



PROGRESS REPORT ON RADIOACTIVE WASTE INVESTIGATION IN PORT HOPE, ONTARIO

FEBRUARY 19, 1976

1. INTRODUCTION

In accordance with the provisions of revised Atomic Energy Control Regulations¹ which became effective on June 3, 1974, Eldorado Nuclear Limited (ENL) initiated a review of its operations in consultation with the staff of the Atomic Energy Control Board. A plan was developed by the AECB calling for the consolidation of all licences and authorizations issued to ENL into a general licence governing the operations of the Company's uranium refinery and uranium hexafluoride conversion plant at Port Hope, Ontario and the issuance of separate waste management facility licences for each of the residue disposal areas currently or previously operated by the Company.

As a result of the above-mentioned review and actions resulting therefrom, members of the public became aware of the developments underway and brought them to the attention of the media and certain public-interest groups. Particular attention was drawn to the residue disposal areas of ENL following the issuance on July 29, 1975 of a report² by the AECB and subsequent press releases. The July 29, 1975 report was prepared on the basis of AECB staff field reports on its investigations of ENL's waste disposal operations and in the light of information obtained during staff level meetings involving representatives of federal and provincial ministries and agencies concerned with public health and environmental matters. Concern was expressed by elected representatives, the public and the media that the "Summary" report of July 29, 1975 did not reveal all of the data pertinent to the subject that was available at that time.

.... 2

1 Atomic Energy Control Regulations, SOR/74-334, P.C. 1974-1195, May 30, 1974.

2 Summary of Report by the Atomic Energy Control Board on the Waste Disposal Sites of Eldorado Nuclear Limited, July 29, 1975.

The purpose of this report is:

- 1) to provide an up to date account of the investigation as of February 6, 1976;
- 2) to outline the corrective actions already taken or planned as a result of information brought to light during the investigations; and
- 3) to make public the full texts of the AECB staff memoranda of 6 and 16 July, 1975, upon which the "Summary" report of July 29, 1976, was based. These memoranda and an explanatory note are attached as an Annex.

2. BACKGROUND INFORMATION

2.1 Residue Disposal Areas of Eldorado Nuclear Limited

2.1.1 Historical review

Eldorado Gold Mines Limited commenced operation in 1932 of a plant in Port Hope, Ontario, to process the ores mined at Port Radium, Northwest Territories for the recovery of radium. In 1944, the Company was taken over by the Canadian Government and renamed Eldorado Mining and Refining Limited. A further name change occurred in 1968 with the renaming of the Company as Eldorado Nuclear Limited (ENL).

The first residues from the radium recovery operation were produced in 1933 and were disposed of on the plant site from 1933 to 1939. During the period 1945 to 1948, these residues were reprocessed and the waste disposed of at the Monkey Mountain Residue Area in Port Hope. Eldorado Nuclear Limited has since built over the original disposal area on the plant site as described in Section 4 of this report.

From 1939 to 1944, residues were deposited in the Lakeshore Residue Area. This area is a short distance to the west of the plant and is adjacent to a railway embankment just south of the CNR freight shed (since demolished). In the latter part of the 1939-1944 period, the nature of the residue changed as the plant processes were altered from radium extraction to the production of uranium. Approximately 4000 to 5000 tons of radium extraction residues were removed from the Lakeshore Residue Area in 1957 and 1958 and sold to Vitro Corporation in the United States for the recovery of other metals; the remaining residue was transferred to the Port Granby Residue Area, 10 miles west of Port Hope.

The Monkey Mountain Residue Area within the Town of Port Hope was used from 1945 to 1948 for the disposal of residue and large quantities were removed from this site to Port Granby in 1959 and 1966 with some 800 tons being sold to Deloro Smelting and Refining Co. in 1959.

The Welcome Residue Area, about 3 miles to the northwest of Port Hope, was used from 1948 to 1954. About 4000 tons of residue were sold in 1956 to the Vitro Corporation in the U.S. for the recovery of other metals, and again in 1959 and 1960 about 1000 tons of "geiger picker" rejects were sold to Deloro Smelting and Refining. During the early 1950's approximately 900 tons of a material known as speiss was also sent from Port Hope to Deloro.

Contamination of an adjacent watercourse by surface run-off from the Welcome site had posed some problems, so that a 2 mile long pipeline was installed in 1956 with the approval of provincial authorities to overcome these problems. The run-off water is collected in a series of ponds on adjoining ENL property and is then pumped intermittently into Lake Ontario. Monitoring of the water by the Ontario Ministry of the Environment has shown that any contaminants in the relatively small discharge stream are quickly diluted in the lake.

The Port Granby Residue Area was first used in 1955 and remains the principal disposal area at the present time.

From 1948 to 1974, the Pidgeon Hill Storage Area was used for the storage of contaminated equipment and radium waste, and some incineration of combustible wastes was carried out prior to 1954, but no burial of waste was made on this site.

3. RESULTS OF INVESTIGATIONS DURING 1975

- 3.1 At the end of June 1975, the news media drew public attention to the waste disposal operations of Eldorado Nuclear Limited, and questions were asked in the House of Commons of both the Minister of Energy, Mines and Resources, and the Minister of the Environment. A member of the AECB staff investigated the matter and submitted a number of recommendations; these are listed below along with the respective actions taken:

Recommendations made in July 1975

1. The fencing at the Monkey Mountain and Welcome Residue Areas should be extended to the boundary of the ENL property. This would have the effect of bringing the contaminated area at Monkey Mountain within the fence, and of ensuring that the public at the Welcome Residue Area would not have access to areas where radiation fields above statutory levels existed.

frequency of security guards

2. A systematic radiation survey should be conducted outside the southern boundary fence at the Port Granby Residue Area (possibly backed up by analysis of soil samples) to establish the extent of contamination in this area.

Actions taken as of February 6, 1976

The fence at Monkey Mountain has been extended to include the ENL property to the east of the residue area. A new chain-link fence (6 ft. high topped with 1 ft. of barbed wire) has been erected along the property boundary at Welcome to establish an exclusion area between the property and residue area boundaries.

On September 24, 1975, the exposure rate along the east and north sections of new fencing was measured by AECB staff. It was found that while the new fence prevents members of the public from approaching the section of inner fence where the exposure rate is up to 17 mR/h, the measured rate along the east side of the new outer fence is still above permissible limits (the rate ranges from 0.070 to 0.190 mR/h over a length of 300 ft. of fence as compared to a permissible rate of 0.060 mR/h. It will be necessary to either move some of the material from the north-east corner of the residue area or provide better shielding by additional cover. The AECB has ordered ENL

to take action on this matter during the spring of 1976.

A detailed radiation survey was carried out at the Port Granby Residue Area to determine the extent of the contaminated area at the lakeshore where the west gorge stream meets the beach. Approximately 500 cubic yards of soil were removed to the trench area at the top of the bluffs and the maximum

3. Guidelines should be developed regarding what is an acceptable exposure rate at the boundary of a disposal area.

4. Guidelines should be provided regarding what is an acceptable concentration of contaminants in the surface and ground waters affected by these sites. The water quality criteria would provide a conservative guideline, but it may be necessary to consider other factors to establish a more realistic level where the water is not used for drinking purposes, or else to consider the feasibility of water treatment before discharge into the lake.

exposure rate at the boundary fence, measured in contact with the stream bed by AECB staff, has been reduced from 0.9 mR/h to 0.020 mR/h.

A person would accumulate a whole-body dose of 500 mrem in a year if continuously exposed to 0.057 mR/h (500 mrem is the maximum permissible annual dose allowed by the Atomic Energy Control Regulations for persons who are not atomic radiation workers). In the absence of dwellings in the vicinity of the site boundary, it is unlikely that anybody would spend their entire time at the boundary fence, so that an exposure rate of 0.060 mR/h above the natural background rate would be quite conservative and is being applied at present.

The Ontario Ministry of the Environment and Environment Canada have been requested to develop appropriate guidelines. Consultation with the Ontario Ministry of Health and the Department of National Health and Welfare has been initiated. The long established federal/provincial environmental monitoring program has been reviewed and continues in effect.

5. The fences along the East boundary of the Welcome Residue Area and the South boundary of the Port Granby Residue Area should be repaired immediately.

The east boundary fence at Welcome has been repaired, and additional fencing was erected as noted above.

An additional 1800 feet of farm fence (4 feet high topped with barbed wire) was installed along the top of the bluffs at Port Granby and along the east side of the west gorge to prevent animals approaching the trench area. While the fence along the lakeshore boundary may be effective in stopping animals from entering the property, further measures are necessary to prevent entry by unauthorized persons. The AECB has ordered ENL to take action on this matter.
6. The existing warning notices should be replaced by more appropriate ones as approved by the AECB, and they should be placed at more frequent intervals along each boundary fence.

New radiation warning signs approved by the AECB have been placed at 200 ft. intervals along the property boundary fence at Port Granby and Welcome.

The old warning signs are to be removed now that the new approved signs are in place. At Port Granby, some of the radiation warning signs along the lakeshore boundary are to be relocated to more appropriate positions so that at least one sign is obvious to an observer at any point along the beach.

Additional signs saying "This water not safe to drink") were placed at the points where the west and east gorge streams passed under the lakeshore boundary fence. Malicious damage to warning signs continues to be a problem. Security patrols will be necessary to counter these acts and have been ordered by the AECB.
7. ENL should be asked to comply with the requirements of the Prescribed Substance Licence 18/74 with regard to obtaining approval from the AECB for the disposal of material.

A Waste Management Facility Operating Licence No. WFOL 2/75-1 for the Port Granby Residue Area was issued by the AECB on 15 December, 1975, following a review and assessment of the Company's disposal operations.

8. The chemical forms of the radioactive contaminants (principally uranium and radium) should be determined to assist in deciding the appropriateness of the water contamination limits.
9. Formal channels should be established for the transmission of effluent and environmental monitoring data between ENL and the various regulatory bodies (particularly the AECB).
10. The feasibility of establishing a single waste management site for ENL should be studied.

Discussions have been initiated with the University of Toronto concerning a proposed study. It is expected that a comprehensive research contract will be negotiated by 31 March, 1976 for a study which will provide the necessary technical data.

ENL has been directed to supply copies of its monthly analyses to the AECB. The Ontario Ministry of the Environment has agreed to supply environmental monitoring data to the AECB on a regular basis.

While the establishment of a single waste management site may take considerable study, remedial action has been taken at both the Monkey Mountain and Lakeshore Residue Areas. At Monkey Mountain, contaminated soil has been removed from the adjacent property to the north of the ENL property and replaced by clean fill. Exposure rates at waist level in this area now range from 0.015 to 0.030 mR/h. Contaminated soil has also been removed from the newly enclosed area to the east of the residue area and from the ditch running alongside Pidgeon Hill. In the ditch, it was found that the contamination was confined to a 1 ft. thick layer about 4 ft. below the present surface (presumably the original surface before the new road was put in). Exposure rates on contact with the 'original' surface were about 0.2 mR/h and as high as 0.4 mR/h in spots, but the rate at the present surface is between 0.030 to 0.040 mR/h. Further soil testing and where necessary, removal of additional material is planned for the spring of 1976.

Radiation surveys made by AECB staff at the Lakeshore Residue Area showed that about 3 acres were contaminated at a level ranging from 0.020 to 0.100 mR/h with some 'hot spots' as high as 2.5 mR/h at waist level. About 15,000 cubic yards of soil have been removed from this area. The embankment and road have been completed and backfilled so that exposure rates are generally about 0.010 mR/h, and work is in progress at the west end of the area. Soil with levels of less than 0.200 mR/h has been sent to the Welcome Residue Area for use as cover, and soil with higher levels has been sent to the Port Granby Area where soil with contact rates about 1.5 mR/h has been buried and the remainder with contact rates ranging from 0.2 to 1.5 mR/h will be graded and covered with clean fill. The clean up in this area is proceeding satisfactorily. The main source of contamination appears to have been traces of the original residue which were not removed during the clean up in the late 1950's. Final landscaping of this area will have to await the better weather conditions in the spring of 1976.

4. INVESTIGATION AND CLEANUP OF AREAS IN PORT HOPE
OTHER THAN THE RESIDUE AREAS

4.1 Historical review

Following investigation by ENL staff of the earlier residue disposal practices, it became evident that there were areas within the town of Port Hope that could have become contaminated. Possible contamination could have resulted from any of the following causes:

- (a) spillage of residue during shipment by road to the residue disposal areas, or during loading at the rail docks.

- (b) during the 1940's residues were stored in a variety of locations awaiting recovery of other metals (e.g. cobalt and silver) and it was possible that these temporary storage locations could have become contaminated.
- (c) there were several periods during which there was an active building programme on the ENL property. In 1938 and 1939 a building which had contained the original radium processing plant set up in 1932 was demolished. The refining of radium ceased in 1953 and in the following two years, the radium laboratories were dismantled and buried at the Welcome Residue Area. In 1954 and 1955, the old radium circuit was removed and a new solvent extraction circuit installed; at about this time, several other buildings were demolished. In 1959, the original main office building and the uranium processing building were demolished.

All of these actions produced building rubble, fill and reclaimed building materials, any of which might have been contaminated and may have been used in the Town for various purposes. Although spot checks for radioactivity were made by ENL on material leaving ENL property, not all material was checked.

- (d) surface run-off from the Monkey Mountain Residue Area in particular may have resulted in surface contamination of the surrounding area, particularly Pidgeon Hill.

As a result of the above, ENL conducted a very thorough investigation during late summer of 1975 which included interviewing long-term employees, searching plant records, and inviting assistance from local citizens through advertisements in the local newspaper and on the local radio station. This approach has brought to light most of the areas currently under investigation. Notwithstanding this investigation, the Atomic Energy Control Board and the Ontario Ministry of Health concluded in December 1975 that a more systematic approach to the problem was called for. As a result, it was decided to conduct a complete survey of the town to search for higher-than-normal levels of external radiation, and, if such areas were found, to delineate the areas with a careful survey on foot, and, finally, to take selective air samples inside buildings and homes for radon analysis.

To accomplish this survey, a very sensitive detector was borrowed from the Chalk River Nuclear Laboratories of Atomic Energy of Canada Limited. This detector was mounted initially on an Ontario Ministry of Health vehicle and eventually transferred to an Atomic Energy Control Board vehicle in order to carry out a street-by-street survey of the whole community. Whenever abnormal radiation levels were detected, the Ontario Ministry of Health was notified and arrangements made to collect air samples within buildings for careful analysis at the Ministry's Laboratories in Toronto.

Briefly, the sampling in a room consists of opening an evacuated 2 litre glass bottle thereby obtaining a sample of room air. The sample bottle is then sealed and taken to the laboratory in Toronto where the sampled air is transferred to a counting chamber that has a window coated with zinc sulphide which scintillates when it absorbs the radiation in the air inside the flask. By coupling this counting chamber to a photomultiplier tube and associated electronic circuitry, it is possible to determine the radioactivity in the air sample and, hence, with a suitable calibration, to determine the number of picocuries of radon in a litre of the original room air. Since the actual radon concentrations are very low, it is necessary to count the radioactivity in the samples for several hours in order to obtain satisfactory accuracy. An additional problem is that the actual radon concentration varies considerably from hour to hour, day to day, and season to season due to a variety of factors including air velocity, barometric pressure, temperature of the soil, the vertical temperature gradient, and relative humidity, hence it is necessary to take repeated air samples to establish the range of radon concentrations. Consideration is being given to the use of integrating devices that were developed for use in Grand Junction, Colorado and which will yield the average concentrations over a long period of time. The systematic road survey commenced between Christmas and New Year 1975, and, by the time of writing this report, had included all roads in the town at least once.

The general status of the investigation and clean up is covered in the following two sections.

4.2 Areas that are in process of cleanup, or have been cleaned up

4.2.1 CNR loading dock between the viaducts

Approximately 1 acre was contaminated probably as a result of spillage while loading railway cars with residue. Contaminated soil was removed and replaced by clean fill and seeded. Exposure rates have been reduced to acceptable levels.

At the perimeter of the area, contaminated building rubble was found at a depth of about 3 ft. This rubble will be removed during the summer of 1976.

4.2.2 Dawson-Coleman Building, John Street

The basement of this building was used for the temporary storage of radium-bearing materials during the period 1943 to 1944. The basement floor has been vacuumed and washed, but exposure rates on contact remain 0.07 to 0.20 mR/h. Core samples have shown that the contamination is confined to the surface of the concrete.

The ramp was excavated to a depth of about 2½ ft. and further excavation is needed to reduce the contact rates from a maximum of 0.8 mR/h.

A small area of contamination was found in the vicinity of a basement window at the north end of the building where rates up to 0.3 mR/h at waist level were found.

Air samples taken inside the basement on November 19 by the Ontario Ministry of Health indicated radon concentrations up to 6 times the permissible level for occupational exposure.

The decontamination of this building is scheduled for the summer of 1976.

4.2.3 108 John Street

This building was used as a radiation laboratory by Mr. M. Pochon. The building has been cleaned up by removal of all contaminated items including shelves, plumbing fixtures and work benches. A contaminated window frame remains, but there is concern that the wall will collapse if this is removed.

An air sample taken on November 19 gave an acceptable radon concentration.

4.2.4 Smith Transport Shed

This building was used for the temporary storage of residue in the period 1943 to 1944. Low levels of surface contamination were found by AECB staff. An air sample taken on November 19 gave an acceptable radon concentration.

4.2.5 CPR loading dock

This area was contaminated probably as a result of spillage while loading railway cars with residue. All timbers have been removed to Port Granby. ENL is in the process of removing contaminated soil, and final clean up is scheduled for the spring of 1976.

4.2.6 76 Thomas Street

This private home is occupied by the Lewis family. A considerable quantity of contaminated fill had been used to fill a ravine behind the house. Exposure rates at waist level outside the house ranged as high as 0.35 mR/h.

Air samples taken on November 19, 1975 gave radon concentrations ranging from 200 to 400 times the acceptable level for continuous exposure.

Approximately 8000 cubic yards of contaminated fill have been removed, and air samples taken since by the Ontario Ministry of Health have shown radon concentrations that are acceptable.

4.3 Other areas that are under investigation

4.3.1 St. Mary's Separate School

An extension to the school was built in 1963 on contaminated fill that had been placed in 1955. Radon levels were found to be well above the acceptable level of 3 pCi/l for work-day occupancy, and the school was closed by the Ontario Ministry of Health before Christmas 1975. Since then, an improved ventilation system has been installed, but, so far, has failed to reduce the radon concentrations to acceptable levels in all parts of the school. The investigation is continuing, and in the meantime, the children have moved to temporary quarters.

4.3.2 Dr. Powers Public School

As a result of the discovery of higher than normal radon concentrations in St. Mary's Separate School, all schools in the Port Hope area were checked for radioactivity. Two unventilated storage rooms in the basement of the Dr. Powers Public School were found to have higher than normal radon concentrations. A detailed radiation survey was conducted but no sources of radioactivity were detected. Samples of

the concrete walls in the two rooms have been taken to the Ontario Ministry of Health laboratories in Toronto for analysis. It is believed that the higher than normal radon concentrations may be due to the emanation of naturally occurring radon into these unventilated rooms.

4.3.3 George Hamilton Public School, Welcome, Ontario

A single measurement of the radon concentration in the main corridor in the George Hamilton Public School indicated higher than normal levels. However, repeated tests have since confirmed that the radon concentrations in the School are normal and that the first measurement was incorrect due to a measurement error.

4.3.4 Private homes and businesses

A number of private homes and businesses have been checked and found to have radon levels above the acceptable.

Five families have been asked by the Ontario Ministry of Health to vacate their homes until corrective measures can be taken; one family (the Lewis's) has moved back into their home since the radon levels have been reduced to normal background levels.

The majority of locations identified to date have been found on Pidgeon Hill Road and Cavan Street. The remaining locations appear to be quite isolated and are generally of a much lower level in terms of radiation fields and radon concentrations. In order to respect the wishes of the homeowners, all of whom have been notified, the exact addresses are being withheld pending cleanup action. All Port Hope property owners may request, through the AECB's Port Hope office, that checks be made of radiation fields and radon concentrations on their properties. The AECB has already fulfilled a number of such requests.

ANNEX

AECEB Staff Memoranda of 6 July, 1975,
and 16 July, 1975

Explanatory Note

There are some differences between the two memoranda dated July 6 and July 16 that require a brief explanation.

The memorandum dated July 6 was written shortly after a July 2 inspection of Eldorado Nuclear Limited's waste management sites. Even at that time, it was realised that some revisions would be necessary in order to make a complete report on the subject; for example, in Section 1.5 it is noted that a copy of a more complete radiation survey around the boundary of the Port Granby Disposal Area by Mr. S. E. Frost of Eldorado Nuclear Limited was expected. This information, together with verbal comments received over the telephone, resulted in a partial rewriting of the memorandum which was dated July 16.

At a meeting held on July 18, representatives from the AECEB, Environment Canada, the Ontario Ministry of the Environment, and Eldorado Nuclear Limited, reviewed the original memorandum together with what new data had been received in the interim. The main criticism raised was that since this was an AECEB report all references to arsenic concentrations should be deleted since it fell within the jurisdiction of the Ontario Ministry of the Environment. With this, and a few other points, in mind the partially re-written memorandum was revised, but, unfortunately, the issue date was not altered but remained July 16.

Except for these differences, the two memoranda are essentially the same.

M E M O R A N D U M

TO: Dr. A.T. Prince

File: 15-2-E1

FROM: G.B. Knight

Date: 6 July 1975

SUBJECT: Visit to Waste Management Sites of Eldorado
Nuclear Limited on 2 July 1975

1. Exposure rates at the boundary of the residue areas

On 2 July 1975, I visited the four waste management sites of ENL, i.e. Monkey Mountain, Pidgeon Hill, Welcome, and Port Granby. I was accompanied by Mr. S. Frost, Health Physicist for ENL, and, using a Berthold Model LB 1200 Monitoring Instrument borrowed from Health and Welfare Canada, we measured the external gamma radiation exposure rates at waist height at points around the boundaries of each site. All measurements, unless otherwise noted, were made with the instrument window closed, i.e. only penetrating gamma radiation was measured.

As a reference, the exposure rate was measured on Walton Street in Port Hope just opposite the offices of the 'Port Hope Evening Guide' - the level ranged from 0.009 to 0.013 mR/h. A second reference measurement in the front garden of Mr. Frost's home at 75 Jocelyn Street, Port Hope, gave a rate of 0.008 mR/h.

1.1 Monkey Mountain Residue Area

The site is in the NE corner of Pine Street and Pidgeon Hill in Port Hope. Pine Street is no more than a gravel track with no dwellings on it, but Pidgeon Hill is a paved road that runs along the South boundary with dwellings towards the SE corner of the site.

The site itself is quite small (about 1 1/4 acres) and is located on a hillside that slopes down from the NW to the SE. The SE corner is the lowest point and a water sampling point is located here.

The site is covered with long grass and a few young trees are growing along the East side. The area is surrounded by a 4' wire fence that carries notices warning that it is a 'protected place' by order of the AECB. The gate is padlocked.

Dr. A.T. Prince

6 July 1975

Most of the radiation measurements were made inside the fenced area either at, or a few feet from the fence. The measurements are listed in Table 1. As can be seen, the rate measured at the fence ranged from 10 μ R/h at the highest point of land (at the NW corner) to 60 μ R/h at the lowest point of land (at the SE corner). There appears to be further contamination outside the fenced area to the east and in the vicinity of the South-east corner where rates as high as 200 μ R/h and 65 μ R/h, respectively, were measured. ENL owns the property to the East of the site, but it is not completely fenced.

1.2 Dr. Hunt's Property

Dr. Hunt owns the property to the South of Pidgeon Hill, and the ground water from the Monkey Mountain Area comes to the surface in two springs on this property. The gamma exposure rates were found to be as follows:

West spring	0.012 mR/h
East spring	0.015 mR/h

1.3 Pidgeon Hill Storage Area

This site is located a short distance along Pidgeon Hill to the West of the Monkey Mountain site. The Port Hope Municipal 'Dump' adjoins the North side of the site, but the other three sides are bordered by undeveloped land.

The site is about 2 acres in extent, is fairly level and covered by long grass and is surrounded by a 6' wire fence topped by a further 1' of barbed wire. Warning signs similar to those at the Monkey Mountain site are placed on each fence and the gate is padlocked. All buildings have been removed.

The exposure rates were measured just outside the fence, and are listed in Table 2. As can be seen, the rates ranged from 15 to 40 μ R/h with most readings falling in the range from 20 to 30 μ R/h. There was no evidence of radioactive contamination outside the fenced area.

ENL plans to complete cleanup of this site and then to donate it to the Town of Port Hope for a recreational area.

Dr. A.T. Prince

6 July 1975

Apparently, this site was used for storage of radium waste (some incineration was carried out prior to 1954), but no burial of waste was done.

1.4 Welcome Residue Area

This site is located West of Port Hope near the village of Welcome. The site is rectangular in shape and measures about 1100' X 500'. It adjoins a gravel pit along its North side and is bordered by agricultural land on the other three sides. ENL owns a strip of land about 50 yards wide along the north side of the site another strip of land about 100 yards wide along the east side, and a third parcel of land that adjoins the North-west corner of the site.

The highest part of the site lies along the East side and it slopes gently towards the North-west corner which is the lowest point on the site.

The site was generally covered with grass, but there were areas towards the East where there was no ground cover, and shallow drainage ditches had been dug parallel to the West and North boundaries about 10' to 15' inside the boundary fence. There was evidence that the drainage ditches had handled a considerable surface run-off.

The whole site was surrounded by a 6' high wire fence topped by a further 1' of barbed wire. The fence had collapsed for a distance of about 100' along the East side of the site near the South-east corner; otherwise, the fence appeared to be in reasonable condition. Warning signs similar to those at the Monkey Mountain site were placed on the fence at infrequent intervals. The gate was padlocked.

In addition to residues, the equipment from the dismantled radium laboratories was buried at this site.

Measurements were made at intervals along the inside of the boundary fence, and, at arbitrarily selected points, over the drainage ditch. The measurements are listed in Table 3. As can be seen, the exposure rates along the boundary

Dr. A.T. Prince

6 July 1975

covered the following ranges:

South side	0.15 to 1.10 mR/h
West side	0.15 to 0.52 mR/h
North side	0.28 to 1.00 mR/h
East side	0.28 to 17.00 mR/h

Measurements made along the gravel road to the East of the site, which incidentally marks the eastern boundary of the ENL property, gave exposure rates of 50 to 70 μ R/h. The exposure rate at the junction of Marsh Road with the gravel road between lots 12 and 13 was 18 to 20 μ R/h - this marks the nearest dwellings to the disposal site (a distance of about half a mile).

1.5 Port Granby Residue Area

This site is located about 10 miles West of Port Hope and covers 28 acres. The site is bounded on the South side by Lake Ontario and by farm land in active use on the other three sides - there is a farm house and barns about 100 yards from the gate leading into the site. The site is surrounded by a 6' wire fence topped by 1' of barbed wire; the gate is padlocked, and warning signs similar to those at the other sites are posted at various points.

Refinery residue has been dumped at this site since the mid-1950's, and some material from the other sites has been transferred here. At the present time, residues from the UF₆ Plant and from solvent extraction are buried at the site routinely.

Due to the large area covered by this site, measurements of the exposure rate were made at selected points for comparison with a more complete survey carried out by Mr. S. Frost. Mr. Frost has agreed to supply the results of this survey to me. Those measurements that were made are given in Table 4.

Generally, all residue dumped into the East gorge has been covered with topsoil which now supports a thick cover of grass, and all current residues are buried in trenches.

Dr. A.T. Prince

6 July 1975

While it is claimed that the present residues have a low radioactive content, measurements on a recent batch of solvent extraction residue indicated about 1.0 to 1.5 mR/h of penetrating gamma radiation on contact, and 67 to 68 mR/h of low energy radiation which is, presumably, the beta radiation resulting from decay of thorium-234 with a half-life of 24.3 days. Contact measurements on UF₆ plant residue gave 0.3 to 0.4 mR/h.

2. Water samples from the residue areas

Mr. S. Frost has supplied copies of the analysis of water samples obtained at each of the residue areas for the past several years. Similar data have been obtained by MOE, but their data in our possession is less complete than those supplied by ENL. Samples were collected and analysed usually on a monthly basis by ENL staff.

I have reviewed these data and have tabulated the maximum, minimum and average concentrations measured for arsenic, radium-226, and natural uranium. (See Tables 5, 6, and 7)

The various limits applied to drinking water by the Ontario Ministry of the Environment and by the AECB are summarized in the table on page 5A attached.

It should be noted that the MOE does not distinguish between soluble and insoluble forms while the ICRP does do so.

2.1 Monkey Mountain Residue Area

The data for the Monkey Mountain Area are given in Table 5 and include samples dating back to 1962 taken from sampling point 4 located just outside the South-east corner of the residue area, sampling point 5 just inside the East boundary of the area, and sampling points at the East and West tributaries and the pond on Dr. Hunt's property that are fed by ground water from the residue area.

In discussing these data with Mr. P. Hughes of the MOE Peterborough office, I understood that MOE has not conducted a

DRINKING WATER STANDARDS

<u>Contaminant</u>	<u>Maximum Permissible Limit</u>	<u>Acceptable Limit</u>	<u>Objective or Desirable Limit</u>
Arsenic ⁽¹⁾	0.05 $\mu\text{g/ml}$	0.01 $\mu\text{g/ml}$	Absent
Ra-226 - total ⁽¹⁾	-----	3 pCi/l	<1 pCi/l
- soluble ⁽²⁾	10 pCi/l	-----	-----
- insoluble ⁽²⁾	30 nCi/l	-----	-----
Nat. U - total ⁽¹⁾	-----	5 $\mu\text{g/ml}$	Absent
- soluble ⁽²⁾	1.8 $\mu\text{g/ml}$	-----	-----
- insoluble ⁽²⁾	60.6 $\mu\text{g/ml}$	-----	-----
Gross β activity ⁽¹⁾	-----	1000 pCi/l	100 pCi/l

(1) These limits are those used by the Ontario Ministry of the Environment and are taken from "Guidelines and Criteria for Water Quality Management in Ontario", July 1974.

(2) These limits are based on the MPC_w for a 168 hour week for members of the public and are taken from ICRP Publications 2 and 6.

Dr. A.T. Prince

6 July 1975

monitoring programme at the Monkey Mountain Residue Area, but that they plan to commence some monitoring there and will study the same data from ENL that are reviewed in this memorandum.

In comparing the data shown in Table 5 with the drinking water standards, it is obvious that the arsenic concentrations are considerably higher than the maximum permissible limit at all the sampling points, the recent radium concentrations on average are close to the acceptable limit although the East tributary on Dr. Hunt's property is generally higher, and that the uranium concentrations are acceptable. In commenting on the arsenic levels, Mr. Hughes noted that while drinking water standards were being applied, the water was not used for this purpose and that the hazard to health was small in reality.

2.2 Welcome Residue Area

Mr. Hughes has confirmed that MOE includes the Welcome Area in its monitoring programme.

The data for the Welcome Residue Area are given in Table 6 and include samples dating back to 1962 taken from the pump house sampling point 15, from Brand's Creek where it passes under Marsh Road, and from sampling point 5 at a culvert at Highway 401.

Generally, levels of arsenic, radium and uranium are acceptable in Brand's Creek and the Highway 401 culvert, but at sampling point 15 (pump house)*, the arsenic concentrations are considerably higher than the maximum permissible limit for drinking water and radium concentrations are generally ten times higher than the acceptable limit.

2.3 Port Granby Residue Area

MOE mount a fairly extensive monitoring programme around the Port Granby Residue Area where they take water samples periodically and analyse for: radium-226, gross α activity, gross β activity, uranium-238, phosphorus, nitrogen, and fluorine.

* Run-off from the Welcome Residue Area is pumped through a buried pipeline to Lake Ontario so as not to contaminate any adjacent farm land or public watercourses.

Dr. A.T. Prince

6 July 1975

The data for the Port Granby Residue Area are given in Table 7. Once again, the arsenic concentrations are considerably higher than the maximum permissible limit for drinking water, and the radium-226 concentrations are also considerably higher than the acceptable limit. However, examination of the radium concentrations in MOE water samples taken at 50 and 100 yards from the discharge point into Lake Ontario show that the concentration is quickly diluted to below the acceptable level. Uranium concentrations are well below the acceptable limit at the East gorge, but are up to twice the acceptable limit at the West gorge.

Generally, while concentrations may be high, the total discharged into the lake is quite small.

3. Recommendations

3.1 The fencing at the Monkey Mountain and Welcome Residue Areas should be extended to the boundary of the ENL property. This would have the effect of bringing the contaminated area at Monkey Mountain within the fence, and of ensuring that the public at the Welcome Residue Area do not have access to areas of high exposure rate.

3.2 Guidelines should be provided regarding what is an acceptable exposure rate at the boundary of a disposal area. A person will accumulate a dose of 500 mrem in a year if continuously exposed to $57 \mu\text{rem/h}$. (500 mrem is the maximum permissible annual dose allowed by the Atomic Energy Control Regulations for people who are not atomic radiation workers.) In the absence of dwellings in the vicinity of the site boundary, it is unlikely that anybody would spend their entire time at the boundary fence, so that a dose rate of $60 \mu\text{rem/h}$ above the natural background rate would be quite conservative.

3.3 Guidelines should be provided regarding what is an acceptable concentration of contaminants in the surface and ground waters affected by these sites. The drinking water standards would provide a conservative objective, but it may be necessary to consider other facts to establish a more realistic level where the water is not used for drinking purposes.

Dr. A.T. Prince

6 July 1975

- 3.4 The fence along the East boundary of the Welcome Residue Site requires repairing immediately.
- 3.5 The current warning notices should be replaced by more appropriate ones, and they should be placed at more frequent intervals along each boundary fence.
- 3.6 ENL should be asked to comply with the requirements of the Prescribed Substance Licence 18/74 with regard to obtaining approval from the AECB for the disposal of material.
- 3.7 The solubility of the radioactive contaminants (principally uranium and radium) should be determined to assist in deciding the appropriateness of the water contamination limits.
- 3.8 Formal channels must be established for the transmission of effluent and environmental monitoring data between ENL and the various regulatory bodies (particularly the AECB).
- 3.9 The feasibility of establishing a single waste management site for ENL should be studied.

G. B. Knight.

G.B. Knight

GBK:kk

Attachments

cc: J.H. Jennekens
P. Hamel
R.M. Duncan
R.F. Scarth

TABLE 1

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND THE BOUNDARY OF
THE MONKEY MOUNTAIN RESIDUE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
About 30' from ENL property opposite gate	I	0.025 - 0.03
At gate	I	0.015
West side, about 1/3 distance from SW corner	I	0.025 - 0.03
SW corner	I	0.025 - 0.03
South side, middle	I	0.025
SE corner	I	0.045 - 0.06
SE corner, window open	I	0.065 - 0.075
SE corner, outside fence	I	0.05 - 0.06
SE corner, outside near water sampling point	I	0.06 - 0.065
SE corner, outside in ditch about 12' from corner	I	0.04 - 0.045
East side, middle	I	0.05 - 0.055
NE corner	I	0.02 - 0.025
Outside fence, NE corner 15' to E	I	0.03
- 1/3 distance from NE corner 20' to E	II	0.20 (max)
- 1/3 distance from NE corner 50' to E	I	0.05 - 0.06
- SE corner 50' to E	I	0.025 - 0.03
- NE corner 50' to E	I	0.055 - 0.065
- NE corner 10' to N	I	0.07 - 0.08
North side, middle	I	0.015
NW corner	I	0.010

TABLE 2

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND

THE BOUNDARY OF THE PIDGEON HILL

STORAGE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
At gate	I	0.02 - 0.03
South side, middle	I	0.02 - 0.025
SW corner	I	0.025
West side, middle	I	0.02 - 0.025
NW corner	I	0.015
North side, middle	I	0.016 - 0.018
NE corner	I	0.020
East side - not accessible		
SE corner	I	0.03 - 0.04

TABLE 3

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND THE BOUNDARY OF
THE WELCOME RESIDUE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
<u>South side:</u>		
SE corner	II	0.18 - 0.20
50' west of SE corner	II	0.20
100' " " " "	II	0.28 - 0.35
150' " " " "	II	0.85 - 0.95
200' " " " "	III	1.10
250' " " " "	II	0.45 - 0.50
300 " " " "	II	0.80
At gate	III	0.75
180' west of gate	III	0.5
250' " " "	III	0.65
300' " " "	III	0.85
350' " " "	III	0.80
400' " " "	III	0.70
450' " " "	III	0.85 - 0.9
500' " " "	III	0.80 - 0.85
550' " " "	III	0.65 - 0.70
600' " " "	III	0.65 - 0.70
650' " " "	III	0.60 - 0.70
700' " " "	III	0.75 - 0.85
750' " " "	III	0.35 - 0.40
800' " " "	III	0.15 - 0.20
SW corner	II	0.065 - 0.075

Table 3 (continued)

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
<u>West side:</u>		
50' north of SW corner	II	0.12
100' " " " "	II	0.15 - 0.17
150' " " " "	II	0.20 - 0.24
200' " " " "	II	0.45 - 0.50
250' " " " "	II	0.47 - 0.52
300' " " " "	II	0.42 - 0.48
350' " " " "	II	0.45 - 0.50
400' " " " "	II	0.40 - 0.45
450' " " " "	II	0.42 - 0.46
450' " " " " 20' inside property	III	1.00 - 1.20
NW corner - lowest point of property	II	0.18 - 0.25
<u>East side:</u>		
NE corner - poison ivy	--	-- --
50' south of NE corner	IV	17.00
50' " " " " 20' inside property	IV	22.00
100' " " " "	IV	17.00
150' " " " "	III	4.20
200' " " " "	III	2.80
250' " " " "	III	5.80 - 6.20
250' " " " " 10' inside property	III	4.60
300' " " " "	III	5.60
300' " " " " 10' inside property	III	5.60
350' " " " "	II	1.00
400' " " " "	II	0.40 - 0.50
450' " " " "	II	0.28
SE corner	II	0.18 - 0.20

Table 3 (continued)

<u>Location</u>	<u>Scale</u>	<u>Reading mR/h</u>
<u>North side:</u>		
NW corner	II	0.18 - 0.25
50' east of NW corner	II	0.38 - 0.42
100' " " " "	II	0.58 - 0.62
150' " " " "	II	0.50
150' " " " " 10' inside property	III	1.20
200' " " " "	II	0.45 - 0.55
250' " " " "	II	0.28 - 0.32
300' " " " "	II	0.30 - 0.40
350' " " " "	II	0.32 - 0.38
400' " " " "	II	0.45 - 0.50
400' " " " " 10' inside property	II	0.80
450' " " " "	II	0.55 - 0.60
500' " " " "	II	0.50 - 0.55
550' " " " "	II	0.55
600' " " " "	II	0.50 - 0.60
650' " " " "	II	0.55 - 0.60
650' " " " " 15' inside property	III	2.80
675' " " " " 15' inside property	III	3.50
700' " " " "	III	0.90 - 1.00
800' " " " " 15' inside property	III	2.10
850' " " " "	II	0.85 - 0.90
850' " " " " 15' inside property	III	5.50
900' " " " "	II	0.85 - 0.95
950' " " " "	III	1.00

Table 3 (continued)

<u>Location</u>	<u>Scale</u>	<u>Reading mR/h</u>
1000' east of NW corner	II	0.80 - 0.90
1050' " " " "	III	0.75 - 0.85
1070' " " " " 15' inside property	IV	16.00
NE corner - poison ivy	--	-- --

TABLE 4

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND THE BOUNDARY OF
THE PORT GRANBY RESIDUE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
At gate	I	0.04 - 0.05
NW corner, near water sampling point	I	0.02 - 0.025
North fence at 'dog leg'	I	0.05 - 0.06
Middle of old east gorge area	III	1.30
UF ₆ residue, contact - window closed	II	0.30 - 0.40
- window open	II	0.40 - 0.45
Solvent extraction residue		
- window closed	III	1.00 - 1.50
- window open	IV	67.00 - 68.00

TABLE 5

MONKEY MOUNTAIN RESIDUE AREA AND HUNT PROPERTY

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC $\mu\text{g/ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Sampling Point No. 4 near street.	1962	50.0	13.0	26.3	---	---	---	---	---	---
	1963	19.0	1.8	9.2	---	---	---	---	---	---
	1964	24.0	0.9	7.4	---	---	---	---	---	---
	1965	35.0	0.45	11.0	---	---	---	---	---	---
	1966	27.0	5.0	11.0	170	6	88	---	---	---
	1967	15.0	1.1	3.7	15	3	5.9	---	---	---
	1968	2.4	1.5	1.9	6	2	3.6	---	---	---
	1969	2.3	0.15	0.9	4	<0.5	1.5	---	---	---
	1970	1.6	0.7	1.2	2.8	<0.5	1.7	---	---	---
	1971	4.8	0.7	1.8	2.1	<0.5	1.2	---	---	---
	1972	1.5	0.6	1.2	5	0.5	2.5	---	---	---
	1973	3.4	1.5	2.4	9	2	5	---	---	---
	1974	3.7	0.5	1.8	30	4	14	---	---	---
1975	---	---	1.3	---	---	<0.1	---	---	---	
MONKEY MOUNTAIN Sampling Point No. 5 inside residue area.	1962	80	7.7	28.7	---	---	---	---	---	---
	1963	37	15	28	---	---	---	---	---	---
	1964	35	0.01	16	---	---	---	---	---	---
	1965	53	3.5	19.1	---	---	---	---	---	---
	1966	95	47	66	35	20	27.5	---	---	---
	1967	56	38	49.5	30	2	9.5	---	---	---
	1968	54	11	32.5	---	---	4	---	---	---
	1969	14	1.7	8.4	8	<0.5	3.8	1.9	1.9	1.9
1970	18	7.5	11.5	4.3	<0.5	2.6	---	---	---	

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC $\mu\text{g}/\text{ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Sampling Point No. 5 (continued)	1971	26	18	21.3	15	<0.5	5.6	---	---	8
	1972	45	0.37	28.1	---	---	---	---	---	---
	1973	23.2	12	18.3	---	---	2	---	---	---
	1974	27.8	4.2	12.4	9	2	5.5	---	---	---
	1975	---	---	0.7	---	---	3	---	---	---
MONKEY MOUNTAIN Hunt Property East tributary	1962	12	3.5	8.4	---	---	---	---	---	---
	1963	16	3.3	9.6	---	---	---	---	---	---
	1964	11	4.5	8.0	---	---	---	---	---	---
	1965	28.8	4	15.7	---	---	---	---	---	9
	1966	31	6	23.4	4	2	3	---	---	---
	1967	38	20.3	28	30	2	11	---	---	---
	1968	29	17	22.7	100	5	33	---	---	---
	1969	30	0.7	16.9	95	<0.5	18.5	8.3	0.6	5.2
	1970	17	1	10.5	34	0.8	7.7	7.7	0.5	4.7
	1971	17	3.4	10.7	5	<0.5	1.9	8.2	2.9	5.1
	1972	13.3	1.2	5.9	8.3	0.5	3.9	5.1	2.3	3.8
	1973	13.1	2.0	8.9	13	<0.1	5.8	3.7	1.5	2.9
	1974	9.7	4.5	7.5	8	0.5	3.1	3.3	1.4	2.3
	1975	9.4	4.9	5.9	20	0.8	6.2	2.5	1.8	2.1

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC $\mu\text{g/ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Hunt Property West tributary.	1962	14	2.5	6.9	---	---	---	---	---	---
	1963	60	0.6	13.5	---	---	---	---	---	---
	1964	30	0.75	12.2	---	---	---	---	---	---
	1965	33.4	2	20.1	---	---	---	---	---	14
	1966	29	1	12	8	2	5	---	---	---
	1967	14	6.2	10.8	25	<0.5	7.9	---	---	---
	1968	22	5.8	11.1	65	5	15.9	---	---	---
	1969	14	0.1	6.9	45	<0.5	8.6	5.7	0.3	3.6
	1970	6.2	3.4	4.9	4.9	<0.5	2.2	7.5	4.7	5.8
	1971	9.7	2.5	5.0	52	<0.5	5.1	8.5	3.6	6.0
	1972	12.5	1.2	4.3	4.3	<0.5	2.0	5.4	0.3	3.9
	1973	8.0	1.2	5.3	7	<0.5	2.6	5.2	2.3	3.8
	1974	6.1	2.9	4.4	5	0.1	2.1	4.7	2.3	3.1
1975	6.4	2.4	3.5	7	<0.1	2.2	3.1	2.4	2.7	
MONKEY MOUNTAIN Hunt Property Upper Pond.	1962	0.65	0.03	0.23	---	---	---	---	---	---
	1963	0.44	0.04	0.18	---	---	---	---	---	---
	1964	0.65	0.22	0.34	---	---	---	---	---	---
	1965	2	0.28	0.85	---	---	---	---	---	1
	1966	2	0.6	0.9	3	2	2.5	---	---	---
	1967	5.8	0.39	1.05	3	<0.5	1.2	---	---	---
	1968	0.77	0.36	0.61	3	<0.5	1.1	---	---	---
	1969	0.7	0.27	0.5	18	<0.5	2.4	0.52	0.4	0.47
	1970	0.49	0.23	0.34	6	<0.5	1.3	1.1	0.26	0.53
1971	0.52	0.18	0.33	3	<0.5	0.7	1.9	0.09	0.59	

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC $\mu\text{g/ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN	1972	1.18	<0.01	0.22	2.4	<0.5	1.0	0.77	0.15	0.30
Hunt Property	1973	0.36	<0.01	0.22	7	<0.1	2.0	0.46	0.03	0.23
Upper Pond	1974	0.24	0.13	0.18	4	<0.1	1.2	0.26	0.05	0.15
(continued).	1975	0.19	0.12	0.14	5	<0.1	1.8	0.17	0.07	0.13

TABLE 6

WELCOME RESIDUE AREA

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC $\mu\text{g}/\text{ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
WELCOME Pump House Sampling Point No. 15	1963	11	5	8.7	---	---	---	---	---	---
	1964	13	5	8.9	---	---	---	---	---	---
	1965	61	1	24.5	---	---	---	---	---	---
	1966	73	25	54	---	---	80	---	---	---
	1967	58	20.7	40.5	160	12	71	---	---	---
	1968	59	5.6	38.5	450	30	182	---	---	---
	1969	33	13	25.3	115	6.6	52.4	6.4	5.6	6.0
	1970	27	8.5	16.3	40	15	24.5	7.0	3.8	5.5
	1971	22	3.8	12.9	20	2	9.9	6.5	1.9	4.4
	1972	18.5	3.3	8.6	41.1	5.1	16.1	4.2	2.0	3.3
	1973	23.9	2.0	14.2	60	9	31.3	3.4	1.4	2.6
	1974	18.3	8.0	12.6	140	10	39.7	3.1	1.5	2.0
	1975	9.6	6.1	7.9	65	14	34.5	1.9	0.7	1.4
	WELCOME Marsh Road, Brand's Creek Sampling Point No. 9	1962	0.062	0.004	0.022	---	---	---	---	---
1963		0.04	0.01	0.019	---	---	---	---	---	---
1964		0.02	<0.01	0.019	---	---	---	---	---	---
1965		0.16	0.01	0.06	---	---	---	---	---	---
1966		0.34	<0.01	0.08	---	---	4	---	---	---
1967		0.44	<0.01	0.07	2	<0.5	1.4	---	---	---
1968		0.12	<0.01	0.046	14	<0.5	2.8	---	---	---
1969		0.06	<0.01	0.026	2	<0.5	<0.5	0.4	0.21	0.3
1970		0.05	<0.01	0.019	1.3	<0.5	0.63	---	---	---
1971		0.23	<0.01	0.04	2.2	<0.5	0.67	---	---	---
1972		0.03	<0.01	<0.01	6.5	0.3	2.25	---	---	---
1973		0.04	0.02	0.03	3	<0.5	1.55	---	---	---

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC $\mu\text{g}/\text{ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
WELCOME Marsh Road Brand's Creek (continued)	1974	0.018	0.003	0.009	3	0.2	1.38	---	---	---
	1975	---	---	0.006	---	---	0.18	---	---	---
WELCOME Culvert, Highway 401 Sampling Point No. 5	1964	1.50	0.02	0.19	---	---	---	---	---	---
	1965	4.30	0.04	0.55	---	---	---	---	---	---
	1966	1.30	0.05	0.23	---	---	230	---	---	---
	1967	0.34	<0.01	0.09	7	<0.5	1.4	---	---	---
	1968	0.56	0.01	0.19	7	<0.5	2.0	---	---	---
	1969	1.40	<0.01	0.34	2	<0.5	0.58	0.30	0.27	0.30
	1970	0.43	0.04	0.13	3	<0.5	1.10	---	---	---
	1971	2.2	0.04	0.62	1.4	<0.5	0.71	---	---	3.5
	1972	0.24	<0.01	0.12	64	1.1	25.4	---	---	---
	1973	0.25	0.01	0.12	24	<0.1	6.5	---	---	---
	1974	0.29	0.08	0.19	2	<0.1	1.2	---	---	---
1975	---	---	0.05	---	---	8	---	---	---	

TABLE 7

PORT GRANBY RESIDUE AREA

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	ARSENIC, $\mu\text{g}/\text{ml}$			RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
PORT GRANBY East gorge	1967	12	0.82	4.0	360	35	191	---	---	---
	1968	66	<0.01	7.72	130	20	42	---	---	---
	1969	19	0.2	5.74	255	18	74.1	1.0	0.66	0.82
	1970	65	0.13	7.66	94	25	48.6	3.4	0.20	0.66
	1971	4.3	<0.01	0.73	140	4.3	38.8	1.5	0.09	0.44
	1972	6.5	<0.01	1.10	200	9.2	52	0.62	0.09	0.28
	1973	36	0.15	3.62	200	12	58	0.64	0.06	0.20
	1974	31.5	0.03	3.5	220	9	68	0.40	0.03	0.14
	1975	4.9	0.15	2.01	190	55	110	0.21	0.04	0.12
PORT GRANBY West Gorge	1967	8.6	1.8	4.67	730	65	395	---	---	---
	1968	36	<0.01	7.7	910	260	530	---	---	---
	1969	4.5	1.3	2.43	535	191	372	6.0	2.8	4.2
	1970	3.2	0.83	2.04	415	130	276	6.6	1.4	3.68
	1971	3.9	0.60	1.98	330	95	162	7.1	0.93	3.98
	1972	2.8	0.09	1.26	375	160	242	6.17	2.00	4.51
	1973	5.5	0.93	3.16	600	160	410	9.25	4.01	6.6
	1974	3.2	0.62	2.22	2180	370	957	9.14	5.53	7.07
	1975	1.68	1.00	1.26	1780	920	1500	11.03	5.53	8.00

M E M O R A N D U M

TO: Dr. A.T. Prince File: 15-2-E1
FROM: G.B. Knight Date: July 16, 1975
SUBJECT: Eldorado Nuclear Limited Waste Management Sites

This memorandum summarizes measurements made of the exposure rates around the boundaries of the ENL waste management sites, and reviews the radiological analyses of water samples taken at these sites by ENL.

1. Exposure rates at the boundary of the residue areas

On 2 July 1975, I visited the four waste management sites of ENL, i.e. Monkey Mountain, Pidgeon Hill, Welcome, and Port Granby. I was accompanied by Mr. S. Frost, Health Physicist for ENL, and, using a Berthold Model LB 1200 Monitoring Instrument borrowed from Health and Welfare Canada, we measured the external gamma radiation exposure rates at waist height at points around the boundaries of each site. All measurements, unless otherwise noted, were made with the instrument window closed, i.e. only penetrating gamma radiation was measured.

As a reference, the exposure rate was measured on Walton Street in Port Hope just opposite the offices of the 'Port Hope Evening Guide' - the level ranged from 9 to 13 μ R/h. A second reference measurement in the front garden of Mr. Frost's home at 75 Jocelyn Street, Port Hope, gave a rate of 8 μ R/h.

1.1 Monkey Mountain Residue Area

The site is in the NE corner of Pine Street and Pidgeon Hill in Port Hope. Pine Street is no more than a gravel track with no dwellings on it, but Pidgeon Hill is a paved road that runs along the South boundary with dwellings towards the SE corner of the site.

The site itself is quite small (about 1 1/4 acres) and is located on a hillside that slopes down from the NW to the SE. The SE corner is the lowest point and a water sampling point is located here.

The site is covered with long grass and a few young trees are growing along the East side. The area is surrounded by a 4' wire fence that carries notices warning that it is a 'protected place' by order of the AECB. The gate is padlocked.

Dr. A.T. Prince

16 July 1975

Most of the radiation measurements were made inside the fenced area either at, or a few feet from the fence. The measurements are listed in Table 1. As can be seen, the rate measured at the fence ranged from 10 μ R/h at the highest point of land (at the NW corner) to 60 μ R/h at the lowest point of land (at the SE corner). There appears to be further contamination outside the fenced area to the east and in the vicinity of the South-east corner where rates as high as 200 μ R/h and 65 μ R/h, respectively, were measured. ENL owns the property to the East of the site, but it is not completely fenced.

1.2 Dr. Hunt's Property

Dr. Hunt owns the property to the South of Pidgeon Hill, and the ground water from the Monkey Mountain Area comes to the surface in two springs on this property. The gamma exposure rates were found to be as follows:

West spring	0.012 mR/h
East spring	0.015 mR/h

1.3 Pidgeon Hill Storage Area

This site is located a short distance along Pidgeon Hill to the West of the Monkey Mountain site. The Port Hope Municipal 'Dump' adjoins the North side of the site, but the other three sides are bordered by undeveloped land.

The site is about 2 acres in extent, is fairly level and covered by long grass and is surrounded by a 6' wire fence topped by a further 1' of barbed wire. Warning signs similar to those at the Monkey Mountain site are placed on each fence and the gate is padlocked. All buildings have been removed.

The exposure rates were measured just outside the fence, and are listed in Table 2. As can be seen, the rates ranged from 15 to 40 μ R/h with most readings falling in the range from 20 to 30 μ R/h. There was no evidence of radioactive contamination outside the fenced area.

ENL plans to complete cleanup of this site and then to donate it to the Town of Port Hope for a recreational area.

Dr. A.T. Prince

16 July 1975

Apparently, this site was used for storage of radium waste (some incineration was carried out prior to 1954), but no burial of waste was done.

1.4 Welcome Residue Area

This site is located West of Port Hope near the village of Welcome. The site is rectangular in shape and measures about 1100' X 500'. It adjoins a gravel pit along its North side and is bordered by agricultural land on the other three sides. ENL owns a strip of land about 50 yards wide along the north side of the site another strip of land about 100 yards wide along the east side, and a third parcel of land that adjoins the North-west corner of the site.

The highest part of the site lies along the East side and it slopes gently towards the North-west corner which is the lowest point on the site.

The site was generally covered with grass, but there were areas towards the East where there was no ground cover, and shallow drainage ditches had been dug parallel to the West and North boundaries about 10' to 15' inside the boundary fence. There was evidence that the drainage ditches had handled a considerable surface run-off.

The whole site was surrounded by a 6' high wire fence topped by a further 1' of barbed wire. The fence had collapsed for a distance of about 100' along the East side of the site near the South-east corner; otherwise, the fence appeared to be in reasonable condition. Warning signs similar to those at the Monkey Mountain site were placed on the fence at infrequent intervals. The gate was padlocked.

In addition to residues, the equipment from the dismantled radium laboratories was buried at this site.

Measurements were made at intervals along the inside of the boundary fence, and, at arbitrarily selected points, over the drainage ditch. The measurements are listed in Table 3. As can be seen, the exposure rates along the boundary

Dr. A.T. Prince

16 July 1975

covered the following ranges:

South side	0.15 to 1.10 mR/h
West side	0.15 to 0.52 mR/h
North side	0.28 to 1.00 mR/h
East side	0.28 to 17.00 mR/h

Measurements made along the gravel road to the East of the site, which incidentally marks the eastern boundary of the ENL property, gave exposure rates of 50 to 70 μ R/h. The exposure rate at the junction of Marsh Road with the gravel road between lots 12 and 13 was 18 to 20 μ R/h - this marks the nearest dwellings to the disposal site (a distance of about half a mile).

1.5 Port Granby Residue Area

This site is located about 10 miles West of Port Hope and covers 28 acres. The site is bounded on the South side by Lake Ontario and by farm land in active use on the other three sides - there is a farm house and barns about 100 yards from the gate leading into the site.

Refinery residue has been dumped at this site since the mid-1950's, and some material from the other sites has been transferred here. At the present time, residues from the UF₆ Plant and from solvent extraction are buried at the site routinely.

Generally, all residue dumped into the East gorge has been covered with topsoil which now supports a thick cover of grass, and all current residues are buried in trenches.

While it is claimed that the present residues have a low radioactive content, measurements on a recent batch of solvent extraction residue indicated about 1.0 to 1.5 mR/h of penetrating gamma radiation on contact, and 67 to 68 mR/h of low energy radiation which is, presumably, due to beta radiation resulting from decay of thorium-234 with a half-life of 24.3 days. Contact measurements on UF₆ plant residue gave 0.3 to 0.4 mR/h.

Due to the large area covered by this site, measurements

Dr. A.T. Prince

16 July 1975

of the exposure rate were made at selected points for comparison with a more complete survey carried out by Mr. S. Frost; these measurements are given in Table 4.

A map of the Port Granby Residue Area is given in Figure 1 (following Table 4) on which the external exposure rates measured at waist height by ENL are marked in $\mu\text{R/h}$. The map shows that the area is bounded by a complete fence along three sides, but that the fence along the southern boundary is not continuous. It was observed that the fence along the west, north and east boundaries were 6-foot wire fences in good condition topped by 1 foot of barbed wire; the gate was padlocked, and warning signs similar to those at the other sites were posted at various points. I have discussed the condition of the southern boundary fence with Mr. Frost, and note the following points:

- a) the fence running parallel to the shoreline from the western boundary is in good condition for a distance of about 650 feet to the east.
- b) the remaining fence towards the east along the lake-shore is discontinuous due to land erosion and the difficulties of fence maintenance along the bluffs. It is considered by ENL that the nature of the shoreline discourages entry into the site at this point - the steepness of the shore can be appreciated from the 50' and 100' elevation contours drawn on the map.

Note that the steel cribs shown on the map act as anchors for the southern ends of the west and east boundary fences.

Selected ENL measurements and those listed in Table 4 are compared below:

<u>Location</u>	<u>ENL reading,</u> <u>$\mu\text{R/h}$</u>	<u>AECB reading,</u> <u>$\mu\text{R/h}$</u>
At gate	50	40 - 50
NW corner, near sampling point	60	20 - 25
North fence at 'dog leg'	60	50 - 60

While the ENL measurement was 2 to 3 times higher than that of the AECB at one location, there was good agreement at the other two locations.

On the basis of this comparison, the ENL measurements appear to be acceptable.

Referring to Figure 1, the exposure rates along the boundary cover the following ranges:

West side	50 to 70 μ R/h
North side	50 to 70 μ R/h
East side	40 to 70 μ R/h
South side	50 to 600 μ R/h

There appears to be cause for concern that the higher rates (up to 600 μ R/h) along the southern boundary may be due to seepage of radioactive residues from the trench burial area.

2. Water samples from the residue areas

Mr. S. Frost has supplied copies of the analysis of water samples obtained at each of the residue areas for the past several years. Similar data have been obtained by MOE, but their data in our possession are less complete than those supplied by ENL. Samples were collected and analysed usually on a monthly basis by ENL staff.

I have reviewed these data and have tabulated the maximum, minimum and average concentrations measured for radium-226 and natural uranium. (See Tables 5, 6, and 7.)

The various criteria applied to water contamination for public surface water supplies and livestock watering by the Ontario Ministry of the Environment are given in Table 8; limiting concentrations applied by the AECB at reactor sites are included for comparison. It should be noted that MOE applies these limits to the total amount of the contaminant present and does not distinguish between soluble and insoluble forms, but the International Commission on Radiological Protection does distinguish between transportable and non-transportable forms.

2.1 Monkey Mountain Residue Area

The data for the Monkey Mountain Area are given in Table 5 and include samples dating back to 1962 taken from sampling point 4 located just outside the South-east corner

of the residue area, sampling point 5 just inside the East boundary of the area, and sampling points at the East and West tributaries and the pond on Dr. Hunt's property that are fed by ground water from the residue area.

In discussing these data with Mr. P. Hughes of the MOE Peterborough office, I understood that MOE has not conducted a monitoring programme at the Monkey Mountain Residue Area, but that they plan to commence some monitoring there and will study the same data produced by ENL that are reviewed in this memorandum.

In comparing the data shown in Table 5 with the drinking water standards, it can be seen that the recent radium concentrations on average are close to the permissible criterion although the East tributary on Dr. Hunt's property is generally higher (as much as double the permissible criterion), and the uranium concentrations are acceptable.

2.2 Welcome Residue Area

Mr. Hughes has confirmed that MOE includes the Welcome Area in its monitoring programme.

The data for the Welcome Residue Area are given in Table 6 and include samples dating back to 1962 taken from the pump house sampling point 15 (run-off from the Welcome Residue Area is pumped through a buried pipeline to Lake Ontario so as not to contaminate any adjacent farm land or public watercourses), from Brand's Creek where it passes under Marsh Road, and from sampling point 5 at a culvert at Highway 401.

Generally, levels of radium and uranium are acceptable in Brand's Creek and the Highway 401 culvert, but at sampling point 15 (pump house), the radium concentrations are generally ten times higher than the permissible criterion.

2.3 Port Granby Residue Area

MOE mount a fairly extensive monitoring programme around the Port Granby Residue Area where they take water samples periodically and analyse for: radium-226, gross α activity, gross β activity, uranium-238, phosphorus, nitrogen and fluorine.

Dr. A.T. Prince

16 July 1975

The data for the Port Granby Residue Area are given in Table 7. As can be seen, the radium-226 concentrations are considerably higher than the permissible criterion. However, examination of the radium concentrations in MOE water samples taken at 50 and 100 yards from the discharge point into Lake Ontario show that the concentration is quickly diluted to below the permissible criterion. Uranium concentrations are well below the permissible criterion at the East gorge, but are up to twice the permissible criterion at the West gorge.

Generally, while concentrations may be high, the discharge rate into the lake is quite small, i.e. an average of 15 Imperial gallons per minute.

3. Recommendations

- 3.1 The fencing at the Monkey Mountain and Welcome Residue Areas should be extended to the boundary of the ENL property. This would have the effect of bringing the contaminated area at Monkey Mountain within the fence, and of ensuring that the public at the Welcome Residue Area do not have access to areas where high radiation fields exist.
- 3.2 A systematic radiation survey should be conducted outside the southern boundary fence at the Port Granby Residue Area (possibly backed up by analysis of soil samples) to establish the extent of contamination in this area.
- 3.3 Guidelines should be provided regarding what is an acceptable exposure rate at the boundary of a disposal area. A person will accumulate a dose of 500 mrem in a year if continuously exposed to 0.057 mR/h (500 mrem is the maximum permissible annual dose allowed by the Atomic Energy Control Regulations for people who are not atomic radiation workers.) In the absence of dwellings in the vicinity of the site boundary, it is unlikely that anybody would spend their entire time at the boundary fence, so that an exposure rate of 0.060 mR/h above the the natural background rate would be quite conservative.

Dr. A.T. Prince

16 July 1975

- 3.4 Guidelines should be provided regarding what is an acceptable concentration of contaminants in the surface and ground waters affected by these sites. The water quality criteria would provide a conservative guideline, but it may be necessary to consider other factors to establish a more realistic level where the water is not used for drinking purposes, or else to consider the feasibility of water treatment before discharge into the lake.
- 3.5 The fences along the East boundary of the Welcome Residue Site and the South boundary of the Port Granby Residue Site should be repaired immediately.
- 3.6 The existing warning notices should be replaced by more appropriate ones as approved by the AECB, and they should be placed at more frequent intervals along each boundary fence.
- 3.7 ENL should be asked to comply with the requirements of the Prescribed Substance Licence 18/74 with regard to obtaining approval from the AECB for the disposal of material.
- 3.8 The chemical forms of the radioactive contaminants (principally uranium and radium) should be determined to assist in deciding the appropriateness of the water contamination limits.
- 3.9 Formal channels should be established for the transmission of effluent and environmental monitoring data between ENL and the various regulatory bodies (particularly the AECB).
- 3.10 The feasibility of establishing a single waste management site for ENL should be studied.

G.B. Knight.

G.B. Knight

GBK:kk

Attachments

cc: J.H. Jennekens
P. Hamel
R.M. Duncan
R.F. Scarth

TABLE 1

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND THE BOUNDARY OF
THE MONKEY MOUNTAIN RESIDUE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
About 30' from ENL property opposite gate	I	0.025 - 0.03
At gate	I	0.015
West side, about 1/3 distance from SW corner	I	0.025 - 0.03
SW corner	I	0.025 - 0.03
South side, middle	I	0.025
SE corner	I	0.045 - 0.06
SE corner, window open	I	0.065 - 0.075
SE corner, outside fence	I	0.05 - 0.06
SE corner, outside near water sampling point	I	0.06 - 0.065
SE corner, outside in ditch about 12' from corner	I	0.04 - 0.045
East side, middle	I	0.05 - 0.055
NE corner	I	0.02 - 0.025
Outside fence, NE corner 15' to E	I	0.03
- 1/3 distance from NE corner 20' to E	II	0.20 (max)
- 1/3 distance from NE corner 50' to E	I	0.05 - 0.06
- SE corner 50' to E	I	0.025 - 0.03
- NE corner 50' to E	I	0.055 - 0.065
- NE corner 10' to N	I	0.07 - 0.08
North side, middle	I	0.015
NW corner	I	0.010

TABLE 2

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND

THE BOUNDARY OF THE PIDGEON HILL

STORAGE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
At gate	I	0.02 - 0.03
South side, middle	I	0.02 - 0.025
SW corner	I	0.025
West side, middle	I	0.02 - 0.025
NW corner	I	0.015
North side, middle	I	0.016 - 0.018
NE corner	I	0.020
East side - not accessible		
SE corner	I	0.03 - 0.04

TABLE 3

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND THE BOUNDARY OF
THE WELCOME RESIDUE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
<u>South side:</u>		
SE corner	II	0.18 - 0.20
50' west of SE corner	II	0.20
100' " " " "	II	0.28 - 0.35
150' " " " "	II	0.85 - 0.95
200' " " " "	III	1.10
250' " " " "	II	0.45 - 0.50
300' " " " "	II	0.80
At gate	III	0.75
180' west of gate	III	0.5
250' " " "	III	0.65
300' " " "	III	0.85
350' " " "	III	0.80
400' " " "	III	0.70
450' " " "	III	0.85 - 0.9
500' " " "	III	0.80 - 0.85
550' " " "	III	0.65 - 0.70
600' " " "	III	0.65 - 0.70
650' " " "	III	0.60 - 0.70
700' " " "	III	0.75 - 0.85
750' " " "	III	0.35 - 0.40
800' " " "	III	0.15 - 0.20
SW corner	II	0.065 - 0.075

Table 3 (continued)

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
<u>West side:</u>		
50' north of SW corner	II	0.12
100' " " " "	II	0.15 - 0.17
150' " " " "	II	0.20 - 0.24
200' " " " "	II	0.45 - 0.50
250' " " " "	II	0.47 - 0.52
300' " " " "	II	0.42 - 0.48
350' " " " "	II	0.45 - 0.50
400' " " " "	II	0.40 - 0.45
450' " " " "	II	0.42 - 0.46
450' " " " " 20' inside site fence	III	1.00 - 1.20
NW corner - lowest point of site	II	0.18 - 0.25
<u>East side:</u>		
NE corner - poison ivy	--	-- --
50' south of NE corner	IV	17.00
50' " " " " 20' inside site fence	IV	22.00
100' " " " "	IV	17.00
150' " " " "	III	4.20
200' " " " "	III	2.80
250' " " " "	III	5.80 - 6.20
250' " " " " 10' inside site fence	III	4.60
300' " " " "	III	5.60
300' " " " " 10' inside site fence	III	5.60
350' " " " "	II	1.00
400' " " " "	II	0.40 - 0.50
450' " " " "	II	0.28
SE corner	II	0.18 - 0.20

Table 3 (continued)

<u>Location</u>	<u>Scale</u>	<u>Reading mR/h</u>
<u>North side:</u>		
NW corner	II	0.18 - 0.25
50' east of NW corner	II	0.38 - 0.42
100' " " " "	II	0.58 - 0.62
150' " " " "	II	0.50
150' " " " " 10' inside site fence	III	1.20
200' " " " "	II	0.45 - 0.55
250' " " " "	II	0.28 - 0.32
300' " " " "	II	0.30 - 0.40
350' " " " "	II	0.32 - 0.38
400' " " " "	II	0.45 - 0.50
400' " " " " 10' inside site fence	II	0.80
450' " " " "	II	0.55 - 0.60
500' " " " "	II	0.50 - 0.55
550' " " " "	II	0.55
600' " " " "	II	0.50 - 0.60
650' " " " "	II	0.55 - 0.60
650' " " " " 15' inside site fence	III	2.80
675' " " " " 15' inside site fence	III	3.50
700' " " " "	III	0.90 - 1.00
800' " " " " 15' inside site fence	III	2.10
850' " " " "	II	0.85 - 0.90
850' " " " " 15' inside site fence	III	5.50
900' " " " "	II	0.85 - 0.95
950' " " " "	III	1.00

Table 3 (continued)

<u>Location</u>	<u>Scale</u>	<u>Reading mR/h</u>
1000' east of NW corner	II	0.80 - 0.90
1050' " " " "	III	0.75 - 0.85
1070' " " " " 15' inside site fence	IV	16.00
NE corner - poison ivy	--	-- --

TABLE 4

MEASUREMENTS OF GAMMA EXPOSURE RATES AROUND THE BOUNDARY OF
THE PORT GRANBY RESIDUE AREA

<u>Location</u>	<u>Scale</u>	<u>Reading, mR/h</u>
At gate	I	0.04 - 0.05
NW corner, near water sampling point	I	0.02 - 0.025
North fence at 'dog leg'	I	0.05 - 0.06
Middle of old east gorge area	III	1.30
UF ₆ residue, contact - window closed	II	0.30 - 0.40
- window open	II	0.40 - 0.45
Solvent extraction residue		
- window closed	III	1.00 - 1.50
- window open	IV	67.00 - 68.00

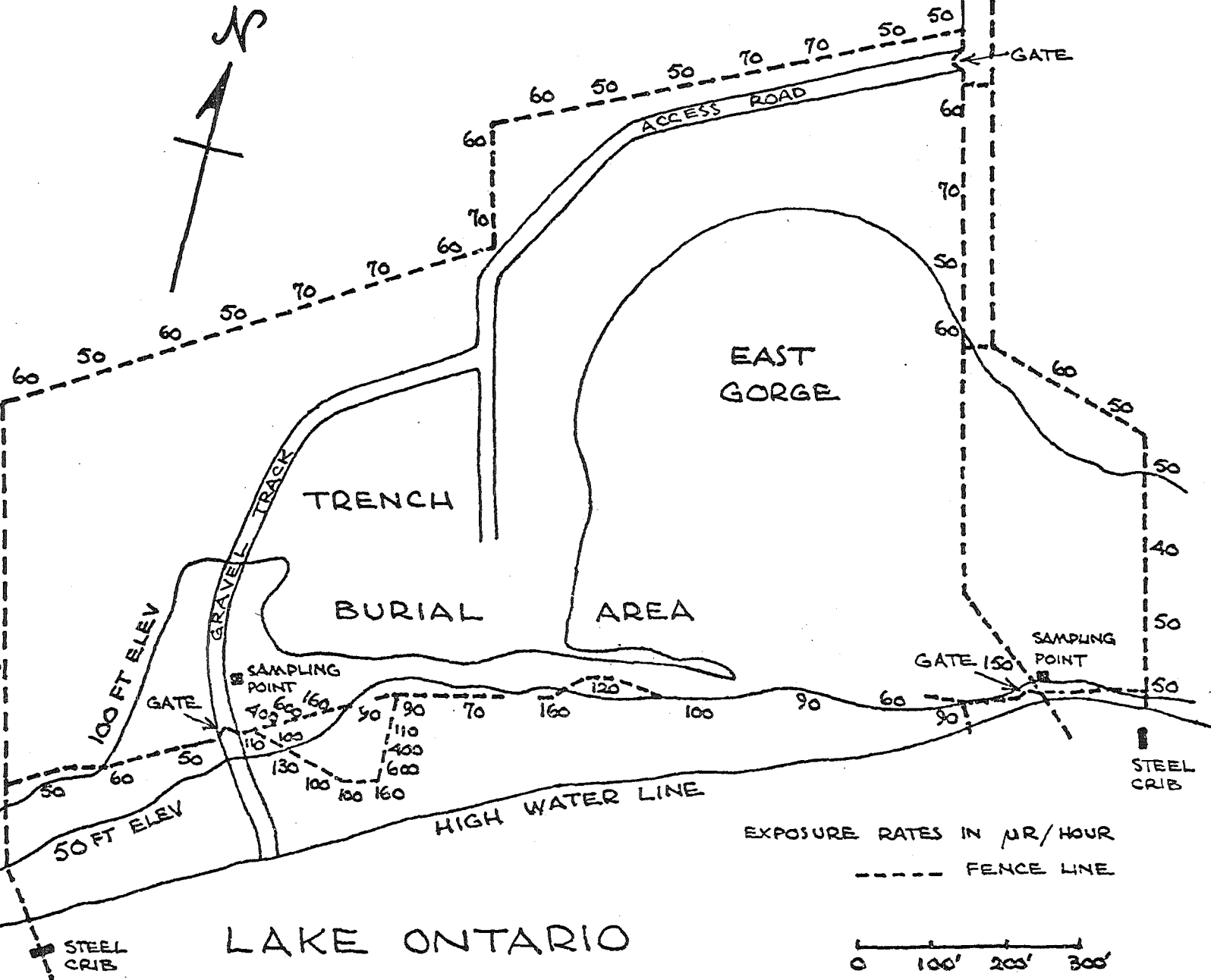
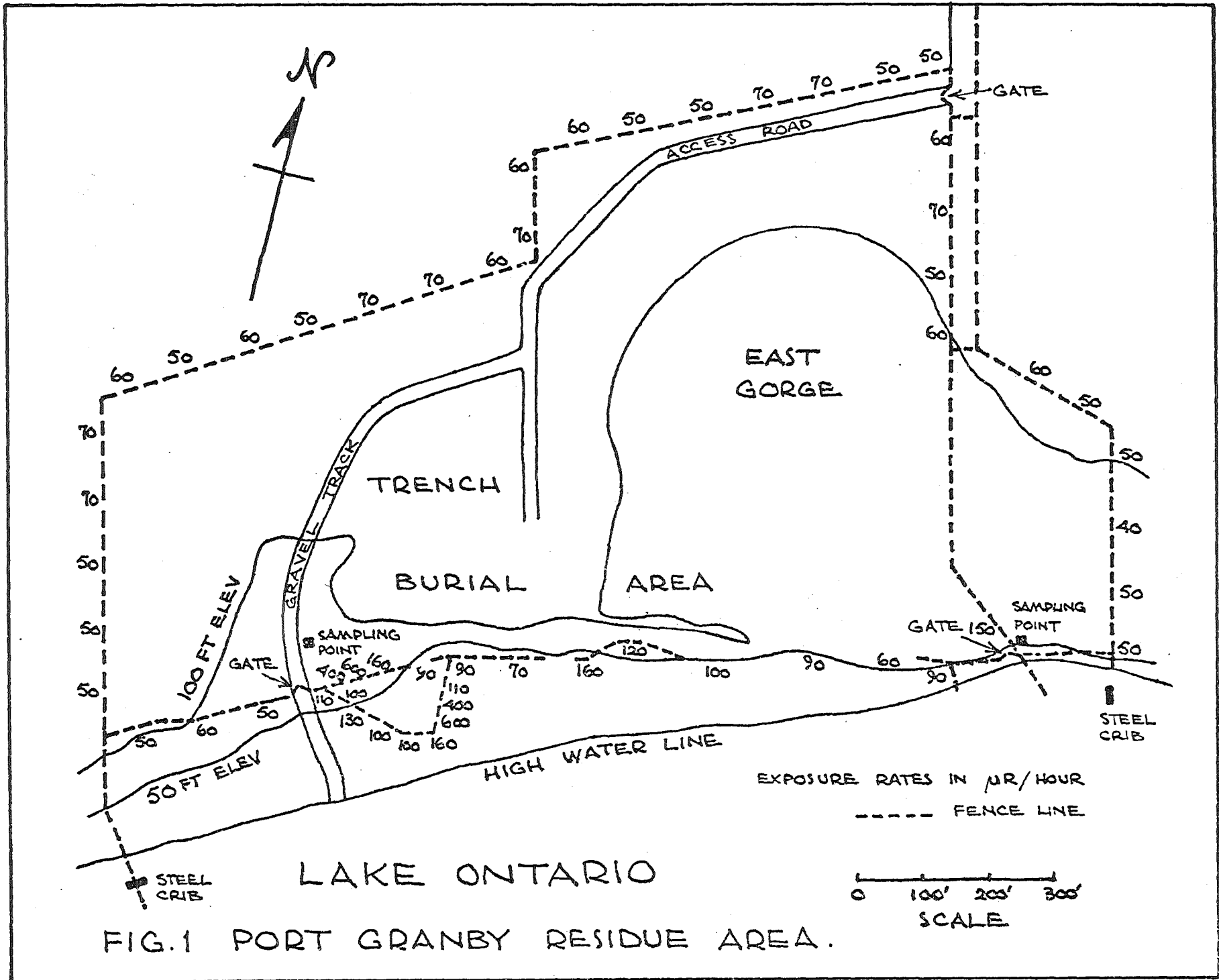


FIG. 1 PORT GRANBY RESIDUE AREA.

TABLE 5

MONKEY MOUNTAIN RESIDUE AREA AND HUNT PROPERTY

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Sampling Point No. 4 near street.	1962	---	---	---	---	---	---
	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	---
	1966	170	6	88	---	---	---
	1967	15	3	5.9	---	---	---
	1968	6	2	3.6	---	---	---
	1969	4	<0.5	1.5	---	---	---
	1970	2.8	<0.5	1.7	---	---	---
	1971	2.1	<0.5	1.2	---	---	---
	1972	5	0.5	2.5	---	---	---
	1973	9	2	5	---	---	---
	1974	30	4	14	---	---	---
	1975	---	---	<0.1	---	---	---
MONKEY MOUNTAIN Sampling Point No. 5 inside residue area.	1962	---	---	---	---	---	---
	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	---
	1966	35	20	27.5	---	---	---
	1967	30	2	9.5	---	---	---
	1968	---	---	4	---	---	---
	1969	8	<0.5	3.8	1.9	1.9	1.9
1970	4.3	<0.5	2.6	---	---	---	

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Sampling Point No. 5 (continued)	1971	15	<0.5	5.6	---	---	8
	1972	---	---	---	---	---	---
	1973	---	---	2	---	---	---
	1974	9	2	5.5	---	---	---
	1975	---	---	3	---	---	---
MONKEY MOUNTAIN Hunt Property East tributary	1962	---	---	---	---	---	---
	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	9
	1966	4	2	3	---	---	---
	1967	30	2	11	---	---	---
	1968	100	5	33	---	---	---
	1969	95	<0.5	18.5	8.3	0.6	5.2
	1970	34	0.8	7.7	7.7	0.5	4.7
	1971	5	<0.5	1.9	8.2	2.9	5.1
	1972	8.3	0.5	3.9	5.1	2.3	3.8
	1973	13	<0.1	5.8	3.7	1.5	2.9
	1974	8	0.5	3.1	3.3	1.4	2.3
	1975	20	0.8	6.2	2.5	1.8	2.1

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Hunt Property West tributary.	1962	---	---	---	---	---	---
	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	14
	1966	8	2	5	---	---	---
	1967	25	<0.5	7.9	---	---	---
	1968	65	5	15.9	---	---	---
	1969	45	<0.5	8.6	5.7	0.3	3.6
	1970	4.9	<0.5	2.2	7.5	4.7	5.8
	1971	52	<0.5	5.1	8.5	3.6	6.0
	1972	4.3	<0.5	2.0	5.4	0.3	3.9
	1973	7	<0.5	2.6	5.2	2.3	3.8
	1974	5	0.1	2.1	4.7	2.3	3.1
1975	7	<0.1	2.2	3.1	2.4	2.7	
MONKEY MOUNTAIN Hunt Property Upper Pond.	1962	---	---	---	---	---	---
	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	1
	1966	3	2	2.5	---	---	---
	1967	3	<0.5	1.2	---	---	---
	1968	3	<0.5	1.1	---	---	---
	1969	18	<0.5	2.4	0.52	0.4	0.47
	1970	6	<0.5	1.3	1.1	0.26	0.53
1971	3	<0.5	0.7	1.9	0.09	0.59	

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
MONKEY MOUNTAIN Hunt Property Upper Pond (continued).	1972	2.4	<0.5	1.0	0.77	0.15	0.30
	1973	7	<0.1	2.0	0.46	0.03	0.23
	1974	4	<0.1	1.2	0.26	0.05	0.15
	1975	5	<0.1	1.8	0.17	0.07	0.13

TABLE 6

WELCOME RESIDUE AREA

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g}/\text{ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
WELCOME Pump House Sampling Point No. 15	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	---
	1966	---	---	80	---	---	---
	1967	160	12	71	---	---	---
	1968	450	30	182	---	---	---
	1969	115	6.6	52.4	6.4	5.6	6.0
	1970	40	15	24.5	7.0	3.8	5.5
	1971	20	2	9.9	6.5	1.9	4.4
	1972	41.1	5.1	16.1	4.2	2.0	3.3
	1973	60	9	31.3	3.4	1.4	2.6
	1974	140	10	39.7	3.1	1.5	2.0
	1975	65	14	34.5	1.9	0.7	1.4
WELCOME Marsh Road, Brand's Creek Sampling Point No. 9	1962	---	---	---	---	---	---
	1963	---	---	---	---	---	---
	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	---
	1966	---	---	4	---	---	---
	1967	2	<0.5	1.4	---	---	---
	1968	14	<0.5	2.8	---	---	---
	1969	2	<0.5	<0.5	0.4	0.21	0.3
	1970	1.3	<0.5	0.63	---	---	---
	1971	2.2	<0.5	0.67	---	---	---
	1972	6.5	0.3	2.25	---	---	---
1973	3	<0.5	1.55	---	---	---	

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
WELCOME Marsh Road Brand's Creek (continued)	1974	3	0.2	1.38	---	---	---
	1975	---	---	0.18	---	---	---
WELCOME Culvert, Highway 401 Sampling Point No. 5	1964	---	---	---	---	---	---
	1965	---	---	---	---	---	---
	1966	---	---	230	---	---	---
	1967	7	<0.5	1.4	---	---	---
	1968	7	<0.5	2.0	---	---	---
	1969	2	<0.5	0.58	0.30	0.27	0.30
	1970	3	<0.5	1.10	---	---	---
	1971	1.4	<0.5	0.71	---	---	3.5
	1972	64	1.1	25.4	---	---	---
	1973	24	<0.1	6.5	---	---	---
	1974	2	<0.1	1.2	---	---	---
	1975	---	---	8	---	---	---

TABLE 7

PORT GRANBY RESIDUE AREA

ANALYSIS OF WATER SAMPLES BY ELDORADO NUCLEAR LIMITED

MONITORING LOCATION	YEAR	RADIUM-226, pCi/l			URANIUM, $\mu\text{g/ml}$		
		MAX.	MIN.	AVE.	MAX.	MIN.	AVE.
PORT GRANBY East gorge	1967	360	35	191	---	---	---
	1968	130	20	42	---	---	---
	1969	255	18	74.1	1.0	0.66	0.82
	1970	94	25	48.6	3.4	0.20	0.66
	1971	140	4.3	38.8	1.5	0.09	0.44
	1972	200	9.2	52	0.62	0.09	0.28
	1973	200	12	58	0.64	0.06	0.20
	1974	220	9	68	0.40	0.03	0.14
	1975	190	55	110	0.21	0.04	0.12
PORT GRANBY West Gorge	1967	730	65	395	---	---	---
	1968	910	260	530	---	---	---
	1969	535	191	372	6.0	2.8	4.2
	1970	415	130	276	6.6	1.4	3.68
	1971	330	95	162	7.1	0.93	3.98
	1972	375	160	242	6.17	2.00	4.51
	1973	600	160	410	9.25	4.01	6.6
	1974	2180	370	957	9.14	5.53	7.07
	1975	1780	920	1500	11.03	5.53	8.00

TABLE 8

WATER QUALITY CRITERIA

<u>Contaminant</u>	<u>Maximum Permissible Concentration</u>	<u>Permissible Criteria</u>	<u>Desirable Criteria</u>
Radium-226 - MOE ⁽¹⁾	-----	3 pCi/l	<1 pCi/l
- AECB ⁽²⁾	10 pCi/l	-----	-----
Nat. uranium			
- MOE ⁽¹⁾	-----	5 µg/ml	Absent
- AECB ⁽²⁾	2 µg/ml	-----	-----
Gross β activity ⁽¹⁾	-----	1000 pCi/l	<100 pCi/l

(1) These criteria are those used by the Ontario Ministry of the Environment and are taken from their "Guidelines and Criteria for Water Quality Management", July, 1974.

(2) These limits are based on the MPC_w for continuous intake by members of the public and are derived from figures given in ICRP Publications 2 and 6. The MPC_w is usually applied to the concentration measured at the point of discharge to the environment and is averaged over a period of one month.

