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URANIUM MINING

IN

PORT RADIUM, N.W.T.;

OLD WASTES, NEW CONCERNS

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for: The Native Women's Federation
Canadian Arctic Resources Committee

October, 1981

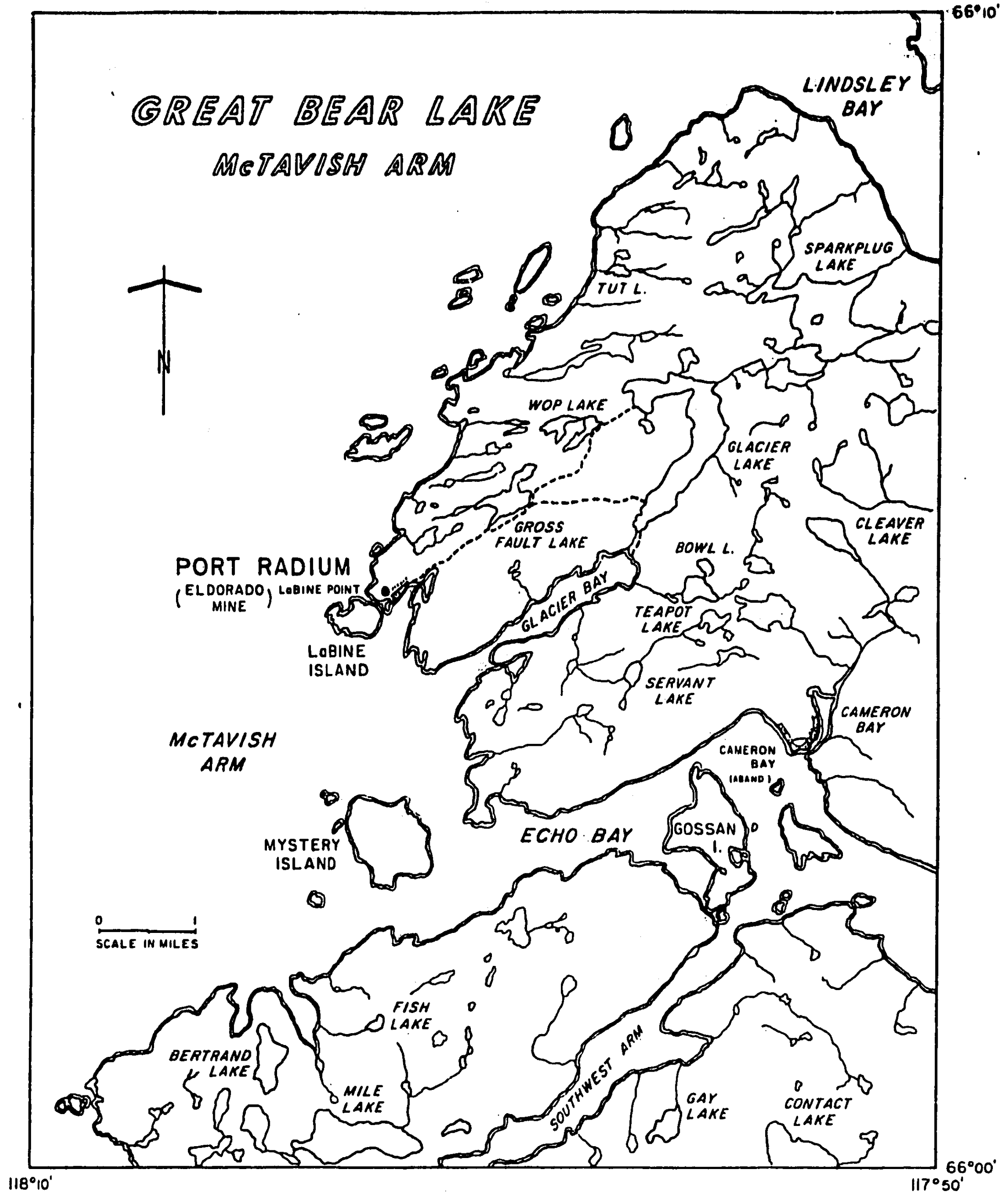
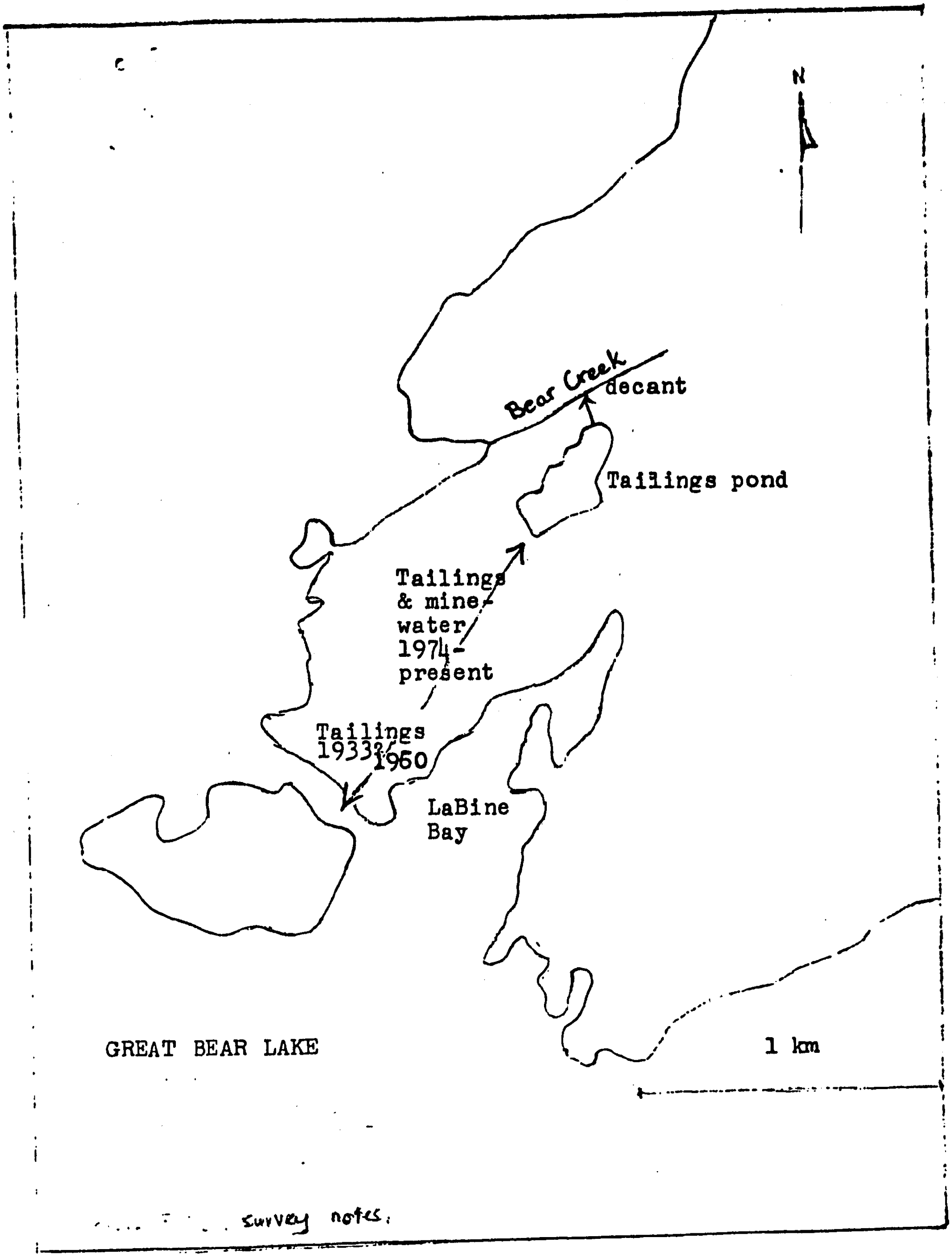


Figure 24 — Echo Bay Area. After topographic maps on scale 1:50,000; areas 86-K-5 and 86-L-1; Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa.

Source: Kupsch, 1978



draft map - for
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Mining at Port Radium

A member of the Atomic Energy Control Board (AECB) Advisory Panel on the long term management of uranium mine tailings has described the low level wastes from mine/mill operations as one of the most serious management problems of the industry (Brook, [1977]). Indeed, those wastes probably contribute more to public radiation than other phases of the nuclear industry, yet the associated pollution problems receive little attention compared to the more politicized sections of the nuclear industry.

Mining for radioactive products has been carried out in the Port Radium area of the Northwest Territories since the 1930's, producing radium at first (and coincidental silver), then uranium since 1942. Ore was initally shipped to Port Hope, Ontario for milling, but a gravity concentration plant was built near the mine in 1933, which separated ore from rock, leaving broken rock and wash water tailings. With the collapse of the radium market and exhaustion of the silver bodies, the mine was closed in 1940, but requirements for atomic fission experiments led to its re-opening in 1942 for uranium. The deposit proved to be one of the richest uranium mines in the world (Griffith, 1967, p. 316). Originally owned by the Eldorado Gold Mining Company, the mine assets were acquired in 1944 by the Crown company called Eldorado Mining and Refining Limited. Production continued until 1960; though radium recovery ceased after about 1950, the mine was a principal producer of uranium oxide concentrates. Since 1974, Echo Bay Mines Limited has been exploring and developing the underground silver potential of the Eldorado mine (D. Sutherland, pers. comm; EMR, 1976; EMR,1977)

In the interim, the Eldorado waste disposal site has been used for tailings from the nearby Echo Bay mine, which produces silver and copper, with associated lead, zinc, and uranium.

In all, 1 100 000 tons of ore averaging 0.68% U_3O_8 (uranium oxide) passed through the gravity plant during the Eldorado uranium mine's life, generating about 1 000 000 tons of tailings. Waste products from the mine were initially released to Great Bear Lake, but in 1952, a 300 ton per day sulphuric acid leach plant was built, to achieve greater uranium recovery from gravity plant tailings as well as those reclaimed from the lake. Almost 100% of the tailings dumped earlier were recovered; 340 000 tons, averaging 0.28% U_3O_8 were dredged out of the lake between 1952 and 1960. (EMR, 1977). After 1960, tailings were directed through a containment pond (D. Sutherland, pers. comm.).

During debate in the Northwest Territories Legislative Assembly in the spring of 1981, questions were raised regarding the environmental fate of the pollutants associated with Port Radium tailings, and the possible effects which these may have on the health of local inhabitants. It is apparent that much of the mine's activities occurred during a period when the effect of radiation and tailings contamination were little understood, much less monitored. AECB and the Environmental Protection Service (EPS) have no records prior to the last decade, and the age and history of the mine apparently obstruct access to records within Eldorado Ltd.

Some initial attention has been paid to the problem, however. In 1978, E.P.S. conducted some testing of sediments in Great Bear Lake near the mine, and more attention to this matter is anticipated within the next two ar three years (D. Sutherland, pers. comm.). The Department of Northern Affairs Water Resources Branch is responsible for regulating effluent quality for the operating Echo Bay mine, which used the old Eldorado tailings disposal site. The wastes from the current Echo Bay silver/copper mine, at the Port Radium site, have been monitored to some extent, though records prior to 1970 are sketchy. The Department of Fisheries and Oceans also conducted some fish surveys 6 - 8 years ago, in the vicinity of the site of earlier lake disposals of tailings.

The Mining Inspection Service, now in the Department of Justice & Public Services of the Government of the Northwest Territories (GNWT) has conducted some surveys of abandoned mine waste sites, as well as cursory checks for radon daughters and gamma radiation. Tailings studies, until now, have been uncoordinated, carried out by a number of agencies (but not the Mining Inspection Service) who apparently do not cummunicate with one another. The Service will now be attempting to increase the comprehensiveness of studies, and when the Echo Bay mine/mill at Port Radium closes down next spring, more monitoring is anticipated for the recent tailings, and possible for the old wastes as well. (E. Bengts, pers. comm.).

During the NWT Legislative debate on uranium mining, Mrs. Linda Sorensen moved a motion to call for an urgent federal review within the federal Mine Safety Division in Yellowknife, and AECB, regarding the present status, risk levels and effectiveness of the disposal system used for uranium tailings produced during the 1940's. To this date, there has been no action from the federal government or AECB on this request, and few letters have been responded to. The GNWT Department of Justice and Public Services, Occupational Health and Safety Division is now attempting to draw a report out of the available information (Sorensen, pers. comm.).

The nature of uranium mine/mill wastes

There are three main sources of radioactive releases from mining operation: mine ventilation, which releases radon and airborne radioactive particulates; ore stock piles, which give off radon, particulates and leachate; and mine water, in which radioactivity levels can be quite high. (R.E.C.S. & W.W. Radiological and Environmental Consultant Services, Inc., 1978, hereafter referred to as E.P.S., 1978).

Ore processing releases pollutants to the atmosphere during crushing and grinding, leaching, drying and packaging of the product (E.P.S. 1978, p. 17). There are also large quantities of water used during grinding, flotation and conveyance of ores and slurries, and these contain suspended or dissolved metals, flotation reagents and waterborne radioactive materials such as radium and thorium (Ferguson, 1978).

Mill liquid may be relatively highly radioactive, containing most of the radioactive decay products of uranium, such as $radium_{226}$, $thorium_{230}$, $lead_{210}$, and $polonium_{210}$, as well as some residual uranium, thorium and thorium decay products (E.P.S. 1978, p. 18-19).

De-watering of mines must be carried out to permit working or further exploration, and this can release pollutants both chronically, in small amounts, and in single large releases. Before exploration of the mine for silver by Echo Bay Mines, in 1974,the mine had to be de-watered, which could have resulted in a significant release of radio-nuclides to the local environment. Similar de-watering for the 1942 re-opening of the mine involved 12 million gallons of water (Kupsch, 1978).

Mining and milling removes only about 15% of the radioactivity, mostly in the form of uranium oxide (Förstner & Wittman, 1981). The remaining 85% is made up of such elements as $uranium_{238}$ and its isotopes, $thorium_{230}$, $radium_{226}$ and $lead_{210}$ (Bryant et al, 1979); these elements are dispersed throughout vast quantities of inert wastes, which take the form of finely ground solids and large amounts of waste water. These pulverized or slurried solids become a source of radioactive contamination more severe than the original minerals (Jervis, 1976).

Mill tailings constitute the largest single waste product from mine/mill operations. These waste products can be subject to leaching by precipitation, leading to contaminated seepage to ground and surface waters. The contaminated run-off from waste rock piles can be as significant as the main mining effluent waters (Ferguson, 1978). Dry materials can be eroded by wind and weathering actions, thus dispersing dusts and solids over a potentially large distance. Tailings can be stabilized or contained to reduce contamination of the local environment, but the problem of abandoned sites is that these measures may be neglected or ineffective; though isolated sites such as that of Port Radium are removed from attention, the local or regional inhabitants are still vulnerable to impacts.

Of the possible dispersal mechanisms of wind transmission, ground and surface water contamination, and direct irradiation of local life, Brook [1977] considers water transmission as the most serious. He suggests that water-borne radioactivity could reach very large areas, such as the entire Great Lakes system from Lake Huron down, from a source of contamination such as Elliot Lake. Water transmission has been identified as the major cause of pollution in the Serpent River Basin. This has significant implications for the Port Radium wastes.

Radon emissions from tailings are a significant radiological hazard, according to the United States Environmental Protection Agency, because of the potential for inhalation of radon, and lung damage caused by its intensely ionizing, alpha particle-emitting daughter products. The rate of emission depends upon moisture content, particle size and texture, temperature, pressure, atmospheric stability and weather condition. Complete saturation of waste by summer wetness or winter freezing and snow cover may reduce those emissions.

Surveys of the Port Radium tailings site, have revealed "normal" levels of radon daughter products and gamma radiation. In the present storage - a small lake - tailings are covered by water, which probably reduces radon exhalation. (E. Bengts, pers. comm.). John Moelaert pointed out in the NWT Legislature hearings (May 22) that radon exhalation from tailings may be so high that even if reduced by 99%, by heavy clay cover, they would be four times the normal soil exhalation rate. Unless the tailings area is directly used, however, the risk of human exposure to radon may be low. Of more concern in this case, is likely to be the dispersal of solid and liquid radionuclides and pollutants from neglected tailings. Contamination of water, vegetation and wild food resources could pose a hazard to local or regional residents, but determination of this will require specific monitoring. Since the effective radioactive life of wastes is at least 100 000 years, they merit waste management planning which will curtail effects on inhabitants and food chains.

Initial Port Radium Studies

The 1978 E.P.S. sampling of lake sediments covered an area near LaBine Bay and the mouth of Bear Creek, where much of the solid tailings can be expected to have settled. Indeed, high values generally occur in those areas; depressions in the lake bottom probably aided collection of pollutants in those spots. While initial analyses are inconclusive, some high levels of tailings-related elements have been recorded. Uranium and thorium isotopes, $radium_{226}$, and $lead_{210}$ are radioactive isotopes related to mine wastes and they occur in the sediments. Other metals such as cobalt, nickel, lead, zinc, bismuth, manganese, copper and arsenic are related to the local mineralizations and also appear in sediments; all have potential health effects if they are biologically available (Waldbott, 1973). High levels of copper and arsenic have been definitely attributed to tailings input, but these levels are still apparently below the maximum permissible limits, or recommended objectives for drinking water (D. Sutherland, per. comm.).

This is still not a complete indication of the pollution problem however, since conditions elsewhere in the lake have not been tested to indicate dispersal of pollutants, or the level of contamination relative to background levels. These levels may vary considerably, and are important for determination of the mine's impact. Some other water quality surveys do exist, but they have not measured the elements of interest to a study of tailings dispersal.

Metals within the lake will not necessarily be "biologically available" to affect living organisms. These elements may be adsorbed onto sediments or aquatic debris, or chemically altered in the presence of other elements to become less harmful or inert. This is not necessarily a permanent removal mechanism, for changes in water chemistry can cause re-release of the pollutants (Scott & Bragg, 1975, p. 44-5).

If available, metals can be incorporated into, and accumulated by aquatic plants, fish and other organisms, even when only small amounts are present in the environment. It is possible that drinking water standards, set according to relatively short-term intake tolerances, permit too high a concentration, considering the accumulation capabilities of aquatic organisms. Radium levels in algae can be 500-1000 times higher than in the surrounding water, and may be concentrated even more through consumption by fish, and consumption of fish by humans (J. Moelaert, NWT debate, May 22).

Radionuclides bound by sediments can still have biological effects. Kaufman (1964) cited a study of Guadalupe Bay in which cesium content of water was equivalent to allowable daily intakes for the general public. The sediment concentration of radioactivity was 300 times this amount however, and could result in doses,to an individual standing on the sediments, of 10 mrem in five hours, or the allowable weekly exposure. Fresh waters may contain an even higher proportion of the radioactivity load in the sediments than do salt waters, because of the greater adsorption capacities of saline water molecules (Reynolds and Gloyna, 1964). It would seem that allowable levels of radionuclides and metals should be set according to the characteristics of the water body in question; contaminant surveys must realize that the chemical and ecological properties of the system will determine the fate of contaminants and thus, the key factors in a survey.

Distribution of radioactivity and its effects

There are three forms of radiation from radioactive substances. Alpha particles do not penetrate the skin, though they can produce serious damage if ingested, inhaled or absorbed through open wounds. Beta particles can sometimes penetrate the protective layer of skin, or damage the skin or eyes, though they usually do not reach deeper organs. They too, are more important in terms of inhalation or ingestion. Gamma rays are short-wave rays of energy, having effects like x-rays;

they are penetrating and can pose an external hazard, especially if their dose exceeds the natural radiation of the environment (Kupsch, 1978; Waldbott, 1973, p. 239).

Human exposure to radioactive elements can occur in several ways. Atmospheric and terrestrial pathways include: inhalation of radon, radium and decay products or radioactive particles; external radiation; or consumption of food plants, meat and dairy produce which have been contacted by radionuclides. Aquatic pathways include drinking, domestic and recreational use of contaminated water; consumption of fish and other aquatic foods; external radiation from sediments; food crop irrigation with contaminated water; and radon transportation via ground water.

Certain of these pathways could be more significant to the people of the Great Bear Lake region. Radon emissions are likely to be significant only in the near vicinity of the tailings, and will be reduced by water cover. Radon concentrations are generally indistinguishable from background levels beyond 1-2 km of the source (E.P.S. 1978, p. 31), and they are generally less of a hazard outdoors than within houses. Tests in the community of Port Radium for radon daughters and gamma radiation discovered only one dwelling with high readings. Those were traced to part of the concrete foundation, which was replaced. Other unofficial tests in the region have revealed nothing unusual (E. Bengts, pers. comm.). Gordon Edwards, in the NWT Legislature debates, (Feb 26), claimed however, that radon gas can travel one thousand miles or more, raining radioactive material onto the ground and vegetation. If radon emanates from the main area, it could thus constitute a source of additional contamination.

Inhalation risk from other radioactive particulates is also expected to decrease with distance from the mine/mill. The pollution effects of Elliot Lake are, accordingly, greatest within 10 km of source (Nieboer, 1980). Such localization depends, as mentioned before, upon effective containment of radionuclides.

It is possible that radionuclides could be dispersed over, and absorbed by plants, which may either be used by the native poeple or by animals which later reach human diet. The long-lived daughters of $radon_{222}$, such as $lead_{210}$, $bismuth_{210}$, and $polonium_{210}$ could be deposited on soil or vegetation in low concentrations over large areas, following dispersion of $radon_{222}$. $Uranium_{238}$ is not taken up by vegetation, but its decay products, $radium_{226}$ and $lead_{210}$, are readily absorbed and constitute a hazard, since these elements are also readily absorbed by the human body. Concentration of these radionuclides by vegetation will depend upon a number of factors, such as deposition rate and period of contamination, the fraction retained, elimination or biological concentration rates in the plant, decay rate of the radionuclide, as well as soil type, composition and pH.

In general, the radiation passed on from consumption of meat is less than that which occurs through direct vegetation consumption. Heavy metals of concern, such as radium, thorium, uranium, lead and polonium are generally poorly absorbed by the gastrointestinal walls of animals, and thus tend to concentrate more in the bones than the meat (E.P.S. 1978 pg. 41). There is a lack of data on this process in wild animals however. The mobility of these animals further obstructs correlation of body burdens of contaminants with specific sources.

The importance of the meat consumption pathway in the northern context could take on greater magnitude, although the use of locally hunted wild meats may be declining in relation to that of imported foods. The native consumption of meat is traditionally higher, concentrating on wild meats, unlike the dietary pattern of southern study areas. The animals used for human consumption in the North, especially caribou, may feed heavily on lichens, which derive a significant proportion of their nutrients from the air.

It has been found that a wide range of airborne radionuclides can be concentrated in lichens; from natural background levels of $lead_{210}$ of 0.001 - 0.03 pCi/m^3, lichens can concentrate 5 000 - 10 000 pCi/kg dry weight of $lead_{210}$ and $polonium_{210}$. Caribou meat can contain 10-40 pCi/kg of $lead_{210}$ and 100 - 400 pCi/kg of $polonium_{210}$. This could result in a human dose of 150 mrem/year to gonads, and 200 mrem/year to bone lining cells (E.P.S. 1978, pg 41-3). The maximum permissible dose recommended by AECB is 500 mrem/year to the whole body, gonads or bone marrow. These are the most sensitive tissues. Lungs may receive 1.5 rem/year, bone, skin and thyroid are permitted to receive 3 rem/year, and the tissues of hands, forearms, feet or ankles may receive 7.5 rem.

In the Port Radium area, much of the contamination will be in the water and sediments of Great Bear Lake. Though most of the original tailings were removed from the lake for reprocessing, dumping of wastes in the lake continued until 1960, and the tailings pond that has been used since, eventually filters back to the waters of Bear Creek and the lake. Dissolved radionuclides and heavy metals can be expected to have been incorporated into the lake biota, or into sediments where they can be: chemically bound; resuspended and transported, especially during periods of high flow such as spring thaw; or leached and re-dissolved.

The currently used tailings pond is in satisfactory condition, and run-off is controlled. Treatment with barium and ferric sulphate is intended to reduce the content of heavy metals and $uranium_{226}$ in run-off. Water Branch samples indicate that effluents are within the regulatory limits set for the Echo Bay operations. (E. Bengts, pers. comm.). After closing of the silver mine next year, however, it will be important that containment and stabilization of tailings is ensured.

Measurements of surface water quality and sediments near other uranium mine/mill sites have shown higher levels of radioactivity, often greater than or equal to regulatory limits (E.P.S. 1978, p. 45). Sediments constitute a long-term source of aquatic contamination, but the biological availablity of the elements must be ascertained.

Health effects

A certain amount of radiation is reteived normally, from cosmic rays, radioactive elements in the ground, televisions and applicances, and medical uses of radiation. It is only when the dose exceeds certain limits, set by regulatory bodies on the basis of scientific opinion, that health effects are anticipated. The nature of long-term sub-lethal effects from low levels of exposure are poorly understood, however, and Brook [1977] has suggested that there is actually no safe threshold dose.

It is difficult to trace the effects of radiation on health, except in cases of massive dose, such as the Hiroshima and Nagasaki explosions. Over long periods of time, exposure to ionizing radiation may cause a variety of effects, including changes in skin pigmentation and texture, leukemia, cancers, cataracts, or perhaps reductions of the body's immunity and life expectancy. Because of the time span between exposure and possible effects, it is difficult to relate disease, malignancies or genetic damage to radiation, particularly when so many other factors, of diet, lifestyle, heredity and environment influence the incidence of health problems. This identification is complicated in the case of mining effluents, because other metals released, such as arsenic and copper, can also have serious health and genetic effects.

The effects of ionizing radiation depend upon the type of radiation involved, and the amount of energy imparted by radiation, per gram of specific tissue (Waldbott, 1973, p. 238). It is necessary to know the specific targets of nuclides. Radium, thorium and lead tend to concentrate in bones and teeth; radon and its products are most often inhaled and affect the lungs; uranium affects the gastrointestianal tract and kidneys (Arena, 1971, p. 519; Waldbott, 1973, p. 246; Edwards, NWT debate, Feb 26). Other tissues may also be affected, depending upon

The type of exposure, and genetic damage can occur if DNA is altered. Isotopes having longer half-lives, such as several of the decay products of radon, are potentially more serious, because of their slower rate of breakdown or decay.

Existing health records do not facilitate identification of radiation-related health effects, and it would be difficult to draw any real conclusions at the present time. Cancer deaths among Indians of the NWT, from 1974 to 1980, have ranged between 8.3 and 17.5% of total deaths (Chief Medical and Health Officer, GNWT, 1974-1978; Health & Welfare, Canada, 1979, 1980). As a comparison, cancer deaths in Ontario, in 1978 contributed 23% of total deaths in the province (Ontario Health Services, pers. comm.). These raw statistics do not differentiate between geographical locations of victims, or occupation, so cannot really indicate differences attributable to radiation exposure.

Vital statistics also list deaths from congenital anomalies, and conditions originating in the prenatal period, but these broad categories cannot differentiate between radiation-included effects and those health problems brought on by poor nutrition, or poor maternal health or habits such as drinking and smoking. Deaths in these categories ranged from 3.7 to 17% for NWT Indians, between 1974 and 1980, while the total Ontario rate in 1978 was 3.9%. Obviously, there is some possible elevation of the rate in NWT, but more careful examination of conditions to complete records would be necessary to specify a cause, or verify a statistically significant trend.

Several instances exist of human populations traditionally inhabiting areas of relatively high radioactivity, without apparent effect. The native populations of the Great Bear Lake region have presumably been exposed to higher levels as well, because of the richness of the ore bodies in the region. Additional mine/mill-related pollution must be viewed in the context of already elevated radiation levels in the North. While it is probably futile at the moment to attempt to relate low-level radiation exposure to health problems of the local population, it would be reasonable to concentrate future efforts on containing, stabilizing and cleaning up escaped wastes, to minimize further unnecessary exposure.

Conclusions

The nuclear issue is being hotly debated in Canada at the moment, and a major factor in the dispute is uncertainty about the environmental fate and effects of radioactive wastes. Certain educated predictions can be made about the fate of radionuclides and other mine-related metals in the environment, based on knowledge of their physical and chemical properties. These predictions can be substantiated by monitoring.

The effects on living organisms however, particularly of low-level radiation, cannot be as clearly established. Considering the concern evident in southern Canada regarding the safety of uranium industry workers and the general public (both Port Hope and Scarborough, Ontario residents are fighting for removal of radioactive wastes from town-site areas), it seems only logical to extend attention to northern peoples who may be affected. There have been sufficient knowledge gaps outlined to warrant further research and monitoring of exposed populations.

The Port Radium mine presents an excellent opportunity to study the situation of tailings and contaminants decades after their release. In view of the potentially heavy use of local food resources, including plant material, fish, fowl and terrestrial mammals, these pathways of radionuclide and heavy metal distribution deserve special attention. Fundamental, is the identification of all mine-related elements and isotopes which are present, and whether they are chemically inert or biologically available. Environmental monitoring of the lake water, sediments and organisms, and terrestrial soils, plants and animals should be continued or expanded to determine the degree and dispersal of contamination. Biological and medical tests will be needed to ascertain whether or not effects have occurred in animals or humans. Attention should be focussed on those region-specific factors which will affect radiation distribution and exposure. Finally, bearing in mind the stated policy of the AECB, to keep radiation exposure levels to the minimum possible, the stability and segregation of mine tailings needs to be investigated and ensured.

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