

ATOMIC ENERGY  
OF CANADA LIMITED



L'ÉNERGIE ATOMIQUE  
DU CANADA LIMITÉE

**FOLLOW-UP OF CRNL EMPLOYEES INVOLVED IN  
THE NRX REACTOR CLEAN-UP**

**Suivi des employés de Chalk River  
ayant participé au nettoyage du réacteur NRX**

**M.M. WERNER, D.K. MYERS and D.P. MORRISON**

Paper presented at the Third Annual Meeting of the Canadian Radiation  
Protection Association, Vancouver, B.C., 1982 May 4.

Chalk River Nuclear Laboratories

Laboratoires nucléaires de Chalk River

Chalk River, Ontario

July 1982 juillet

ATOMIC ENERGY OF CANADA LIMITED

FOLLOW-UP OF CRNL EMPLOYEES INVOLVED IN THE NRX REACTOR CLEAN-UP\*

by

M.M. Werner, D.K. Myers and D.P. Morrison

\*Presented at the Third Annual Meeting of the Canadian Radiation  
Protection Association, Vancouver, B.C., 1982 May 4.

Chalk River Nuclear Laboratories  
Chalk River, Ontario K0J 1J0  
1982 July

AECL-7760

L'ENERGIE ATOMIQUE DU CANADA, LIMITEE

Suivi des employés de Chalk River  
ayant participé au nettoyage du réacteur NRX\*

par

M.M. Werner, D.K. Myers et D.P. Morrison

Résumé

Les données relevées jusqu'à présent au sujet de la mortalité des employés actuels ou retraités des Laboratoires nucléaires de Chalk River sont en accord avec l'effet du "travailleur en bonne santé" noté lors d'études semblables effectuées dans d'autres installations nucléaires. Suite à un accident survenu en décembre 1952, le réacteur de recherche NRX a dû être en grande partie démonté et reconstruit en 1953-54. Ces opérations ont amené un bon nombre d'employés à être passablement exposés à des rayonnements. Le suivi des 850 employés de l'EACL ayant participé à Chalk River au nettoyage du NRX a révélé qu'il n'y avait rien d'anormal dans le taux de mortalité de ce groupe en comparaison de ceux s'appliquant à la population générale de l'Ontario.

\* Rapport présenté à la troisième assemblée annuelle de l'Association canadienne de protection contre les rayonnements, Vancouver, 1982 mai 4.

Laboratoires nucléaires de Chalk River  
Chalk River, Ontario K0J 1J0

Juillet 1982

AECL-7760

ATOMIC ENERGY OF CANADA LIMITED

FOLLOW-UP OF CRNL EMPLOYEES INVOLVED IN THE NRX REACTOR CLEAN-UP\*

by

M.M. Werner, D.K. Myers and D.P. Morrison

ABSTRACT

Data available to date on the mortality of continuing and retired employees of the Chalk River Nuclear Laboratories are consistent with the "healthy worker" effect that has been observed in similar studies at other nuclear facilities. Because of an accident at the NRX research reactor in December 1952, the reactor was largely dismantled and rebuilt in 1953-54. These operations involved appreciable radiation exposures to a number of employees. The follow-up of the 850 on-site AECL staff involved in the clean-up has indicated that there were no unusual patterns in the mortality of this group when compared with those of the general population of Ontario.

\*Presented at the Third Annual Meeting of the Canadian Radiation Protection Association, Vancouver, B.C., 1982 May 4.

Chalk River Nuclear Laboratories  
Chalk River, Ontario K0J 1J0  
1982 July

AECL-7760

# FOLLOW-UP OF CRNL EMPLOYEES INVOLVED IN THE NRX REACTOR CLEAN-UP

by

M.M. Werner, D.K. Myers and D.P. Morrison

(Text of talk presented by Mary M. Werner at the Third Annual Meeting of the Canadian Radiation Protection Association, Vancouver, B.C., 1982 May 4)

## 1. INTRODUCTION

Nearly 30 years have passed since the NRX reactor accident at Chalk River. Detailed descriptions of this accident have been published elsewhere (1-5). A combination of human error and a mechanical design fault allowed the 30 megawatt research reactor to undergo a brief power surge to 100 megawatts. This occurred on 1952 December 12 during a start-up procedure when the reactor was scheduled to operate at low power with reduced cooling to some of the fuel rods. The accident damaged the reactor and left the basement of the reactor building filled with 1 000 000 gallons of water contaminated with fission products. The building itself was highly contaminated but the surrounding plant area was not. Most of the Chalk River staff were evacuated from the site at the time of the accident on a Friday but resumed work on the following Monday. Since the reactor was badly damaged, it was decided to replace rather than repair the reactor vessel. The initial clean-up operation required personnel to work in radiation fields of up to 10 R/h in certain areas. To accomplish reconstruction in a reasonable time and keep exposures within the accepted limits (15 rem per year at that time), staff resources had to be utilized carefully and extra personnel brought in from outside. However, the majority of the personnel involved in cleaning up the

accident were on-site AECL staff. This paper is concerned with the follow-up of AECL staff involved in the 1953 NRX clean-up operation.

## 2. CLEAN-UP PERSONNEL

Table 1 shows the number of persons involved in the 1953 NRX clean-up operations for whom radiation exposure records are available. Twenty people were from a construction company working on site. Both American and Canadian military services sent some of their staff to assist in the clean-up and to gain some additional experience with the handling of radioactive material. About 150 men came from the United States. These people are not included in our current follow-up since we do not at present have access to U.S. mortality data. The Department of National Defence is currently conducting its own study on the health of Canadian military personnel who were exposed to radiation during military service. Those involved in the 1953 and the 1958 clean-up operations at Chalk River will eventually also be included in the AECL Health Study (7). The total number of Canadian military who were at Chalk River in 1953 is probably about 170.

TABLE 1

Number of persons known to be involved in 1953 clean-up\*

---

ON-SITE AECL STAFF	MILITARY		CONSTRUCTION
	U.S.A.	CANADA	COMPANY
862			
860 MALES	~150	~170	~20
2 FEMALES			
(both alive in 1982)			
850			
TRACEABLE**			
10			
UNTRACEABLE			

---

\* Data largely provided by G. Cowper (6).

\*\* This report is concerned with the follow-up of this group of persons.

The AECL staff who received appreciable radiation exposures during the 1953 clean-up numbered 862; 2 of these were women, both currently living (Table 1). Of the remaining 860 males, 6 were attached staff, mostly from outside Canada, and 4 are currently untraceable because no further information on them could be found other than presumed surname, initials and radiation exposure. Of the remaining 850 male AECL employees, 562 remained associated with AECL (most with the Chalk River Nuclear Laboratories, although some have moved to other sites) through continuing employment and eventually, in many cases, retirement. These 562 persons are indicated as group B in Table 2. An up-to-date listing of current and retired employees is available at CRNL, as is a listing of CRNL employees who have died during employment or after retirement. With the help of these listings plus invaluable assistance from CRNL Plant Administration and Operations in tracing persons who had moved from CRNL to other AECL sites, we were able to trace all of the 562 persons in group B of Table 2.

The remaining group of 288 males presented more problems. This group, indicated as group A in Table 2, were AECL employees in 1953 but subsequently left AECL to work elsewhere. Although we do know where some of these people are currently employed (e.g., with the federal government in Ottawa, Ontario government in Toronto, and with Ontario Hydro), we have no means of knowing either the whereabouts of all of these persons or if they are still living. From personnel files at CRNL it is possible to obtain a certain amount of identifying information on these people. As part of the overall AECL Health Study (7), an Employee Identity Summary form (Fig. 1) was filled in for all past CRNL employees. With the information (usually incomplete) available from this form, it was possible to conduct a manual search for people from group A in the Canadian Mortality Data Base at Statistics Canada in Ottawa (8,9). The Canadian Mortality Data Base currently contains a computer and microfiche record of all deaths occurring in Canada up to the end of 1979. The primary cause of death as derived from the death certificate is listed on

the Mortality Data Base by ICD code - an international classification of diseases established by the WHO (10-12). Statistics Canada releases the information from the Canadian Mortality Data Base in tabular form only. Although it is believed that most of the deaths that occurred among persons in group A between 1953 and 1979 were located during this manual search of the Mortality Data Base, it is not certain that all deaths were recorded. For example, persons in group A who left Canada and died elsewhere would not be recorded.

TABLE 2

Subdivision of identifiable AECL male staff involved in clean-up operations at NRX reactor in 1953

	Group A	Group B
Subsequent employment	Left AECL	Remained with AECL
Number of persons	288	562
Collective recorded clean-up dose in rem (Sv)*	542 (5.4)	1479 (14.8)
Collective recorded lifetime occupational dose in rem (Sv)*	**	9400 (94.0)

\* Note: 100 rem equals one sievert (Sv).

\*\* Although some information on lifetime occupational doses received at AECL is available, it is known that some of the persons in group A have moved into non-AECL jobs associated with additional radiation exposure. For this reason, no attempt has been made to estimate cumulative lifetime dose for persons in group A.

### 3. RADIATION EXPOSURE RECORDS

The original dosimetry records for this clean-up were lost in February 1956 when a fire in the laundry destroyed the dosimetry section



EMPLOYEE IDENTITY SUMMARY

RESTRICTED STAFF INFORMATION

SITE .....

DATE .....

PLEASE PRINT	
1. Surname .....	
2. Any other surname(s) you may have had .....	
3. First given name .....	
4. Second given name .....	
5. Third given name (if any) .....	
6. Usual name or nickname .....	
7. Sex .....	<input type="checkbox"/> Male <input type="checkbox"/> Female
8. Marital status .....	
9. Birth date .....	Year    Month (spell out)    Day
10. Birth country .....	
11. Birth place .....	Village/Town/City    County    Province
12. Father's surname .....	
13. Father's first name .....	
14. Father's second name .....	
15. Father's birth place .....	Province    Country
16. Mother's maiden surname .....	
17. Mother's first name .....	
18. Mother's second name .....	
19. Mother's birth place .....	Province    Country
20. Spouse's birth surname .....	
21. Spouse's first name .....	
22. Spouse's second name .....	
FOR OFFICE USE ONLY	
23. Badge Number .....	
24. Employee Number .....	
25. Social Insurance Number .....	
26. Provincial Health Insurance Number .....	Province    Number
27. Superannuation Number .....	
28. Starting date .....	Year    Month (spell out)    Day
.....	
.....	
29. Termination date .....	Year    Month (spell out)    Day
.....	
.....	
30. Date of death .....	Year    Month (spell out)    Day
31. Place of death .....	City    Province    Country
32. Last known year alive .....	

housed above it. However, much of the information for the 1953 clean-up was retrieved. Dosimeter readings for non-AECL personnel were kept in separate files and were believed to be essentially complete (6). Because of the notification system used to inform AECL workers and their supervisors of doses in excess of 0.3 rem per week, it was possible to recover most of the data on AECL employees with individual exposures greater than 0.3 rem during the clean-up. The data recovered are not complete but are believed to include the significant exposures received by AECL employees at that time (6,13).

In 1953, ICRP recommendations permitted radiation workers to receive up to 0.3 rem per week or 15 rem per year. Table 3 shows the distribution of recorded doses received by the AECL clean-up participants. All except one were below the annual limit and 86% of all recorded exposures were below the 5 rem per year limit adopted by CRNL in 1956 (13), two years before the ICRP recommendations (14). The maximum dose received by any non-AECL participant was 6.2 rem.

TABLE 3

Distribution of recorded doses accumulated by AECL staff during NRX clean-up\*

Dose range in rem (Sv)	0 - 4.99 (0 - 0.05)	5.00 - 9.99 (0.05 - 0.1)	10.00 - 14.99 (0.1 - 0.15)	16.2 (0.16)
Number of traceable males	730	107	12	1
Number of untraceable males	10	0	0	0
Number of females	1	1	0	0

\* Data provided by G. Cowper (6).

Problems involved in measuring radiation exposures have been discussed elsewhere (13). The dosimeters in general use in 1953

is thus good reason to believe that the actual doses received during the NRX clean-up were smaller than those recorded, probably somewhere between 50 and 100 percent of the recorded doses given in Tables 2 and 3.

The total recorded doses accumulated during the entire clean-up period from December 1952 to the end of February 1954 amounted to 542 rem for AECL staff in group A and 1479 rem for group B. About 600 additional rem were accumulated by the non-AECL personnel involved. According to the widely accepted estimates of risk provided by various committees (15, 16, 17), the total recorded dose of about 2600 rem received by all clean-up participants together would probably not be sufficient to cause a single fatal cancer.

#### 4. MORTALITY OF AECL CLEAN-UP PERSONNEL

Almost all the deaths occurred in Ontario. Therefore, the control population used for this study was the general population of Ontario from 1953 to 1978 - the last year for which vital statistics data were available at the time this report was prepared (18). To calculate the expected number of deaths in any given year, the number of people in each 5-year age category during that year was multiplied by the fraction of Ontario residents of the same age and sex who died during that same year. The data for each year were then summed to give the total expected figure for a given time period.

In group A, eight deaths or 22.2% of the total for this group were due to cancer; 19 deaths or 52.8% of the total for this group were due to cardiovascular diseases (Table 4). These proportions are similar to those found for adult males in the general population. None of the cancer deaths were of the types (e.g., leukemia) that are associated with exposure to high doses of radiation (15-17,19-21). Because it seems improbable that all deaths in group A have been located, standard mortality ratios (SMR = observed:expected deaths) were not calculated.

TABLE 4

Mortality among AECL clean-up participants

Cause of death	Group A 1953 - 1979	Group B		Group B 1953 - 1980 SMR*
		1953 - 1965 Obs./Exp	1966 - 1980 Obs./Exp.	
Cancers	8	5/ 7.2	23/26.7	0.83
Cardiovascular diseases	19	21/20.3	63/61.6	1.03
Accidents	5	7/ 6.5	3/ 8.0	0.69
Other	4	5/ 6.5	13/19.3	0.70
Total	36	38/40.5	102/115.6	0.90

\* SMR is the standard mortality ratio, i.e., the ratio of observed (OBS) to expected (EXP) numbers of deaths.

For group B, there were 140 deaths up to the end of 1980. The causes of death were ascertained from the Canadian Mortality Data Base and also from records in the Office of the Registrar General for Ontario as described in another publication (22). The data were subdivided into two groups covering the years 1953-65 and 1966-80 in order to see if there were any trends in the data with increasing time after the clean-up operation. No unusual trends were observed (Table 4).

For the period from 1966 to 1980, 23 cancer deaths were observed where 26.7 were expected. Special attention was paid to certain types of cancer that might be of interest in view of reports on the mortality of hanford workers (23-25). Of the 23 cancer deaths in this time period, 10 were from lung cancer where 8.7 were expected, 2 were from cancer of the pancreas where 1.6 were expected, 0 were from leukemia where 0.9 were expected, and there was 1 observed lymphatic cancer where 1.3 were expected<sup>†</sup>.

<sup>†</sup> Of the 5 cancer deaths that occurred during the years 1953-1965, 1 was from cancer of the pancreas and 1 from lymphatic cancer.

None of these data suggest a highly unusual pattern of cancer mortality as a result of participation in the NRX clean-up. The overall SMR for the 562 persons in group B was 0.90, which means that these people are on average living a year or so longer than expected by comparison with the general population of Ontario. The number of deaths from cardiovascular disease is slightly higher than might be expected. The SMR for cancer deaths was 0.83, with no excess in those types of cancer that might be associated with radiation. It would appear therefore that participation in the 1953 NRX reactor clean-up did not have a harmful effect on the health of those involved.

Work is just underway on a follow-up of those persons involved in the 1958 NRU clean-up operation. The radiation exposure to all personnel during the major part of the 1958 clean-up was between 800 and 900 rem (26) as compared with about 2600 rem for the 1953 NRX clean-up.

#### ACKNOWLEDGEMENTS

The authors wish to thank the many people who assisted in obtaining the information necessary for this paper: notably G. Cowper, R.M. Rondeau and J.M. Vincent who helped with the dose records, M.M. Hanlon and C. Lamb of the Office Services Branch who abstracted information from personnel files for Employee Identity Summary forms, C.L. Nagy of Health Sciences Division who searched the Division files for information relating to the clean-up, M.E. Smith who assisted in extracting information from the Mortality Data Base, E.W. Pike for access to the death records in the Office of the Registrar General of Ontario, and finally to the many other people (D.W.S. Evans, C. Tanner, N. Oelke, D. Peplinski and others) who assisted in tracing AECL personnel.

REFERENCES

1. W.G. CROSS, "The Chalk River accident in 1952". Abstract. Health Physics, 39, 1056 (1980).
2. W.J. EDWARDS, "Fission-product release from the NRX 1952 accident". Atomic Energy of Canada Limited, Report AECL-1877 (1963).
3. D.G. HURST, "The accident to the NRX reactor, Part II". Atomic Energy of Canada Limited, Report AECL-233 (1953).
4. W.B. LEWIS, "The accident to the NRX reactor on December 12, 1952". Atomic Energy of Canada Limited, Report AECL-232 (1953). Also published in Reactor Sci. Technol., 3(4):9 (1953).
5. J.M. ROBSON, "The Canadian nuclear reactor accident". Proceedings of the National Electronics Conference, Vol. 11, held in Chicago, Illinois, 1955 October 3-5.
6. G. COWPER, Personal communication, memo dated 1960 January 20.
7. J.L. WEEKS, "A Study of the health of the employees of Atomic Energy of Canada Limited 1. Setting up the study". Atomic Energy of Canada Limited, Report AECL-6813 (1981).
8. M.E. SMITH, "The present state of automated follow-up in Canada. Part 1: Methodology and files". J. Clin. Computing, Vol. 9, p. 1-18 (1980).
9. M.E. SMITH and H.B. NEWCOMBE, "Automated follow-up facilities in Canada for monitoring delayed health effects". Amer. J. Public Health, Vol. 70, p. 1261-1268 (1980).
10. International Classification of Diseases, Vol. 1, 1955 Revision, World Health Organization, Geneva, 1957.
11. International Classification of Diseases, Vol. 1, 1975 Revision, World Health Organization, Geneva, 1977.
12. Eighth Revision International Classification of Diseases. Adopted for use in the United States, U.S. Department of Health, Education and Welfare, Public Health Service, National Center for Health Statistics, Vol. 1 (1967).
13. G. COWPER and J.R. JOHNSON, "Radiation exposure records in AECL". Appendix G in reference 7 (1981).
14. "Radiation Protection. Recommendations of the International Commission on Radiological Protection". ICRP Publication 1. Pergamon Press, New York (1959).

15. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). "Sources and effects of ionizing radiation". United Nations, New York (1977).
16. Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR). "The effects on populations of exposure to low levels of ionizing radiation". U.S. National Academy of Sciences, Washington (1980).
17. ICRP Publication 26. Recommendations of the International Commission on Radiological Protection, Annals of the ICRP, Vol. 1, No. 3 (1977).
18. Province of Ontario, Vital Statistics. Published annually from the Office of the Registrar General, Toronto (1953....1978).
19. C.E. LAND and J.E. NORMAN, "Latent periods of radiogenic cancers occurring among Japanese A-bomb survivors (IAEA-SM-224/602)", in Late Biological Effects of Ionizing Radiation, Vol. 1, Proceedings of a Symposium, International Atomic Energy Agency, Vienna, 1978 March 13-17.
20. T. OHKITA, H. TAKAHASHI, N. TAKEICHI and F. HIROSE, "Prevalence of leukaemia and salivary gland tumours among Hiroshima atomic bomb survivors (IAEA-SM-224/608)", in Late Biological Effects of Ionizing Radiation, Vol. 1, Proceedings of a Symposium, International Atomic Energy Agency, Vienna, 1978 March 13-17.
21. P.G. SMITH and R. DOLL, "Age and time dependent changes in the rates of radiation-induced cancers in patients with ankylosing spondylitis following a single course of X-ray treatment (IAEA-SM-224/711)", in Late Biological Effects of Ionizing Radiation, Vol. 1, Proceedings of a Symposium, International Atomic Energy Agency, Vienna, 1978 March 13-17.
22. D.K. MYERS, M.M. WERNER, G. COWPER, D.P. MORRISON, R.M. HOLFORD and M.E. SMITH, "Follow-up of past employees of the Chalk River Nuclear Laboratories". Third International Symposium of Society for Radiological Protection, Inverness, Scotland, 1982 June 6-11.
23. T.F. MANCUSO, A. STEWART and G. KNEALE, "Radiation exposures of Hanford workers dying from cancer and other causes". Health Physics 33, pp.369-384 (1977).
24. G.B. HUTCHISON, B. MACMAHON, S. JABLON and C.E. LAND, Review of report by Mancuso, Stewart and Kneale of radiation exposure of Hanford workers. Health Physics, Vol. 37, p. 207-220 (1979).

25. E.S. GILBERT and S. MARKS, "An analysis of the mortality of workers in a nuclear facility." Radiation Res., Vol. 79, p. 122-148 (1979).
26. E.O. HUGHES and J.W. GREENWOOD, "Contamination and clean-up of NRU". Nucleonics, Vol. 18, pp.76-80 (1960).



ISSN 0067 - 0367

To identify individual documents in the series  
we have assigned an AECL- number to each.

Please refer to the AECL- number when re-  
questing additional copies of this document

from

Scientific Document Distribution Office  
Atomic Energy of Canada Limited  
Chalk River, Ontario, Canada  
K0J 1J0

Price \$2.00 per copy

ISSN 0067 - 0367

Pour identifier les rapports individuels faisant  
partie de cette série nous avons assigné  
un numéro AECL- à chacun.

Veillez faire mention du numéro AECL- si  
vous demandez d'autres exemplaires de ce  
rapport

au

Service de Distribution des Documents Officiels  
L'Energie Atomique du Canada Limitée  
Chalk River, Ontario, Canada  
K0J 1J0

Prix \$2.00 par exemplaire