclusion after comparing the results of both studies to standards and guidelines set by the United Nations' *Codex Alimentarius* Commission for maximum acceptable levels of heavy metals in foods and to data collected by the U.S. Food and Drug Administration in an ongoing study of contaminants in the U.S. food supply.

Dr. Youngs' analysis also found an anomaly in the E&E data, and after investigating the anomaly, he discovered the data revealed lead levels in salmonberries collected at Point Hope were nearly an order of magnitude higher than indicated in the E&E report (see Appendix).

Guidelines of the *Codex Alimentarius* Commission

The *Codex Alimentarius* Commission was established by the United Nations' Food and Agriculture Organization and World Health Organization to develop food standards and guidelines to protect human health. The Commission has produced a comprehensive set, and to date the only set, of standards and guidelines for acceptable levels of heavy metals in fruits and vegetables. These are published in the *Codex Alimentarius*, a compilation of the Commission's approved food standards and guidelines.

Acceptable levels of contaminants and toxins in foods are expressed as maximum levels (MLs) in the *Codex*. The *Codex* ML for lead is 0.2 mg/kg for small fruits and berries, 0.1 mg/kg for fruits and vegetables and 0.3 mg/kg for leafy vegetables. The Commission has drafted a set of MLs for cadmium that are scheduled to be reviewed

and approved by Commission members later this year. The draft *Codex* ML for cadmium is 0.05 mg/kg for vegetables and 0.2 mg/kg for leafy vegetables.[89]

Thirteen (15.9 percent) of the 82 berry samples collected in the E&E study equaled or exceeded the maximum levels for lead and cadmium set in the *Codex Alimentarius*. All of the E&E berry samples that exceeded *Codex* MLs for lead and cadmium were from the Terminal site (identified in Youngs' report as the "Port" site) and the Point Hope site. Twenty nine percent of the salmonberry samples collected in the Exponent study equaled or exceeded the *Codex* ML for lead, and 28 percent exceeded the draft *Codex* ML for cadmium.

Twelve (30 percent) of the sourdock samples collected in the E&E study equaled or exceeded the *Codex* ML for lead in fruits and vegetables, and four samples (10 percent) equaled or exceeded the *Codex* ML for lead in leafy vegetables. Two (28 percent) of Exponent's samples equaled or exceeded the draft maximum level for cadmium.

FDA's Total Diet Study

As part of its ongoing Total Diet Study, the U.S. Food and Drug Administration (FDA) collects food samples four times a year from supermarkets and grocery stores in four geographic areas of the United States for analysis of various contaminants and nutrients. The study was initiated in 1960s, and the agency updated its food sample list and study protocol in 1991.

Subsistence foods are not included in the Total Diet Study. So to compare results from the E&E and Exponent studies to FDA information on levels of lead and cadmium, Dr. Youngs used data from the Total Diet Study collected after 1991 for two raw fruits, strawberries and apples.

Mean values for lead and cadmium levels in all subsistence food samples collected in both the E&E and Exponent studies equaled or exceeded mean values for lead and cadmium levels found in strawberries and apples in the FDA study. The lowest mean value for lead levels in salmonberries was found in berries collected at Noatak and was approximately equal to the FDA mean value for lead levels in strawberries and apples. The lowest mean value for cadmium levels in salmonberries was found in the Kivalina subsistence harvest areas, and it was approximately 1.4 times higher than the FDA mean value for cadmium levels in strawberries.

Critique of EPHP Report

In its work, EPHP used a data set compiled by M. Gamberg for the Arctic Monitoring and Assessment Programme that included the results of an analysis of 88 berry samples collected in the Yukon and Northwest Territories. In comparing the E&E data to the Gamberg data, EPHP assumed that the Gamberg data set represented naturally occurring levels of heavy metal contaminants in an Arctic environment, apparently failing to recognize the extensive level of open pit gold and diamond mining that exists in northwestern Canada and without considering the likelihood that some of the samples in the Gamberg data base

had been collected in areas with active mines.

But even if the Gamberg data were representative of normal background levels, an examination of the data for salmonberries in both the E&E and Exponent studies reveals that, with the exception of the E&E samples collected at Noatak, mean lead levels in all the samples from both studies were higher than the Gamberg mean. And mean cadmium levels in all samples, except for the Exponent sample taken on the haul road transect at 100 meters, were greater than the Gamberg mean. Still, EPHP concluded that the "concentrations of heavy metals detected in the salmonberries [were] consistent with typical background levels and do not pose a public health concern."[90]

EPHP also assumed that because the levels of heavy metals concentrations in washed and unwashed vegetation samples collected in the E&E study were similar, "little atmospheric deposition has occurred on the salmonberries." This assumption ignores the conclusion of the E&E study team that "…rinsing the samples was most likely ineffective in reducing concentrations of metals or washing away any metal-laden dust that may have settled on subsistence foods."[91]

Bioavailability of Lead In Red Dog Ore

Perhaps the most significant factor EPHP considered in reaching its conclusions was its own determination that the lead found in the Red Dog ore body is in a form that not easily absorbed in living tissue. To support this conclusion, EPHP cited studies conducted by the National Institute of Environmental Health Sciences' National Toxicology Program (NTP) on the bioavailability of lead found in lead ore concentrate from mining operations near Skagway, Alaska, and from Red Dog Mine.

The NTP's Skagway study was published in 1993. When EPHP conducted its 2001 investigation of the potential public health threats posed by Red Dog Mine, the NTP study on Red Dog ore had not yet been reviewed. However, NTP provided a copy of its contractor's report to EPHP, and the agency determined that the results were directly comparable to the Skagway study. EPHP's report stated that the lead samples analyzed from Red Dog and Skagway had similar compositions; that is, both ore bodies were high in lead sulfide or galena, which, the studies showed, is more insoluble and has a lower bioavailability than lead acetate or lead oxide.

EPHP then concluded that lead released into the environment from Red Dog mining operations posed little health risk to local residents. The agency cited as proof its own 1990 blood studies of Kivalina and Noatak residents,[92] which showed low blood lead levels among the villagers tested. However, at the time of the testing the Red Dog Mine had been in operation for less than a year. EPHP indicated that additional testing was conducted to determine blood lead levels in children in Kivalina in 1993, but that testing was limited to 21 children, less than 20 percent of

Independent Analysis

Independent analysis of the results from the state commissioned study and the study sponsored by Cominco showed that many of the samples collected equaled or exceeded the *Codex* acceptable levels for lead and cadmium.

Independent Analysis

the 1990 sample size. EPHP has not conducted additional comprehensive blood lead level tests for villagers in the region since 1990, most notably not even after mining activities were expanded in 1998 and again in 2001.

A review of the Skagway lead ore study cited by EPHP reveals that the researchers fed male rats lead sulfide, lead oxide, lead acetate and the Skagway ore concen-trate.[93] Researchers found that the blood lead levels of rats fed the lead sulfide and Skagway ore were eight times lower than the levels found in rats fed lead acetate or lead oxide.

But the authors stated that while the lead sulfide and Skagway ore doses resulted in lower blood lead levels, lead from these sources was bioavailable and accumulated, generally in proportion to dose, in bone and kidney tissue.[94] The authors also found that the possibility of prolonged exposure to low levels of less soluble forms of lead such as lead sulfide, which result in the accumulation of lead in bone and kidney tissues to toxic levels, has yet to be investigated.

The NTP studies on Skagway and Red Dog ore concentrates, as well as many other lead-sulfide toxicity studies, used rats as models for predicting potential human health effects. Other recent studies indicate that rats are poor models for the human digestive tract, primarily because rodents, unlike humans, excrete lead through bile at a very high rate and because of significant anatomical and physiological differences between rodents and humans that could influence the venous uptake of lead.[95]

The results of studies using young swine as models for humans (the digestive tracts of young swine are similar to those in human children) indicate that blood absorption rates for lead sulfide were lower than those of lead acetate by a factor of less than two, rather than lower by a factor of eight as was the case in the Skagway study on rats.[96]

Given the conflicting evidence on bioavailability of lead sulfide, it would seem imprudent at best to make determinations about the bioavailability of lead from Red Dog ore concentrate.

Moreover, it makes little sense to base such determinations on the unpublished 1993 NTP study, which used ore concentrate that may not be representative of the current ore concentrate being transported up and down the haul road.[97]

In his review of the EPHP investigation report, Dr. Youngs concluded that "the true bioavailability of the lead from Red Dog Mine is at best unclear and may be significantly higher than previously estimated."

VIII. Conclusions and Recommendations

Information to date indicates that levels of lead and cadmium found in vegetation in the vicinity of Red Dog Mine, along the haul road connecting the mine to DeLong Mountain port and at the port are higher than naturally occurring levels. Data also indicate that operations associated with the mine are the source of the observed elevated metal levels.

But there is conflicting evidence, as well as a clear lack of evidence, to make a definitive judgment about the risk that mining activities at Red Dog Mine pose to residents living in the region and to the wild foods on which they depend for subsistence. A number of steps should be taken to better understand and limit this risk:

1. The state should make new tests for blood lead levels immediately available to residents of Kivalina, Noatak and Point Hope.

2. The state and Cominco should immediately inform residents of Kivalina, Noatak and Point Hope of the results of studies performed to date and of the detrimental effects that lead and cadmium have on human health.

3. The state should advise villagers to limit harvest of subsistence foods in areas — along the haul road and in the Kivalina subsistence harvest sites near the port — where lead and cadmium levels in sampled subsistence plants were found to be higher than normal.

4. The state should examine data from Point Hope to determine if the high levels of lead are naturally occurring or if contaminants from mining operations are being carried through the air

5. The state should take samples of the ore concentrate currently being transported on the haul road to determine its composition and conduct new studies — using young swine, not rats, for models — on the bioavailability of the ore concentrate.

6. The state should conduct additional sampling of vegetation in areas that were previously sampled to develop a more comprehensive database for evaluations of heavy metals levels in subsistence foods.

7. Sampling should be extended to other subsistence harvest areas identified by local residents.

8. The state should establish an ongoing monitoring program that includes sampling of plants and the tissues of fish and wildlife that are used for subsistence as well as sampling of drinking water.

Conclusions and Recommendations

9. All environmental and health assessments conducted by the state and Cominco should be peer-reviewed by independent scientists, including academic scientists and local experts with traditional knowledge.

10. Cominco should aggressively pursue all means to control fugitive dust emissions from activities at the mine, along the haul road and at the port.

11. Cominco and the state should develop a mechanism for providing meaningful public input into decisions regarding operations at Red Dog Mine. The objective is to give the people most directly impacted by mining operations an opportunity to be involved in decisions regarding those operations. At a minimum, local residents should be engaged in the design of monitoring programs and the review of the results of those programs. As well, local residents should be given ample opportunity to review mining permits and permit compliance and proposed plans for the expansion of and changes in ongoing mining operations.

A number of actions can be taken to better understand and limit the risks that Red Dog mining operations pose to people in the region and to the wild foods on which they depend for subsistence. Among those actions, and contrary to the advice of the Alaska Environmental Public Health Program, the state should advise villagers to limit harvest of subsistence foods in areas where lead and cadmium levels in sampled subsistence plants were found to be higher than normal.