Yellowknife Arsenic Soil Remediation Committee

- In 1998, the Canadian Council of Ministers of Environment adopted national soil remediation guidelines. The standard of 12 parts per million (ppm) was established for areas that do not have high background levels of arsenic present. Those areas, such as Yellowknife, with high background levels are to establish appropriate guidelines that reflect local conditions.
- The Yellowknife Arsenic Soil Remediation Committee was formed in 1998 to assess levels of inorganic arsenic in Yellowknife soils and to develop region-specific remediation guidelines for arsenic contaminated soil.
- The committee is a multi-stakeholder group with representatives from federal and territorial government departments and agencies, the City of Yellowknife, and Aboriginal, mining, and environmental organizations.
- In February 2001, the committee contracted Dr. Mark Richardson of Risklogic Scientific Services to conduct an environmental and health risk assessment for the area around Yellowknife, and to develop remediation standards for arsenic.
- Risklogic focused on soil arsenic levels measured within the city limits of Yellowknife, as well as industrial land in and around, the two trailer courts located on the Con Mine property. Other parts of the Con Mine property, as well as the Giant Mine property, are excluded from the study.
- YASRC held a public meeting in May 2001 to discuss the risk assessment process.
- Results of the assessments and recommended remediation guidelines were made available to the public in April 2002.
- Comments on the remediation guidelines are being accepted until May 31, 2002.
- The remediation guidelines will be forwarded to regulatory agencies with the recommendation that they form the basis of restoration planning. These agencies include:
    - Mackenzie Valley Land and Water Board – responsible for issuing permits and licences
    - Department of Indian Affairs and Northern Development – responsible for issuing leases for Crown land
    - GNWT Department of Municipal and Community Affairs – responsible for issuing leases for Commissioner's land
    - GNWT Department of Resources, Wildlife and Economic Development – responsible for dealing with contamination on private lands within municipalities

You can forward comments on the remediation guidelines to:

Stephen Harbicht, Chair, YASRC
by fax (867) 873-8185
or by email to stephen.harbicht@ec.gc.ca

Arsenic Fact Sheet

Arsenic is a natural element widely found in the earth's crust. There are trace amounts of arsenic in all living matter. Not all arsenic is toxic. The body can't absorb some forms of arsenic and, if ingested, it will pass right through the body.

Inorganic Arsenic
Arsenic is usually found in the environment combined with other elements such as oxygen, chlorine and sulphur. Arsenic combined with these elements is called inorganic arsenic. It occurs naturally in soil and in many kinds of rocks, especially in minerals and ores that contain gold, copper or lead. The Giant and Con Mines tapped the gold deposits around Yellowknife. Both mines used ore-roasting to purify the ore before extracting gold. A by-product of ore-roasting was inorganic arsenic, some of which was released into the atmosphere. The process was stopped at Con Mine in 1970 and Giant Mine in 1999.

Arsenic in Yellowknife Soils
Soils in the vicinity of arsenic-rich geological deposits may contain higher levels of arsenic. The ore within the bedrock of Yellowknife contains arsenopyrite, a naturally occurring mineral of iron, sulphur and arsenic. The arsenic found in the rock is in a stable form, and does not present a health hazard.

Natural Levels of Arsenic
A review of the available data concluded that the average natural background concentration of arsenic in the soils in and around Yellowknife is about 150 parts per million (ppm). This is far higher than natural arsenic levels found in agricultural soils of southern Canada, where background levels are usually less than 10 ppm. Higher levels are found in other areas with mineral deposits such as Cape Breton.

Recommended Soil Remedial Guidelines
The Yellowknife Arsenic in Soil Remediation Committee is recommending the following remediation guidelines for areas where arsenic levels exceed 150 ppm:

- 160 ppm for residential areas
- 340 ppm for industrial lands (mining properties)
- 220 ppm for the proposed boat launch area on the Giant Mine property

Soil Testing
For a cost of $60, residents who are concerned soil in their yards or driveways may be above the recommended level of 160 ppm can have their soil tested at the Taiga Lab in Yellowknife. Contact the Taiga Lab at 669-2780 for details on soil testing.

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Yellowknife Arsenic Soil Remediation Committee

Arsenic in Yellowknife soils

An assessment of risks to human health and the environment, and proposed remediation objectives

OVERVIEW

Arsenic is a naturally-occurring element. Elevated levels of arsenic can be found in bedrock, especially in gold deposits and in the soil overlying such deposits. Extensive gold deposits are found in the Yellowknife Greenstone Belt—the geological formation made up of volcanic and mineral deposits upon which the city of Yellowknife is built.

Giant Mine and Con Mine tapped gold deposits in the Greenstone Belt to become, at one time, two of the most significant gold producers in Canada. Con Mine began operating in 1938, followed by Giant Mine a decade later. Both mines employed ore roasting, a process used to purify the ore before extracting gold. Ore roasting released inorganic atmosphere into the atmosphere. The process was stopped altogether at Con Mine in 1970, and at Giant Mine in 1999.

In 1998, the *Yellowknife Arsenic Soil Remediation Committee* (YASRC) was established to assess and provide recommendations for the management of the arsenic in soils resulting from the mining operations in and around Yellowknife. YARSC is a multi-stakeholder group with representatives from federal and territorial government departments and agencies, the City of Yellowknife, and Aboriginal, mining, and environmental organizations.

In 2001, YASRC commissioned Ottawa consultants *Risklogic Scientific Services Inc.* to investigate the potential risks associated with the presence of arsenic in Yellowknife. Specifically, *Risklogic* was to answer four primary questions:

I. What is the natural level of arsenic in local soils (background level)?
II. What are the potential health risks posed to residents of Yellowknife by the area's arsenic in soils?
III. What are the potential ecological risks (to wildlife)?
IV. What should be the remediation objectives (i.e. what level of arsenic can safely be left behind)?

Naturally Occurring Arsenic Levels In Local Soils

The first question to answer when assessing potential man-made risks posed by industrial activity and pollution is "What is the natural, baseline concentration of arsenic in the soil?" To answer this question, a variety of published and unpublished studies and data were reviewed. Based on the available data and, in particular, on data collected by the Geological Survey of Canada, *Risklogic* concluded that the

average natural background concentration of arsenic in the soils in and around Yellowknife is about 150 ppm, and can range much higher.

In fact, naturally occurring arsenic in soils in the Yellowknife area, well away from the areas of mining impact, has been measured at levels up to and exceeding 1,500 ppm. This is far higher than natural arsenic levels found in agricultural soils of southern Canada, for which the Canadian Council of Ministers of the Environment (CCME) determined a usual natural background level of less than 10 ppm. Nor is it unusual. Other areas with mineral deposits, such as Cape Breton and other parts of the Northwest Territories, have high naturally-occurring arsenic levels.

POTENTIAL HUMAN HEALTH RISKS

Residents of Yellowknife may be exposed to arsenic in a variety of ways: unintentionally ingesting soil and dust, eating vegetables from backyard gardens, eating locally-hunted game, inhaling dust from unpaved roads, or absorbing arsenic from water or sediment while swimming or wading. Additionally, arsenic is a natural element, present in all soils, and found in minute amounts in virtually all foods. This exposure exists for all Canadians, regardless of where they reside.

Potential daily arsenic exposures and risks to Yellowknife residents, and to residents of the Con Mine trailer courts, were found to be high when compared to other parts of Canada. However, this is mostly due to the naturally high background levels of arsenic in the Yellowknife area.

As indicated earlier, the baseline concentration for arsenic in soils in the Yellowknife area is 150 ppm. *Risklogic* then focused on the soil arsenic levels that have been measured within the city limits of Yellowknife. Selected areas of tailing deposits and sediments that might be frequented for wading were also considered.

(Areas of very high contamination on the Con and Giant Mine properties, and specific sites such as Rat Lake, were not included in the study. They are the subject of specific direct investigation and discussion within the community and will be considered elsewhere. However, proposed remediation objectives, discussed below, may help in resolving those issues.)

Within the general boundaries of the city of Yellowknife, and in areas that are or could be routinely visited by residents (residential areas, commercial areas, undeveloped land open to public access) it was found that the arsenic level in the soil ranged between a low of 3.5 ppm to a high of 1,570 ppm, with an average of 122 ppm.

The TRAiler courts and an area nearby were found to have soil arsenic levels between 4 ppm and 4950 ppm, with an average of 404 ppm. The area near the trailer courts is thought to have higher arsenic levels because of the release of mine tailings onto the ground.

Drinking Water And Locally Caught Fish Are Safe

Two sources that were not found to present any potential increased exposure in the Yellowknife area are drinking of tap water and eating locally-caught fish. Levels of arsenic in drinking water and fish were found to be no greater in Yellowknife than elsewhere in Canada. Further, when fish absorb arsenic, the arsenic is changed to a non-toxic organic form.

Estimated Risks of Cancer

Health Canada has determined that arsenic is a substance that can cause cancer in humans. Studies of a population in Taiwan that has high levels of arsenic in its drinking water show increased rates of a form of skin cancer. Health Canada has also concluded, based on epidemiological studies in workers, that the inhalation of arsenic can lead to lung cancer.

Based on this information, an assessment was undertaken to estimate the risk of these cancers faced by Yellowknife residents due to exposure to arsenic in soils, sediments, and locally grown foods. For purposes of this risk assessment, 100% of ingested arsenic, irrespective of source (soil, sediment, game or produce), was assumed to be absorbed. The rate of such absorption is certainly less than 100%, but there were no reliable data from Yellowknife to refine this assumption.

The potential skin cancer risks for residents of Yellowknife were estimated for ingesting arsenic (in soil, backyard vegetables and local game) as well as for absorbing arsenic through the skin (from wading, swimming and from dust and dirt that contacts the skin). This cancer risk was estimated to be about 9 in 10,000

residents of Yellowknife who are exposed for a 70 year lifetime. (For the residents of the Con Mine trailer courts, this risk was slightly higher, at about 10 in 10,000 persons exposed over a lifetime, owing to the higher soil contamination in the area of the trailer courts.) This risk is similar to the estimated cancer risk experienced by all Canadians as a result of the intake of arsenic with the typical Canadian diet. Arsenic is a natural element and occurs in virtually all foods. This is also the same level of risk associated with the current Canadian drinking water quality standard for arsenic, a standard that is defined by available treatment technology, not risk.

Potential lung cancer risks were also estimated due to inhalation of arsenic with suspended dust. For Yellowknife residents, the estimated cancer risks were about 1 in 1 million persons exposed, and about 3 in 1 million for the Con Mine trailer court residents. Again, the risks for residents of the trailer courts were slightly higher because of the higher soil arsenic levels near the trailer courts. Health Canada considers estimated cancer risks of less than 10 in 1 million to be "essentially negligible".

The final point to keep in mind is that cancer risk estimation is very conservative, assuming that there is some risk of cancer at any level of exposure other than zero. This conservative approach is thought to over-predict the actual number of cancers that would actually occur, but is used to ensure that, if any remediation is conducted, the remediation objectives are based on the safest, most conservative levels.

Health Effects Other Than Cancer

Arsenic can also cause health effects other than cancer. The effect that appears to occur at the lowest chronic (lifetime) exposure levels is keratosis, or thickening and darkening of the skin. This effect was also observed in the Taiwanese population with arsenic-contaminated drinking water. For this reason, the non-cancer health effects of arsenic were also considered in the Yellowknife study.

Health Canada has not established a tolerable daily intake for the non-cancer effects of arsenic, but the U.S. Environmental Protection Agency (EPA) has. The tolerable daily intake level set by the EPA is 3 times lower than the dose level that was free of effects in the Taiwanese population. This tolerable daily intake is also almost 50 times lower than the lowest dose that was shown to cause keratosis in that same population. Therefore, this tolerable daily intake does not distinguish between health

and disease. Rather, it is a conservative benchmark that is considered to be free of health effects of any kind.

Risklogic assessed the risk of exposure for toddlers as being the greatest, since they are known to ingest more soil than adults, and because their intake of air and food is greater when considered on a per body weight basis. Toddlers living in the Con Mine trailer courts were estimated to have an exposure almost 7 times greater than the tolerable daily intake for inorganic arsenic as set by the U. S. EPA. Toddlers for the greater Yellowknife area were estimated to have an arsenic intake about 4 times greater than the U.S. EPA tolerable daily intake. Again, this exposure is higher than elsewhere in southern Canada, but is predominantly due to the high natural arsenic levels from the mineral deposits of the Yellowknife Greenstone Belt.

POTENTIAL RISKS TO THE ENVIRONMENT

Effects On Wildlife

The assessment of potential impacts on wildlife focused on two bird species and two mammal species that were considered to be representative of wildlife in the Yellowknife area: spruce grouse and goshawk, lynx and snowshoe hare. These species include both herbivores and carnivores, predators and prey. (Previous studies had already demonstrated that arsenic contamination of local fish did not exceed levels measured in other parts of Canada.)

Goshawks can be year-round residents of the NWT. They are North America's largest woodland hawk species, and they are carnivores. Spruce grouse is one of the goshawk's major prey.

The spruce grouse feeds on a variety of plants that may take up arsenic from the soil.

Lynx are year-round residents of the NWT, and their primary food is the snowshoe hare.

The snowshoe hare also feeds on a variety of plants that may take up arsenic from the soil.

Animals ingest soil as they groom themselves and as they feed. In particular, birds may intentionally eat dirt and grit to aid digestion. Herbivores, such as spruce grouse and hare, will also ingest arsenic along with their plant diet, since plants take up arsenic from the soil in which they grow. Some of the arsenic ingested by grouse and hare will enter their tissues and be eaten by hawks and lynx as they feed on their prey. Animals will also ingest some arsenic as they drink from local lakes and rivers.

Based on information about how much soil animals ingest, how much water they drink and food they eat, *Risklogic* estimated their daily exposure to arsenic. This daily intake was then compared to exposure levels thought to be free of harmful effects in wildlife species. For goshawk and spruce grouse, the daily intake of arsenic was estimated to be less than ¼ of the doses considered to be safe for those two species. However, exposures in lynx and hare were higher than their reference dose by about 2 ½ times.

It is uncertain whether mammals such as lynx and hare will have real health effects from the arsenic in soils around Yellowknife. However, some direct studies of wildlife in the Yellowknife area are underway or recently completed, and these will provide a more direct and meaningful determination of the risks that arsenic presents to wildlife in the Yellowknife area. Also, if future research of this type were planned, mammals, rather than birds, would be more relevant to study.

REMEDIATION OBJECTIVES

The national soil quality guideline derived for arsenic by the Canadian Council of Ministers of Environment (CCME) is 12 ppm. It is based on an assumed background (natural) arsenic concentration of 10 ppm. However, CCME recognizes that inorganic elements, such as arsenic, vary widely in natural concentration from one region to another. Also, CCME recognizes that the frequency, duration and intensity of use of a particular contaminated site or area may be very different from the assumed 24 hours per day, 365 days per year used to derive the national guideline.

Naturally-occurring levels of arsenic in soil in the Yellowknife area are much higher than in southern Canada. Therefore, a guideline based on a natural background level of 10 ppm is not applicable to the situation in Yellowknife.

Further, although the CCME national guideline is based on a hypothetical risk level of 1 in 1 million, a risk level of 1 in 100,000 or lower is considered by Health Canada to be "essentially negligible".

Following methods prescribed by CCME to account for local natural background and the other site-specific factors and considerations, Risklogic derived site-specific human health-based soil quality remediation objectives for soil-borne and sediment-borne inorganic arsenic in soils in the Yellowknife area.

Residential Areas

Generally, arsenic levels within the city of Yellowknife were within levels that occur naturally. However, some areas of Yellowknife are known to be contaminated with mine tailings, mine waste rock, and other debris that was industrial in origin. Therefore, *Risklogic* was asked to recommend a remediation objective for arsenic in residential areas that was reasonable with respect to natural background levels but still conservative with respect to health protection.

Although natural levels of arsenic in soil of the Yellowknife area reach and exceed 1,500 ppm, this is considered too high a level to serve as an acceptable remediation standard. It is therefore proposed that the arsenic remediation objective for residential properties would be 160 ppm. This was established as the average background level of 150 ppm + 10 ppm. This level represents an incremental (additional above natural background) skin cancer risk of 1 in 100,000 persons.

(The proposed level for residential properties was based on the fact that yard soil is accessible for only five months per year, due to climatic factors such as snow and ice cover.)

The proposed level does imply that some remediation of natural contamination may occur, but this was considered a reasonable 'error' that ensures a conservative approach to health protection in the area.

Proposed Boat Launch Area

Development has commenced for a public boat launch on the former Giant Mine property. Besides the proposed launching and trailering of boats, the area is currently used for recreational fishing, wading and swimming. It was assumed that a

dedicated fisher or wader/swimmer might spend 2 hours per day, 7 days per week throughout July and August at or near this location.

From this information, a remedial objective for soil of 220 ppm was proposed. This is based on adding an additional 70 ppm to the average natural background concentration of 150 ppm. It represents an added risk that is considered negligible by Health Canada standards.

With regard to sediments near the proposed boat launch, a sediment remediation objective of 150 ppm was proposed. This is based on the estimation that exposure to levels above this during wading and swimming represents an added risk that is above the level considered negligible by Health Canada standards.

Mining Properties (Industrial Lands)

The remediation objective for industrial lands assumed that the site is not intended for public use, with access limited to site workers. Given that these lands are located directly above gold deposits, containing a high concentration of arsenic, a slightly higher "natural" level, or background concentration, of 300 ppm was considered appropriate.

The remediation objective proposed for these lands was 340 ppm, based on adding 40 ppm to the background concentration. This level represents an added risk that is considered negligible by Health Canada standards. The assumption used in calculating the risk to site workers was that there would be direct contact with the soil for 5 months of the year (the snow-free period) and was based on a workday of 10 hours per day, 5 days per week.

OTHER RECOMMENDATIONS

Risklogic maintains that up-to-date data on arsenic in local wildlife are needed. This would improve the assessment of risks to wildlife species, and would also better define the likely intake of arsenic from eating local game.

To reduce potential risks to Yellowknife residents, *Risklogic* advised that risk management should focus on preventing possible exposures such as by restricting public access to or covering up significantly impacted areas.

Risklogic also recommended that:

I. New data on the bioavailability of arsenic from soils and sediments be considered;

II. Arsenic levels in vegetation used as food by hare and spruce grouse (and other herbivores), as well as in hare and spruce grouse tissue (or other prey species) that serve as food for lynx and goshawk (or other predators) should be surveyed; and

III. The health of Yellowknife's wildlife populations should be studied directly to determine if arsenic exposure is having a real impact on survival, reproduction, productivity and population vitality, in comparison to similar wildlife populations in other parts of Canada.

SOURCES

Assessment of Human Health Risks Posed by Arsenic Contamination in Yellowknife, NWT by *Risklogic Scientific Services*

Assessment of Ecological Risks Posed by Arsenic Contamination in Yellowknife, NWT by *Risklogic Scientific Services*

Determining Natural (Background) Arsenic Soil Concentrations in Yellowknife, NWT and Deriving Site Specific Human Health-Based Remediation Objectives for Arsenic in the Yellowknife Area by *Risklogic Scientific Services*