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2002 Report on Occupational Radiation Exposures in Canada

Canada

2002 Report on Occupational Radiation Exposures in Canada

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Abstract

The report provides statistics on occupational radiation exposures for use by regulatory authorities, organizations and private individuals. Out of a total of 134,267 monitored workers, 18 annual doses exceeded the regulatory limit of 50 mSv in 2001. This is substantially more than in previous years; however, 13 of these exposures occurred at the same employer, suggesting a common source of the exposures. Out of 58 specified job categories, 26 had a smaller annual average in 2001 than in 2000, 28 had a higher average, and 4 had the same average rounded to 0.01 mSv. Most of the decreases in average dose occurred in the uranium mines, where the averages may be underestimated because not all data were collected at the time of data extraction for the report. Thus, there may be a small overall increase in dose. It is too early to speculate whether this will be a continuing trend.

Acknowledgements

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Introduction

This series of reports provides statistics on occupational radiation exposures of monitored workers in Canada. The statistics are intended to assist regulatory authorities, organizations, and private individuals in comparing incurred occupational radiation exposures with national or provincial/ territorial averages and trends in similar occupations. Previous issues of the report can be obtained from the authors[1-5].

The information is based on the data in the National Dose Registry (NDR) maintained by the Radiation Protection Bureau of Health Canada[6]. The Registry is a centralized record-keeping system containing dose information on all monitored workers in Canada. It includes data submitted by nuclear power generating stations, Atomic Energy of Canada Ltd., uranium mines, and dosimeter processing companies.

Information for input into the NDR is received either via a direct link or by mail in computer readable form.

The report provides data on the two consecutive years prior to the year in which the data are extracted from the database. The data for the second (i.e. more recent) year will be close to stable at the time of data extraction. Some changes may still occur, for which the most frequent causes are: (1) a high dose to a dosimeter is judged to be non-personal after investigation; (2) a job category of a worker is updated; or, (3) dosimeters or data are returned late. The report therefore contains preliminary data on the second year (Table 1), and more complete data on the first year (Tables 2-4).

For a description and a guide to interpretation of the data, the reader is referred to the next section "General comments". The section "Comments specific to this report" has been included to address situations that do not recur from year to year.

General Comments

The statistics include doses as they exist in the database at the time they are extracted for analysis, which in the case of this report is August 10, 2002. Doses are assigned to the year in which the dosimeter was issued, even though some of the dosimeters may actually have been worn during part of the subsequent year. As the statistics are determined in the same manner each year, the annual dose figures are based on a 12-month period, though not necessarily the strict calendar year.

Dose records submitted by outside organizations such as nuclear power generating stations, uranium mines, and commercial processors, are included to the extent that they have been received. The doses are representative of the calendar year only if the fourth quarter records have been received by the time of analysis. When statistics are based on partial data, the fact is indicated in the section "Comments specific to this report".

All doses are in International System (SI) units and presented to the nearest hundredth of a millisievert (1 mSv = 100 mrem). For the external whole body doses various organizations have set recording thresholds from 0 to 0.2 mSv.

The words "dose" and "exposure" are used interchangeably in this report. Doses of different types of radiation are expressed in mSv and added to give the effective dose stated in the report. The following dose types may be included:

- External whole body gamma.
- External whole body high energy beta.
- External whole body X-ray.
- External whole body neutron.
- Internal whole body tritium, as determined by urinalysis.
- Radon progeny exposures, converted from WLM values (see below).

All types of exposure are given in one total. In Tables 3 and 4, the percentage contribution of radon progeny and tritium components are indicated for occupations related to mining and nuclear power generation, respectively. Skin doses and extremity doses are not included in the report but are recorded in the database.

In the NDR database, radon progeny exposures are expressed in Working Level Months (WLM), which are in most cases calculated by the mines on the basis of area monitoring[7]. In the report the radon progeny exposures are converted to equivalent doses (in mSv). The value used in this report is 5 mSv/WLM, in accordance with the radiation protection regulations[8] under the Nuclear Safety and Control Act, which came into force on May 31, 2000.

Job category designations are based on a standard list provided by the Registry and are updated when the Registry is notified. The job category is selected by the organization from a standard list maintained by the NDR. The NDR keeps the most recent job category that an organization submits for a worker in a given year. However, a worker who has been monitored by more than one organization, can have records under more than one job category for the same year. Some organizations have their own job classifications schemes, and translate them into the Registry's standardized list prior to submission of the records.

In this report, the data are tabulated as follows:

2001: Preliminary analysis

Table 1:

Table 1 gives the annual dose distributions by job category.

2000: Final Analysis

Table 2:

Table 2 contains dose statistics by job category and province or territory.

Table 3:

Table 3 contains dose statistics by age and sex. In this table job categories have been grouped into "job sectors".

Table 4:

Table 4 contains various dose statistics by job category. The table also shows the parameters of the lognormal or hybrid lognormal distribution for positive doses, as produced by maximum likelihood estimation. From that information, it is possible to calculate estimates and confidence intervals of statistics of the distribution. For a more detailed discussion the reader is referred to the Appendix.

Table 4 also includes an accumulated dose distribution over the 5 year period 1996-2000 for the workers under the given job category.

Finally, Table 4 contains a histogram that shows the trend in average annual doses over the period 1991-2000.

It should be noted that in the tables, a worker is counted more than once if he (she) works in more than one job category, in more than one province, or in more than on job sector in the same year. For this reason the totals in Tables 2-4 may slightly differ.

Comments specific to this report

Not all data on exposures in uranium mines were collected at the time of extracting data for the report. As a consequence some annual doses may be underestimated.

Many previously unreported job class codes are now being reported and have been copied to previous years at the same organization . This has impacted particularly on the graphs in Table 4. For example, the average dose of safety officers for 1999 has increased from 0.06 mSv in the 2001 report to 0.22 mSv in this report. This is because of a high dose associated with an unknown job class in the 1999 report, which job class has since been reported as safety officer.

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2001 Preliminary Analysis

Table 1
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Administration										
Administrator	385	188	1	1	1	0	0	576	0.13	0.40
Office staff	3428	433	15	9	0	0	0	3885	0.05	0.39
Safety officer	135	47	6	1	1	0	0	190	0.15	0.52
Industry and Research										
Industrial radiographer	1207	484	212	398	523	54	2	2880	3.01	5.19
Instructor (non-medical)	176	10	0	1	0	0	0	187	0.03	0.51
Instrument technician	1777	420	32	20	10	4	7	2270	0.43	1.98
Laboratory technician (industrial)	3487	701	85	72	13	2	1	4361	0.21	1.06
Nuclear fuel processor	121	265	93	91	33	0	0	603	1.33	1.67
Scientist/Engineer (field)	714	485	32	19	6	0	0	1256	0.25	0.58
Scientist/Engineer (laboratory)	5234	1072	14	8	2	1	5	6336	0.13	0.72
Tradesmen	76	23	2	0	1	0	0	102	0.14	0.57
Well logger	721	449	96	45	10	1	0	1322	0.42	0.93
Medicine										
Chiropractor	967	42	9	3	0	0	0	1021	0.03	0.63
Dental assistant	11147	218	2	1	1	0	0	11369	0.01	0.33
Dental hygienist	7965	146	1	1	0	1	1	8115	0.02	1.23
Dental therapist/nurse	111	2	0	0	0	0	0	113	0.00	0.20
Dentist	7098	169	4	3	3	0	0	7277	0.01	0.48
Gynaecologist	13	1	0	0	0	0	0	14	0.01	0.20
Laboratory technician (medical)	2780	331	24	25	3	0	0	3163	0.07	0.58
Medical physicist	293	38	3	0	0	0	1	335	0.20	1.57
Medical radiation technologist	10400	1654	94	61	13	0	0	12222	0.07	0.50
Nuclear medicine technologist	401	369	319	390	50	1	0	1530	1.47	1.99
Nurse	4397	860	48	16	1	1	0	5323	0.08	0.49
Physician	1647	440	48	25	6	0	0	2166	0.15	0.65
Radiation therapist	1207	278	10	8	3	0	0	1506	0.10	0.52
Radiologist (diagnostic)	1574	294	22	16	8	0	0	1914	0.13	0.74
Radiologist (therapeutic)	191	36	2	3	1	0	0	233	0.14	0.76
Veterinarian	3526	312	11	5	0	0	0	3854	0.03	0.35
Veterinary technician	1820	148	6	0	0	0	0	1974	0.03	0.32
Ward aid/orderly	1221	115	8	5	1	0	0	1350	0.05	0.56

Table 1 (Cont'd)
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Nuclear Power										
Reactor - administration	3863	562	105	98	39	0	0	4667	0.19	1.13
Reactor - chemical and radiation control	130	151	52	51	38	0	0	422	1.45	2.10
Reactor - construction	979	397	181	284	234	2	0	2077	1.65	3.12
Reactor - control technician	68	64	20	17	6	0	0	175	0.83	1.36
Reactor - electrical maintenance	608	395	120	137	71	0	0	1331	0.99	1.82
Reactor - fuel handling	7	8	10	9	13	0	0	47	3.17	3.72
Reactor - general maintenance	917	299	76	99	106	5	0	1502	1.03	2.65
Reactor - health physics	37	18	2	5	1	0	0	63	0.47	1.14
Reactor - industrial radiographer	7	19	7	9	3	0	0	45	1.55	1.84
Reactor - mechanical maintenance	451	465	157	253	230	2	0	1558	2.17	3.05
Reactor - operations	787	774	253	234	121	1	0	2170	1.14	1.78
Reactor - scientific/professional	1869	358	67	94	71	0	0	2459	0.45	1.86
Reactor - training	52	6	2	2	2	0	0	64	0.36	1.90
Reactor - visitor	3819	637	182	278	188	6	0	5110	0.59	2.35
Uranium Mining										
Uranium mine electrician	2	1	0	0	0	0	0	3	0.10	0.30
Uranium mine mill maintenance	6	65	45	41	0	0	0	157	1.39	1.44
Uranium mine mill worker	30	56	49	90	12	0	0	237	1.94	2.22
Uranium mine nurse	12	2	0	0	0	0	0	14	0.05	0.38
Uranium mine office staff	101	75	1	0	0	0	0	177	0.11	0.25
Uranium mine support worker	45	72	23	30	6	0	0	176	1.11	1.50
Uranium mine surface maintenance	29	119	29	8	1	0	0	186	0.59	0.70
Uranium mine surface miner	3	11	5	29	0	0	0	48	2.12	2.26
Uranium mine surface personnel	68	85	24	19	1	0	0	197	0.61	0.93
Uranium mine surface support worker	208	112	10	12	1	0	0	343	0.26	0.66
Uranium mine underground maintenance	22	80	11	2	0	0	0	115	0.46	0.57
Uranium mine underground miner	17	54	28	37	25	0	0	161	2.29	2.56
Uranium mine underground personnel	22	43	5	2	1	0	0	73	0.48	0.69
Uranium mine visitor	38	45	3	7	0	0	0	93	0.37	0.63
Miscellaneous/Unknown										
Miscellaneous/unknown	21853	6271	393	273	137	3	1	28931	0.16	0.65

2000 Final Analysis

Table 2
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Administration													
Administrator	5	0	8	2	58	376	13	3	50	29	1	0	545
	0.00	0.00	0.00	0.10	0.00	0.20	0.00	0.00	0.01	0.02	0.00	0.00	0.14
Office staff	40	8	89	69	654	2088	257	71	293	279	11	2	3861
	0.01	0.06	0.01	0.02	0.02	0.08	0.02	0.01	0.11	0.01	0.00	0.10	0.06
Safety officer	4	1	7	2	27	85	15	4	15	12	0	0	172
	0.00	0.20	0.00	0.00	0.02	0.15	0.06	0.08	0.03	0.55	0.00	0.00	0.13
OVERALL	**49**	**9**	**104**	**73**	**739**	**2549**	**285**	**78**	**358**	**320**	**12**	**2**	**4578**
	0.01	**0.08**	**0.00**	**0.02**	**0.02**	**0.10**	**0.02**	**0.01**	**0.09**	**0.03**	**0.00**	**0.10**	**0.07**
Industry and Research													
Industrial radiographer	70	0	95	126	395	672	36	173	1143	251	1	4	2966
	0.34	0.00	1.17	1.78	1.01	1.41	0.29	1.50	4.36	1.65	0.00	0.08	2.49
Instructor (non-medical)	8	3	18	2	29	48	6	22	24	19	1	0	180
	0.03	0.00	0.02	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.01
Instrument technician	92	1	161	52	478	1114	45	27	203	110	2	0	2285
	0.04	0.00	0.09	0.27	0.06	0.19	0.01	0.03	0.25	0.01	0.00	0.00	0.14
Laboratory technician (industrial)	63	9	80	46	932	1740	246	345	288	186	0	0	3935
	0.06	0.02	0.04	0.03	0.05	0.30	0.08	0.02	0.10	0.07	0.00	0.00	0.16
Nuclear fuel processor	0	0	0	0	0	547	0	0	1	0	0	0	548
	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	1.26
Scientist/Engineer (field)	39	0	27	50	66	794	10	45	117	94	8	0	1250
	0.07	0.00	0.04	0.50	0.06	0.40	0.00	0.02	0.33	0.10	0.00	0.00	0.32
Scientist/Engineer (laboratory)	88	3	123	20	2160	1823	161	90	721	736	0	0	5925
	0.00	0.00	0.01	0.06	0.01	0.07	0.01	0.01	0.11	0.01	0.00	0.00	0.04
Tradesmen	0	0	0	0	4	70	0	0	5	4	0	0	83
	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.14	0.08	0.00	0.00	0.07
Well logger	0	0	1	0	1	0	0	49	1010	10	1	0	1072
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.72	0.00	0.00	0.00	0.68
OVERALL	**360**	**16**	**505**	**296**	**4065**	**6808**	**504**	**751**	**3512**	**1410**	**13**	**4**	**18244**
	0.09	**0.01**	**0.26**	**0.90**	**0.12**	**0.41**	**0.06**	**0.36**	**1.68**	**0.32**	**0.00**	**0.08**	**0.57**
Medicine													
Chiropractor	3	1	1	3	479	302	67	13	123	26	0	0	1018
	0.00	0.00	0.30	0.00	0.01	0.02	0.02	0.00	0.02	0.00	0.00	0.00	0.02
Dental assistant	123	38	283	161	2380	5329	731	300	786	636	19	5	10791
	0.00	0.01	0.00	0.01	0.00	0.00	0.03	0.00	0.01	0.00	0.04	0.00	0.00
Dental hygienist	57	20	186	113	2742	3420	483	129	321	323	8	4	7806
	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01
Dental therapist/nurse	0	0	0	0	11	18	26	30	3	6	6	7	107
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.01
Dentist	102	14	148	98	2743	2892	506	117	282	264	21	3	7190
	0.02	0.00	0.00	0.02	0.01	0.01	0.04	0.00	0.02	0.01	0.00	0.00	0.01
Gynaecologist	1	0	1	0	3	5	4	0	1	1	1	0	17
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2 (Cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Laboratory technician (medical)	37	1	157	9	1184	1020	121	62	154	305	3	0	3053
	0.02	0.00	0.03	0.03	0.04	0.16	0.02	0.07	0.02	0.03	0.00	0.00	0.08
Medical physicist	2	1	10	6	110	96	16	11	8	57	1	0	318
	0.00	0.00	0.41	0.12	0.02	0.15	0.09	0.14	0.14	0.01	0.00	0.00	0.08
Medical radiation technologist	308	71	230	317	2900	4198	517	731	1251	1361	24	10	11918
	0.07	0.10	0.04	0.08	0.06	0.07	0.18	0.03	0.07	0.05	0.63	0.03	0.07
Nuclear medicine technologist	22	5	46	33	475	535	73	26	90	151	0	0	1456
	1.78	0.68	1.46	1.34	1.87	1.24	1.12	1.90	1.04	0.55	0.00	0.00	1.38
Nurse	199	4	152	141	1121	2072	291	57	176	355	120	64	4752
	0.04	0.13	0.05	0.11	0.04	0.13	0.01	0.14	0.18	0.06	0.01	0.04	0.09
Physician	43	5	60	26	668	751	56	24	127	201	3	4	1968
	0.01	0.00	0.04	0.17	0.14	0.19	0.03	0.27	0.12	0.15	0.00	0.00	0.15
Radiation therapist	19	3	42	17	296	582	56	62	70	238	0	0	1385
	0.34	0.10	0.28	0.00	0.10	0.07	0.16	0.12	0.07	0.02	0.00	0.00	0.08
Radiologist (diagnostic)	53	7	33	42	524	652	68	50	159	221	6	0	1815
	0.05	0.04	0.26	0.06	0.08	0.21	0.04	0.19	0.22	0.14	0.00	0.00	0.15
Radiologist (therapeutic)	4	1	4	7	60	86	12	4	0	24	0	0	202
	0.00	0.00	0.73	0.00	0.03	0.07	0.04	0.05	0.00	0.00	0.00	0.00	0.06
Veterinarian	31	47	175	78	777	1160	210	158	679	642	0	10	3967
	0.00	0.08	0.01	0.05	0.01	0.03	0.01	0.03	0.01	0.02	0.00	0.03	0.02
Veterinary technician	7	6	63	27	315	492	79	58	231	311	0	7	1596
	0.00	0.00	0.02	0.09	0.02	0.04	0.00	0.01	0.05	0.01	0.00	0.00	0.03
Ward aid/orderly	22	13	21	35	787	236	120	29	49	107	6	2	1427
	0.00	0.06	0.01	0.04	0.06	0.30	0.01	0.12	0.04	0.01	0.00	0.00	0.09
OVERALL	**1033**	**237**	**1612**	**1113**	**17575**	**23846**	**3436**	**1861**	**4510**	**5229**	**218**	**116**	**60786**
	0.08	**0.07**	**0.08**	**0.09**	**0.08**	**0.08**	**0.07**	**0.06**	**0.07**	**0.05**	**0.08**	**0.03**	**0.08**
Nuclear Power													
Reactor - administration	0	0	0	299	352	3726	0	0	0	0	0	0	4377
	0.00	0.00	0.00	0.06	0.13	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.18
Reactor - chemical and radiation control	0	0	0	26	30	293	0	0	0	0	0	0	349
	0.00	0.00	0.00	0.18	1.23	1.67	0.00	0.00	0.00	0.00	0.00	0.00	1.52
Reactor - construction	0	0	0	0	100	1714	0	0	0	0	0	0	1814
	0.00	0.00	0.00	0.00	0.15	1.64	0.00	0.00	0.00	0.00	0.00	0.00	1.56
Reactor - control technician	0	0	0	0	169	1	0	0	0	0	0	0	170
	0.00	0.00	0.00	0.00	0.82	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.82
Reactor - electrical maintenance	0	0	0	92	43	929	0	0	0	0	0	0	1064
	0.00	0.00	0.00	0.68	1.36	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Reactor - fuel handling	0	0	0	35	17	0	0	0	0	0	0	0	52
	0.00	0.00	0.00	6.79	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.64
Reactor - general maintenance	0	0	0	302	70	981	0	0	0	0	0	0	1353
	0.00	0.00	0.00	0.42	2.34	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.86
Reactor - health physics	0	0	0	49	18	18	0	0	0	0	0	0	85
	0.00	0.00	0.00	0.66	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.40
Reactor - industrial radiographer	0	0	0	0	9	48	0	0	0	0	0	0	57
	0.00	0.00	0.00	0.00	4.51	2.05	0.00	0.00	0.00	0.00	0.00	0.00	2.44
Reactor - mechanical	0	0	0	138	158	990	0	0	0	0	0	0	1286
	0.00	0.00	0.00	0.62	2.53	2.23	0.00	0.00	0.00	0.00	0.00	0.00	2.10

Table 2 (Cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Reactor - operations	0	0	0	103	105	1784	0	0	0	0	0	0	1992
	0.00	0.00	0.00	0.43	0.63	1.19	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Reactor - scientific/professiona	0	0	0	508	215	1265	0	0	0	0	0	0	1988
	0.00	0.00	0.00	0.33	0.40	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.48
Reactor - training	0	0	0	32	58	3	0	0	0	0	0	0	93
	0.00	0.00	0.00	0.62	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43
Reactor - visitor	0	0	0	0	1187	2281	0	0	0	0	0	0	3468
	0.00	0.00	0.00	0.00	0.01	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.17
OVERALL	**0**	**0**	**0**	**1584**	**2531**	**14033**	**0**	**0**	**0**	**0**	**0**	**0**	**18148**
	0.00	**0.00**	**0.00**	**0.50**	**0.45**	**0.81**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.73**
Uranium Mining													
Uranium mine electrician	0	0	0	0	0	0	0	11	0	0	0	0	11
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20
Uranium mine mill maintenance	0	0	0	0	0	0	0	175	0	0	0	0	175
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.72	0.00	0.00	0.00	0.00	1.72
Uranium mine mill worker	0	0	0	0	0	0	0	267	0	0	0	0	267
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.00	0.00	2.06
Uranium mine nurse	0	0	0	0	0	0	0	17	0	0	0	0	17
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.11
Uranium mine office staff	0	0	0	0	0	0	0	177	0	0	0	0	177
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.18
Uranium mine support worker	0	0	0	0	0	0	0	327	0	0	0	0	327
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	1.19
Uranium mine surface maintenance	0	0	0	0	0	0	0	194	0	0	0	0	194
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.64
Uranium mine surface miner	0	0	0	0	0	0	0	89	0	0	0	0	89
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	1.35
Uranium mine surface personnel	0	0	0	0	0	14	0	172	0	0	0	0	186
	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.69	0.00	0.00	0.00	0.00	0.64
Uranium mine surface support	0	0	0	0	0	0	0	292	0	0	0	0	292
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.31
Uranium mine underground	0	0	0	0	0	0	0	194	0	0	0	0	194
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.71
Uranium mine underground miner	0	0	0	0	0	1	0	283	0	0	0	0	284
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.58	0.00	0.00	0.00	0.00	2.57
Uranium mine underground	0	0	0	0	0	9	0	106	0	0	0	0	115
	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.92	0.00	0.00	0.00	0.00	0.85
Uranium mine visitor	0	0	0	0	0	0	0	174	0	0	0	0	174
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.21
OVERALL	**0**	**0**	**0**	**0**	**0**	**24**	**0**	**2478**	**0**	**0**	**0**	**0**	**2502**
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**1.10**	**0.00**	**0.00**	**0.00**	**0.00**	**1.09**

2000 Final Analysis

Table3

Dose distribution broken down by job sector, age and sex.

			Sex			
Job Sector	Age	Statistic	Male	Female	Unknown	Overall
Administration	Below 25	Number of Workers	14	315	0	329
		Average dose (mSv)	0.00	0.01	0.00	0.01
	25-34	Number of Workers	94	930	0	1024
		Average dose (mSv)	0.24	0.03	0.00	0.05
	35-44	Number of Workers	257	1270	0	1527
		Average dose (mSv)	0.27	0.05	0.00	0.09
	45-54	Number of Workers	241	1035	1	1277
		Average dose (mSv)	0.25	0.05	0.00	0.09
	55 up	Number of Workers	109	300	0	409
		Average dose (mSv)	0.22	0.03	0.00	0.08
	Unknown	Number of Workers	0	3	0	3
		Average dose (mSv)	0.00	0.00	0.00	0.00
	Overall	**Number of Workers**	**715**	**3853**	**1**	**4569**
		Average dose (mSv)	**0.25**	**0.04**	**0.00**	**0.07**
Industry and Research	Below 25	Number of Workers	1292	719	0	2011
		Average dose (mSv)	1.66	0.07	0.00	1.09
	25-34	Number of Workers	3581	1723	0	5304
		Average dose (mSv)	0.90	0.08	0.00	0.63
	35-44	Number of Workers	4333	1373	0	5706
		Average dose (mSv)	0.60	0.29	0.00	0.52
	45-54	Number of Workers	3048	675	1	3724
		Average dose (mSv)	0.47	0.09	0.00	0.40
	55 up	Number of Workers	1134	147	0	1281
		Average dose (mSv)	0.30	0.14	0.00	0.28
	Unknown	Number of Workers	9	3	1	13
		Average dose (mSv)	0.01	0.00	0.00	0.01
	Overall	**Number of Workers**	**13397**	**4640**	**2**	**18039**
		Average dose (mSv)	**0.73**	**0.14**	**0.00**	**0.58**
Medicine	Below 25	Number of Workers	396	4870	0	5266
		Average dose (mSv)	0.12	0.04	0.00	0.04
	25-34	Number of Workers	3055	15207	0	18262
		Average dose (mSv)	0.11	0.06	0.00	0.07
	35-44	Number of Workers	4901	13644	0	18545
		Average dose (mSv)	0.13	0.07	0.00	0.09
	45-54	Number of Workers	4576	8550	0	13126
		Average dose (mSv)	0.08	0.09	0.00	0.09
	55 up	Number of Workers	2825	1959	0	4784
		Average dose (mSv)	0.07	0.05	0.00	0.06
	Unknown	Number of Workers	11	13	1	25
		Average dose (mSv)	0.00	0.00	0.00	0.00
	Overall	**Number of Workers**	**15764**	**44243**	**1**	**60008**
		Average dose (mSv)	**0.10**	**0.07**	**0.00**	**0.08**

Table3 (Cont'd)
Dose distribution broken down by job sector, age and sex.

			Sex			
Job Sector	Age	Statistic	Male	Female	Unknown	Overall
Nuclear Power	Below 25	Number of Workers	530	144	0	674
		Average dose (mSv)	0.40	0.09	0.00	0.33
		%tritium	13.62	47.78	0.00	15.58
	25-34	Number of Workers	2028	428	0	2456
		Average dose (mSv)	0.96	0.26	0.00	0.83
		%tritium	21.06	31.94	0.00	21.64
	35-44	Number of Workers	5329	845	0	6174
		Average dose (mSv)	1.04	0.22	0.00	0.92
		%tritium	19.42	24.86	0.00	19.60
	45-54	Number of Workers	5612	517	0	6129
		Average dose (mSv)	0.77	0.16	0.00	0.72
		%tritium	16.45	24.54	0.00	16.61
	55 up	Number of Workers	2136	74	0	2210
		Average dose (mSv)	0.42	0.06	0.00	0.41
		%tritium	16.92	42.56	0.00	17.05
	Unknown	Number of Workers	7	0	0	7
		Average dose (mSv)	0.00	0.00	0.00	0.00
		%tritium	0.00	0.00	0.00	0.00
	Overall	**Number of Workers**	**15642**	**2008**	**0**	**17650**
		Average dose (mSv)	**0.83**	**0.20**	**0.00**	**0.75**
		%tritium	**18.40**	**27.68**	**0.00**	**18.68**
Uranium Mining	Below 25	Number of Workers	125	25	0	150
		Average dose (mSv)	0.90	0.57	0.00	0.85
		% radon progeny	64.82	66.08	0.00	64.96
	25-34	Number of Workers	575	63	0	638
		Average dose (mSv)	1.50	0.43	0.00	1.40
		% radon progeny	48.72	66.23	0.00	49.25
	35-44	Number of Workers	738	63	0	801
		Average dose (mSv)	1.29	0.68	0.00	1.24
		% radon progeny	54.87	47.59	0.00	54.55
	45-54	Number of Workers	546	27	0	573
		Average dose (mSv)	0.99	0.32	0.00	0.96
		% radon progeny	52.78	69.14	0.00	53.04
	55 up	Number of Workers	185	4	0	189
		Average dose (mSv)	0.93	0.20	0.00	0.91
		% radon progeny	50.29	25.00	0.00	50.17
	Unknown	Number of Workers	2	0	0	2
		Average dose (mSv)	0.00	0.00	0.00	0.00
		% radon progeny	0.00	0.00	0.00	0.00
	Overall	**Number of Workers**	**2171**	**182**	**0**	**2353**
		Average dose (mSv)	**1.21**	**0.51**	**0.00**	**1.16**
		% radon progeny	**52.55**	**57.62**	**0.00**	**52.73**

2000 Final Analysi

Table 4
Dose Statistics by job category
Administrator

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	366	0.00	0.00
>0-1	173	66.32	0.38
>1-2	5	6.57	1.31
>2-5	1	4.70	4.70
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	545	77.59	0.14
			Five year period 1996 - 2000
0	589	0.00	0.00
>0-5	333	325.68	0.98
>5-25	2	30.22	15.11
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	924	355.90	0.39

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	0.8900
mu:	-0.8649
sigma-squared:	1.3719

Sample size: 179
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

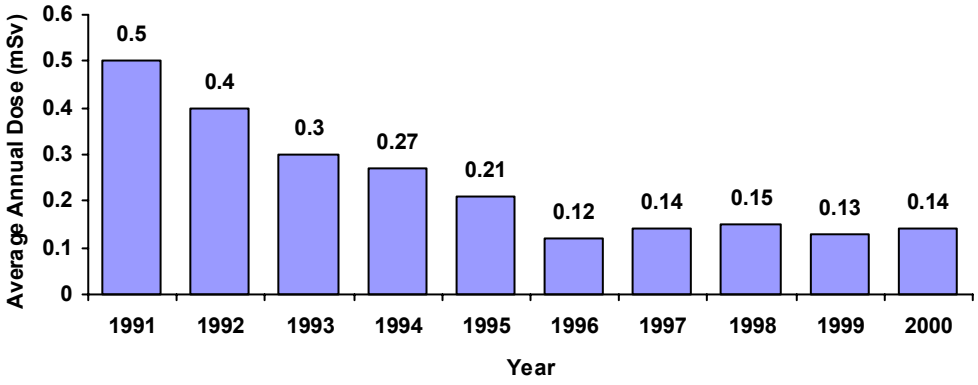


Table 4 (Cont'd)

Office staff

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	3437	0.00	0.00
>0-1	396	157.01	0.40
>1-2	17	26.33	1.55
>2-5	9	28.83	3.20
>5-20	2	14.15	7.08
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	3861	226.32	0.06
			Five year period 1996 - 2000
0	5350	0.00	0.00
>0-5	1155	944.67	0.82
>5-25	18	136.54	7.59
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	6523	1081.21	0.17

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.0010
sigma-squared:	0.7274

Sample size: 424
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

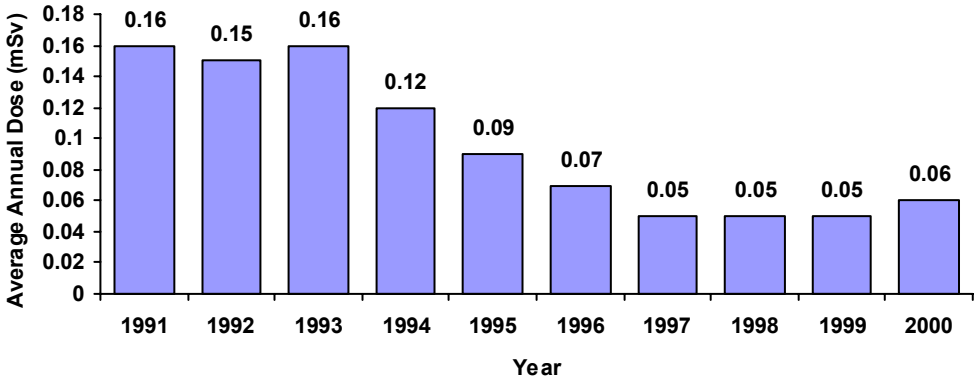


Table 4 (Cont'd)

Safety officer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	133	0.00	0.00
>0-1	33	8.80	0.27
>1-2	4	5.11	1.28
>2-5	2	7.90	3.95
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	172	21.81	0.13
			Five year period 1996 - 2000
0	149	0.00	0.00
>0-5	78	71.32	0.91
>5-25	4	42.76	10.69
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	231	114.08	0.49

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.2453
sigma-squared:	1.1763

Sample size: 39
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

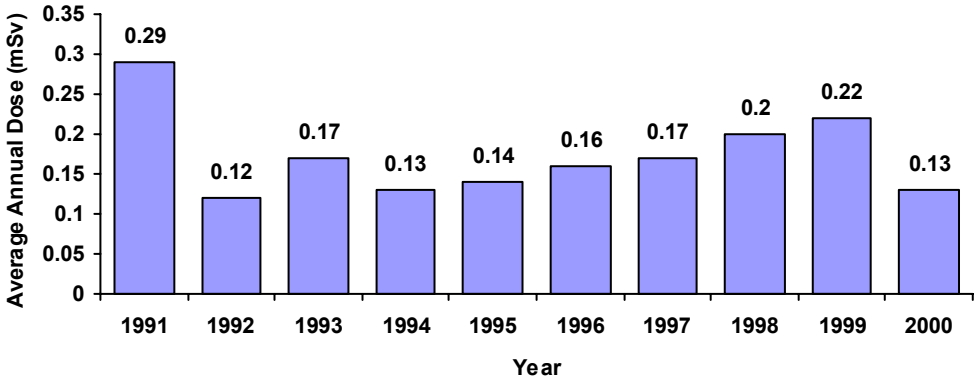


Table 4 (Cont'd)

Industrial radiographer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1404	0.00	0.00
>0-1	389	188.89	0.49
>1-2	210	324.35	1.54
>2-5	348	1183.20	3.40
>5-20	436	4208.13	9.65
>20-50	45	1212.89	26.95
>50	1	254.30	254.30
Total	2833	7371.76	2.60
			Five year period 1996 - 2000
0	1630	0.00	0.00
>0-5	1133	1772.98	1.56
>5-25	847	10770.54	12.72
>25-100	503	22296.96	44.33
>100	28	4232.37	151.16
Total	4141	39072.85	9.44

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	0.0206
mu:	-2.8909
sigma-squared:	2.1541

Sample size: 1429
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

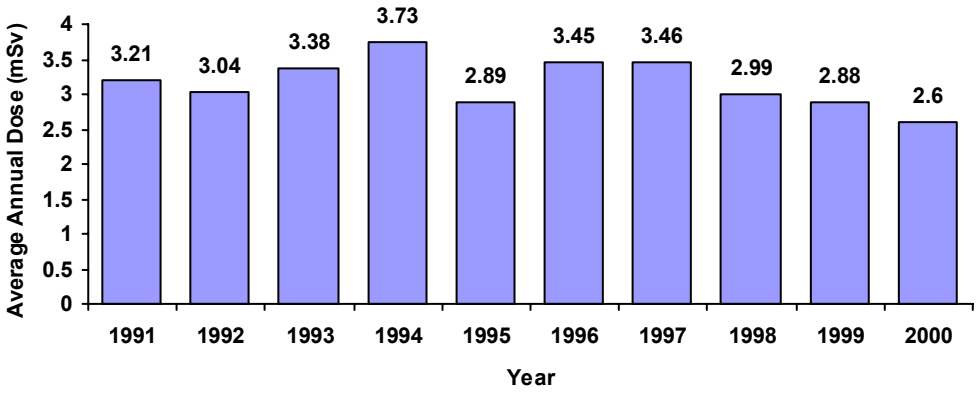


Table 4 (Cont'd)

Instructor (non-medical)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	172	0.00	0.00
>0-1	8	2.20	0.28
>1-2	0	0.00	0.00
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	180	2.20	0.01
			Five year period 1996 - 2000
0	252	0.00	0.00
>0-5	62	29.75	0.48
>5-25	0	0.00	0.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	314	29.75	0.09

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.3707
sigma-squared:	0.1848

Sample size: 8
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

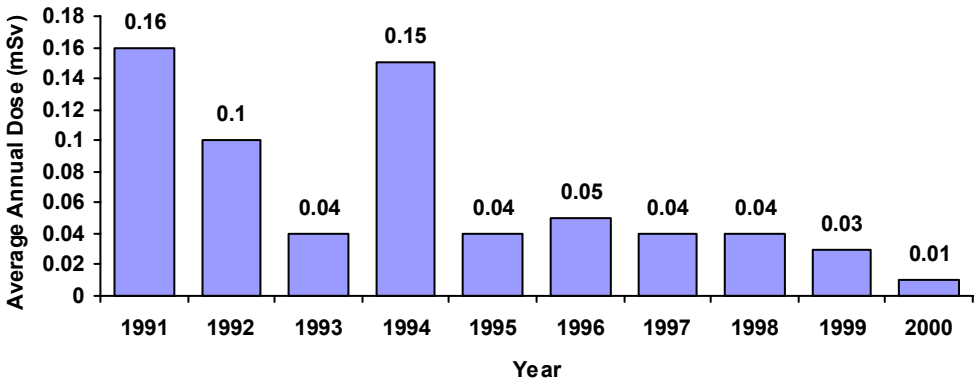


Table 4 (Cont'd)

Instrument technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1884	0.00	0.00
>0-1	331	126.70	0.38
>1-2	36	50.05	1.39
>2-5	21	66.52	3.17
>5-20	10	83.51	8.35
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	2282	326.78	0.14
			Five year period 1996 - 2000
0	2393	0.00	0.00
>0-5	1011	937.95	0.93
>5-25	84	826.70	9.84
>25-100	4	126.02	31.50
>100	0	0.00	0.00
Total	3492	1890.67	0.54

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.7925
sigma-squared:	0.9107

Sample size: 398
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

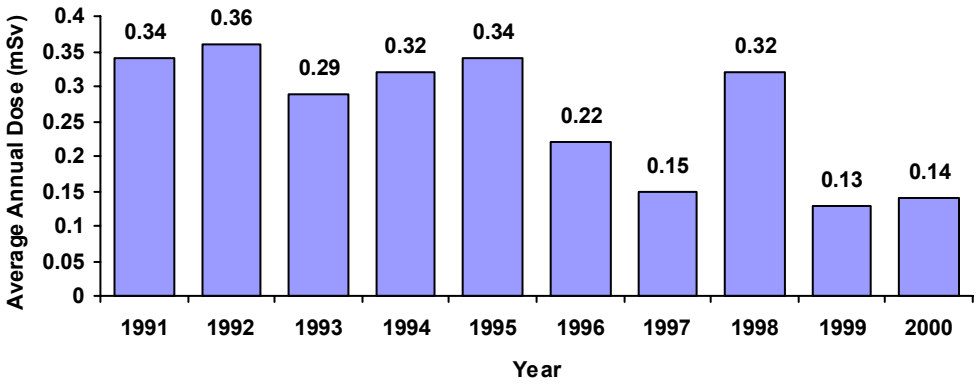


Table 4 (Cont'd)

Laboratory technician (industrial)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	3198	0.00	0.00
>0-1	581	203.60	0.35
>1-2	71	109.49	1.54
>2-5	62	191.28	3.09
>5-20	18	141.01	7.83
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	3930	645.38	0.16
			Five year period 1996 - 2000
0	4956	0.00	0.00
>0-5	2169	1648.13	0.76
>5-25	153	1509.31	9.86
>25-100	4	113.81	28.45
>100	0	0.00	0.00
Total	7282	3271.25	0.45

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.8210
sigma-squared:	1.2472

Sample size: 732
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

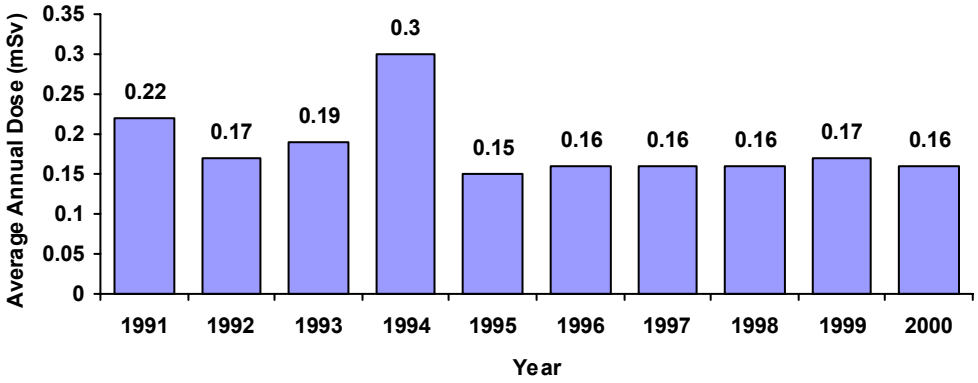


Table 4 (Cont'd)

Nuclear fuel processor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	83	0.00	0.00
>0-1	255	106.67	0.42
>1-2	95	143.93	1.52
>2-5	91	284.95	3.13
>5-20	24	152.84	6.37
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	548	688.39	1.26
			Five year period 1996 - 2000
0	57	0.00	0.00
>0-5	402	632.85	1.57
>5-25	136	1415.51	10.41
>25-100	21	742.88	35.38
>100	0	0.00	0.00
Total	616	2791.24	4.53

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	0.1397
mu:	-1.9784
sigma-squared:	1.9013

Sample size: 465
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

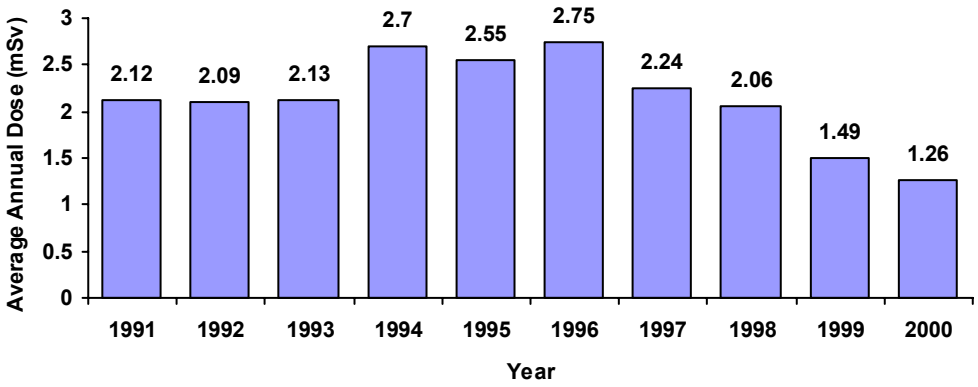


Table 4 (Cont'd)

Scientist/Engineer (field)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	689	0.00	0.00
>0-1	490	195.17	0.40
>1-2	39	53.99	1.38
>2-5	16	58.73	3.67
>5-20	12	92.38	7.70
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1246	400.27	0.32
			Five year period 1996 - 2000
0	1055	0.00	0.00
>0-5	1304	1522.64	1.17
>5-25	54	557.16	10.32
>25-100	6	212.08	35.35
>100	0	0.00	0.00
Total	2419	2291.88	0.95

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.8448
sigma-squared:	0.9628

Sample size: 557
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

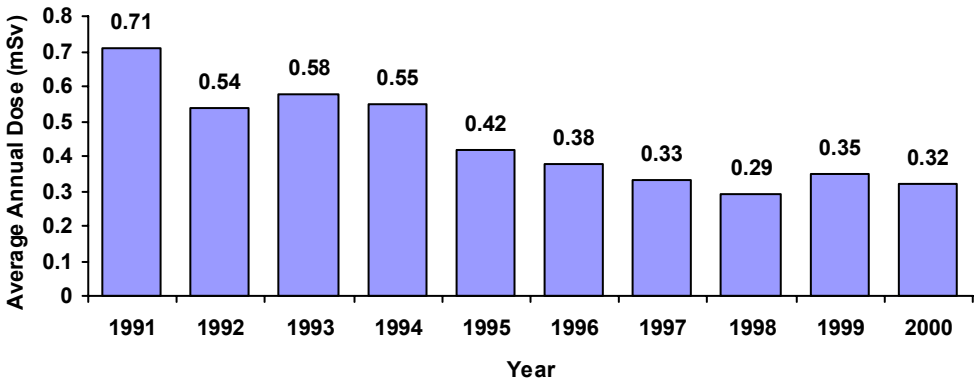


Table 4 (Cont'd)

Scientist/Engineer (laboratory)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	5216	0.00	0.00
>0-1	683	180.42	0.26
>1-2	12	16.40	1.37
>2-5	5	13.72	2.74
>5-20	4	32.70	8.18
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	5920	243.24	0.04
			Five year period 1996 - 2000
0	7438	0.00	0.00
>0-5	2368	1088.52	0.46
>5-25	16	173.92	10.87
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	9822	1262.44	0.13

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.4692
sigma-squared:	0.5728

Sample size: 704
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

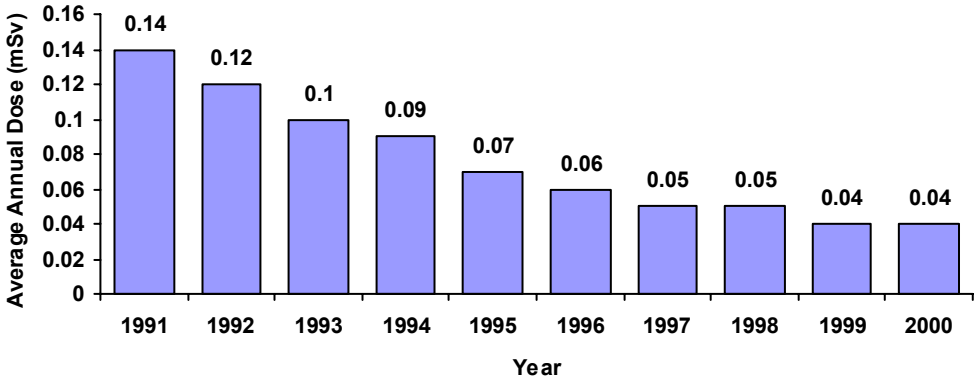


Table 4 (Cont'd)

Tradesmen

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	62	0.00	0.00
>0-1	21	5.90	0.28
>1-2	0	0.00	0.00
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	83	5.90	0.07
			Five year period 1996 - 2000
0	60	0.00	0.00
>0-5	28	14.50	0.52
>5-25	0	0.00	0.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	88	14.50	0.16

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.5260
sigma-squared:	0.5164

Sample size: 21
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

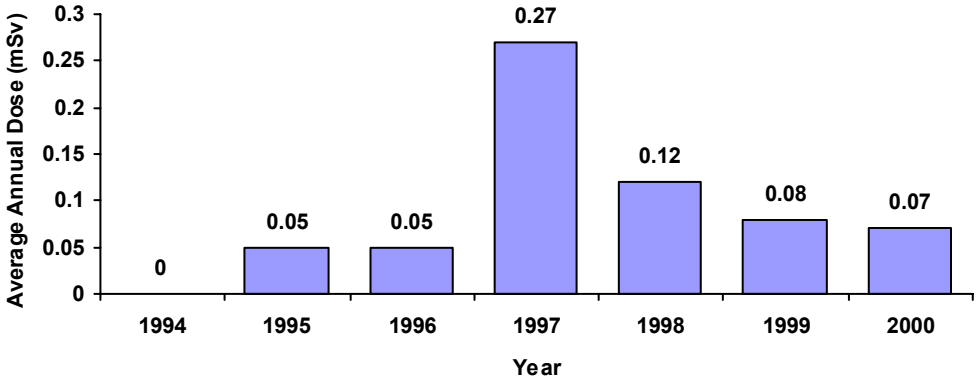


Table 4 (Cont'd)

Well logger

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	582	0.00	0.00
>0-1	315	148.50	0.47
>1-2	87	124.00	1.43
>2-5	56	167.70	2.99
>5-20	29	238.50	8.22
>20-50	2	54.20	27.10
>50	0	0.00	0.00
Total	1071	732.90	0.68
			Five year period 1996 - 2000
0	862	0.00	0.00
>0-5	1049	1263.50	1.20
>5-25	126	1220.90	9.69
>25-100	6	197.70	32.95
>100	0	0.00	0.00
Total	2043	2682.10	1.31

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.2603
sigma-squared:	1.1235

Sample size: 489
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

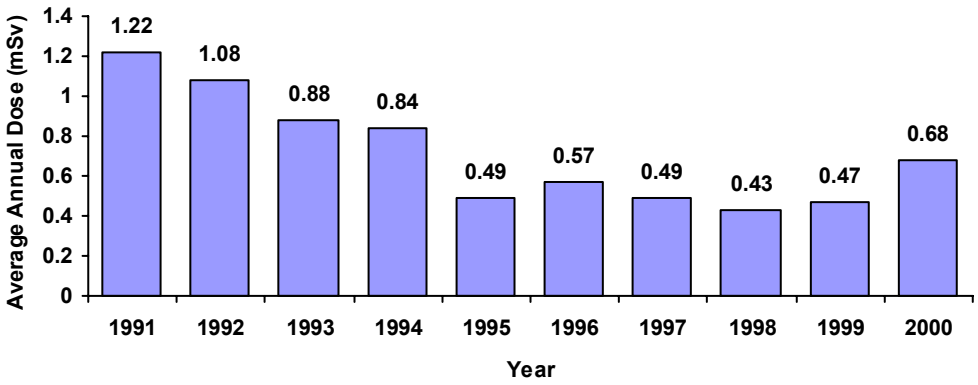


Table 4 (Cont'd)

Chiropractor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	983	0.00	0.00
>0-1	33	12.10	0.37
>1-2	1	1.50	1.50
>2-5	1	3.20	3.20
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1018	16.80	0.02
			Five year period 1996 - 2000
0	1213	0.00	0.00
>0-5	170	120.70	0.71
>5-25	2	22.80	11.40
>25-100	1	32.10	32.10
>100	0	0.00	0.00
Total	1386	175.60	0.13

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.0089
sigma-squared:	0.4027

Sample size: 35
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

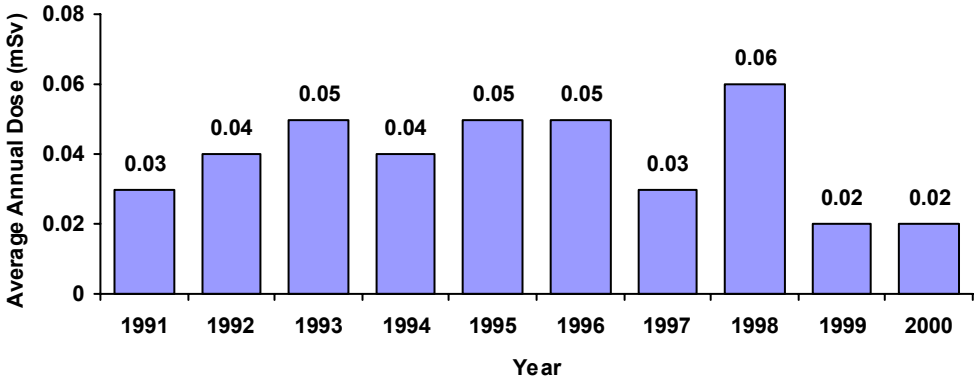


Table 4 (Cont'd)

Dental assistant

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	10668	0.00	0.00
>0-1	97	30.00	0.31
>1-2	3	5.00	1.67
>2-5	0	0.00	0.00
>5-20	1	15.60	15.60
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	10769	50.60	0.00
			Five year period 1996 - 2000
0	15151	0.00	0.00
>0-5	658	252.90	0.38
>5-25	11	101.70	9.25
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	15820	354.60	0.02

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.1986
sigma-squared:	0.4762

Sample size: 101
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

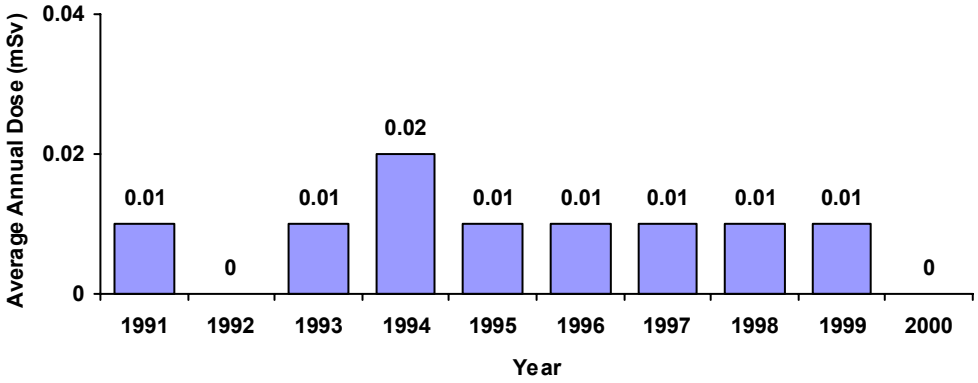


Table 4 (Cont'd)

Dental hygienist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	7702	0.00	0.00
>0-1	76	26.80	0.35
>1-2	5	7.60	1.52
>2-5	0	0.00	0.00
>5-20	3	22.60	7.53
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	7786	57.00	0.01
			Five year period 1996 - 2000
0	9930	0.00	0.00
>0-5	545	237.50	0.44
>5-25	5	49.20	9.84
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	10480	286.70	0.03

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.9698
sigma-squared:	0.6946

Sample size: 84
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

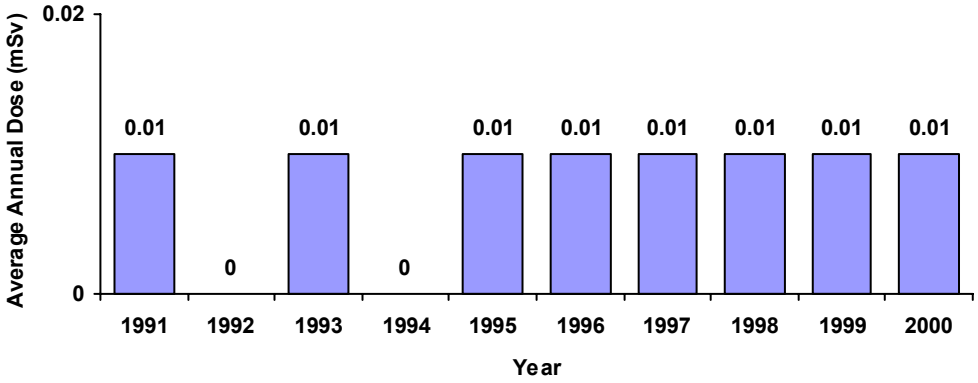


Table 4 (Cont'd)

Dental therapist/nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	104	0.00	0.00
>0-1	3	0.70	0.23
>1-2	0	0.00	0.00
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	107	0.70	0.01
			Five year period 1996 - 2000
0	135	0.00	0.00
>0-5	15	5.90	0.39
>5-25	0	0.00	0.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	150	5.90	0.04

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.4743
sigma-squared:	0.0365

Sample size: 3
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

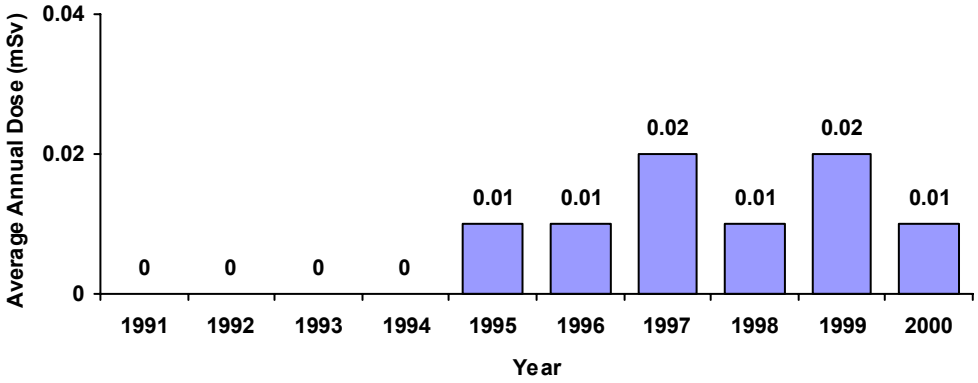


Table 4 (Cont'd)

Dentist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	7059	0.00	0.00
>0-1	96	31.60	0.33
>1-2	5	7.50	1.50
>2-5	3	10.20	3.40
>5-20	1	17.40	17.40
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	7164	66.70	0.01
			Five year period 1996 - 2000
0	8243	0.00	0.00
>0-5	657	281.70	0.43
>5-25	4	40.10	10.02
>25-100	1	26.34	26.34
>100	0	0.00	0.00
Total	8905	348.14	0.04

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.0531
sigma-squared:	0.6480

Sample size: 105
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

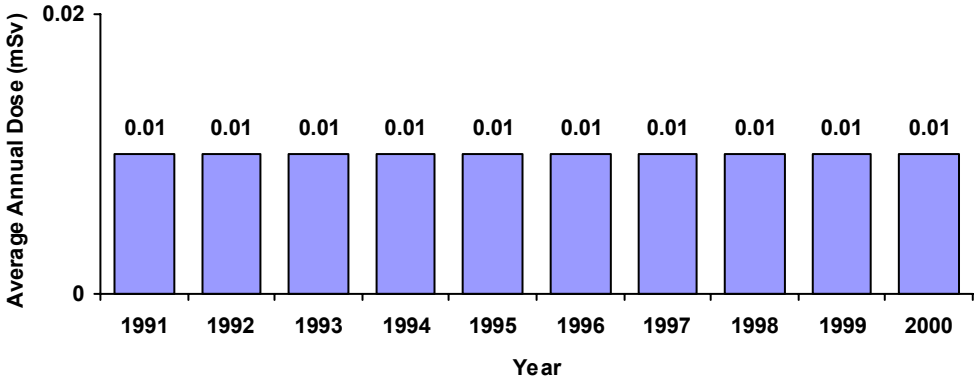


Table 4 (Cont'd)

Gynaecologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	17	0.00	0.00
>0-1	0	0.00	0.00
>1-2	0	0.00	0.00
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	17	0.00	0.00
			Five year period 1996 - 2000
0	35	0.00	0.00
>0-5	10	10.40	1.04
>5-25	0	0.00	0.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	45	10.40	0.23

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	n/a
sigma-squared:	n/a

Sample size: 0
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

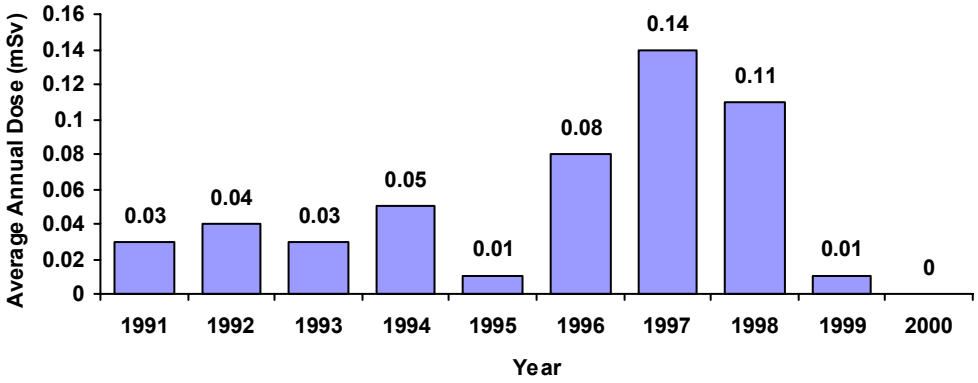


Table 4 (Cont'd)

Laboratory technician (medical)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	2810	0.00	0.00
>0-1	202	70.06	0.35
>1-2	21	28.77	1.37
>2-5	17	48.80	2.87
>5-20	1	5.60	5.60
>20-50	0	0.00	0.00
>50	1	77.20	77.20
Total	3052	230.43	0.08
			Five year period 1996 - 2000
0	4828	0.00	0.00
>0-5	1243	689.72	0.55
>5-25	22	225.27	10.24
>25-100	2	70.50	35.25
>100	1	197.30	197.30
Total	6096	1182.79	0.19

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.9416
sigma-squared:	1.0253

Sample size: 242
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

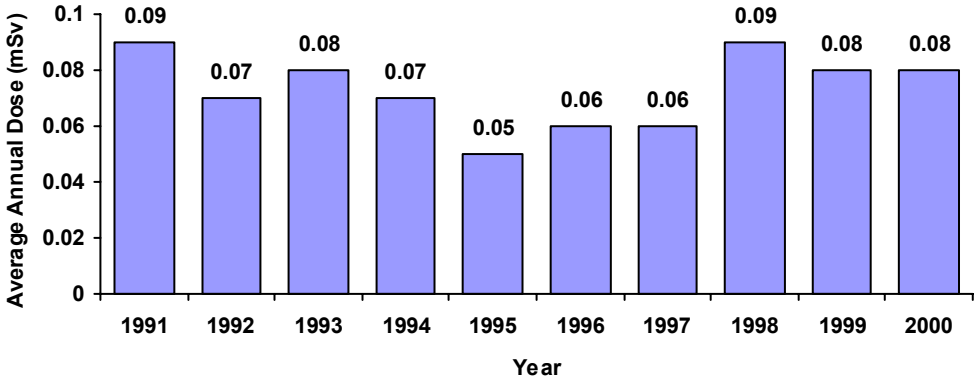


Table 4 (Cont'd)

Medical physicist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	280	0.00	0.00
>0-1	30	9.20	0.31
>1-2	2	2.78	1.39
>2-5	2	5.10	2.55
>5-20	1	8.90	8.90
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	315	25.98	0.08
			Five year period 1996 - 2000
0	308	0.00	0.00
>0-5	134	76.42	0.57
>5-25	6	53.38	8.90
>25-100	1	41.80	41.80
>100	0	0.00	0.00
Total	449	171.60	0.38

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.0168
sigma-squared:	0.9525

Sample size: 35
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

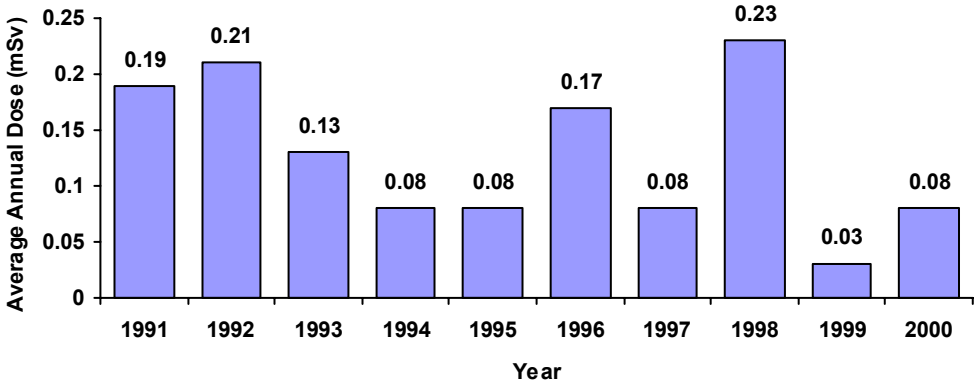


Table 4 (Cont'd)

Medical radiation technologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	10623	0.00	0.00
>0-1	1083	379.62	0.35
>1-2	76	107.90	1.42
>2-5	53	159.60	3.01
>5-20	13	98.57	7.58
>20-50	0	0.00	0.00
>50	1	84.90	84.90
Total	11849	830.59	0.07
			Five year period 1996 - 2000
0	9731	0.00	0.00
>0-5	5562	3738.62	0.67
>5-25	107	950.77	8.89
>25-100	6	266.50	44.42
>100	0	0.00	0.00
Total	15406	4955.89	0.32

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.9928
sigma-squared:	0.7868

Sample size: 1226
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

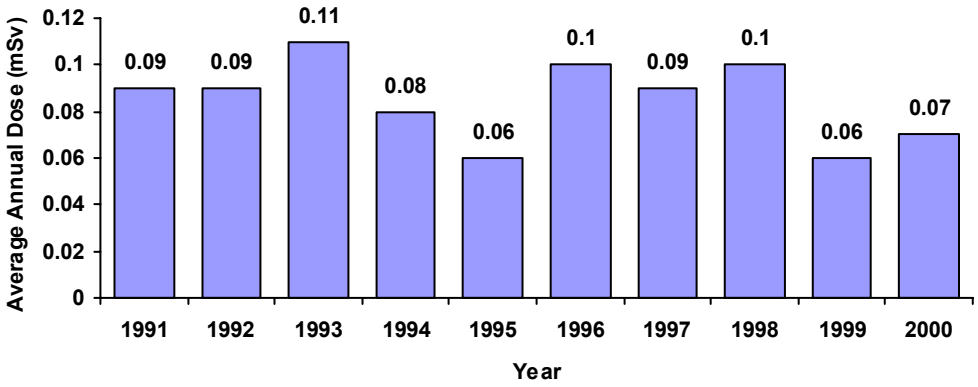


Table 4 (Cont'd)

Nuclear medicine technologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	439	0.00	0.00
>0-1	326	180.80	0.55
>1-2	278	429.13	1.54
>2-5	350	1076.90	3.08
>5-20	51	323.60	6.35
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1444	2010.43	1.39
			Five year period 1996 - 2000
0	489	0.00	0.00
>0-5	870	1686.97	1.94
>5-25	690	7284.93	10.56
>25-100	21	717.80	34.18
>100	0	0.00	0.00
Total	2070	9689.70	4.68

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	0.3122
mu:	-0.1890
sigma-squared:	1.8414

Sample size: 1005
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

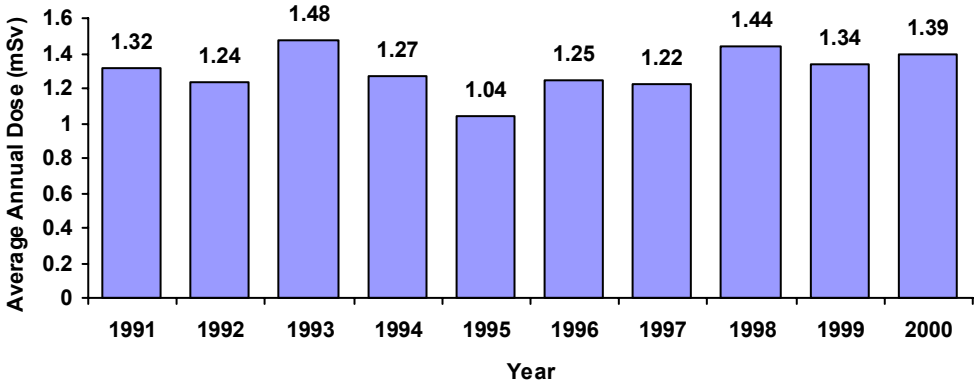


Table 4 (Cont'd)

Nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	4039	0.00	0.00
>0-1	606	250.02	0.41
>1-2	86	111.80	1.30
>2-5	15	42.00	2.80
>5-20	1	9.90	9.90
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	4747	413.72	0.09
			Five year period 1996 - 2000
0	5552	0.00	0.00
>0-5	2714	2502.79	0.92
>5-25	26	212.80	8.18
>25-100	1	33.00	33.00
>100	0	0.00	0.00
Total	8293	2748.59	0.33

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.9226
sigma-squared:	0.7762

Sample size: 708
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

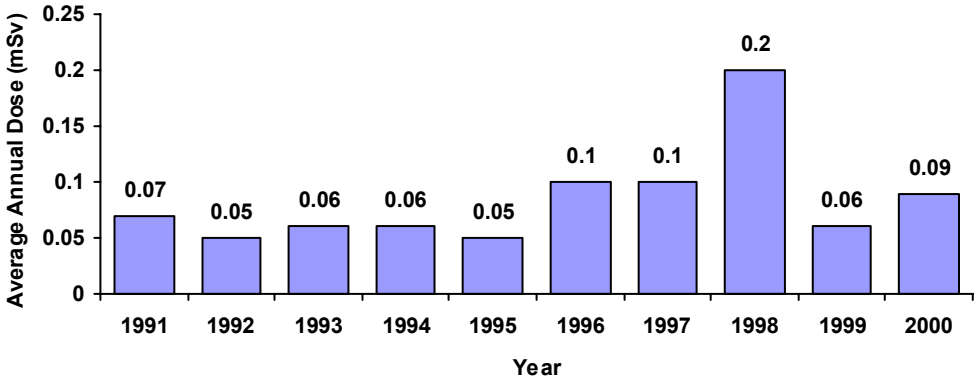


Table 4 (Cont'd)

Physician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1571	0.00	0.00
>0-1	310	118.10	0.38
>1-2	50	70.70	1.41
>2-5	24	69.80	2.91
>5-20	6	41.60	6.93
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1961	300.20	0.15
			Five year period 1996 - 2000
0	1818	0.00	0.00
>0-5	1203	1108.09	0.92
>5-25	58	527.20	9.09
>25-100	5	222.30	44.46
>100	0	0.00	0.00
Total	3084	1857.59	0.60

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.7917
sigma-squared:	0.9299

Sample size: 390
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

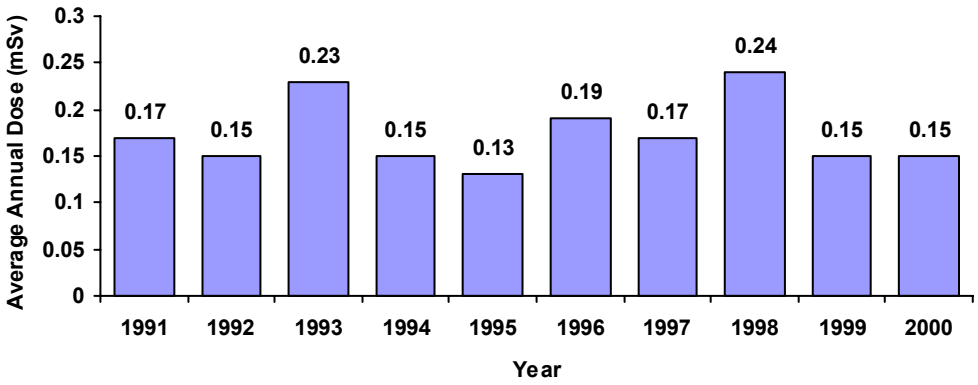


Table 4 (Cont'd)

Radiation therapist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1127	0.00	0.00
>0-1	207	60.50	0.29
>1-2	14	19.50	1.39
>2-5	9	26.80	2.98
>5-20	1	5.80	5.80
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1358	112.60	0.08
			Five year period 1996 - 2000
0	872	0.00	0.00
>0-5	784	518.30	0.66
>5-25	20	206.50	10.32
>25-100	2	101.90	50.95
>100	0	0.00	0.00
Total	1678	826.70	0.49

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.1906
sigma-squared:	0.7389

Sample size: 231
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

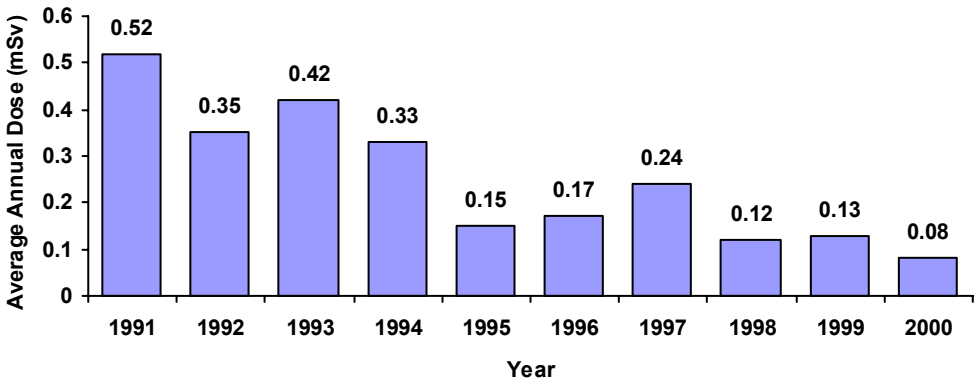


Table 4 (Cont'd)

Radiologist (diagnostic)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1530	0.00	0.00
>0-1	219	87.10	0.40
>1-2	33	43.40	1.32
>2-5	13	41.50	3.19
>5-20	8	76.36	9.54
>20-50	1	22.00	22.00
>50	0	0.00	0.00
Total	1804	270.36	0.15
			Five year period 1996 - 2000
0	1360	0.00	0.00
>0-5	992	840.50	0.85
>5-25	43	418.27	9.73
>25-100	3	98.10	32.70
>100	0	0.00	0.00
Total	2398	1356.87	0.57

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.7268
sigma-squared:	1.0278

Sample size: 274
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

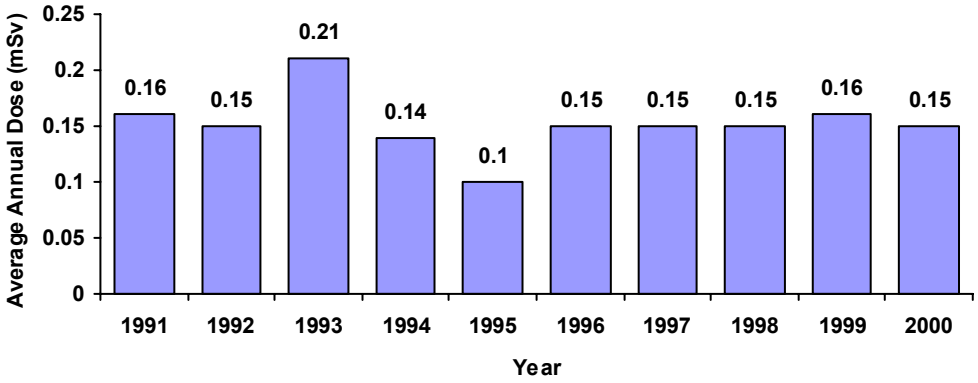


Table 4 (Cont'd)

Radiologist (therapeutic)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	168	0.00	0.00
>0-1	30	8.10	0.27
>1-2	1	1.10	1.10
>2-5	1	2.30	2.30
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	200	11.50	0.06
			Five year period 1996 - 2000
0	181	0.00	0.00
>0-5	96	48.30	0.50
>5-25	1	9.10	9.10
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	278	57.40	0.21

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.3847
sigma-squared:	0.5914

Sample size: 32
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

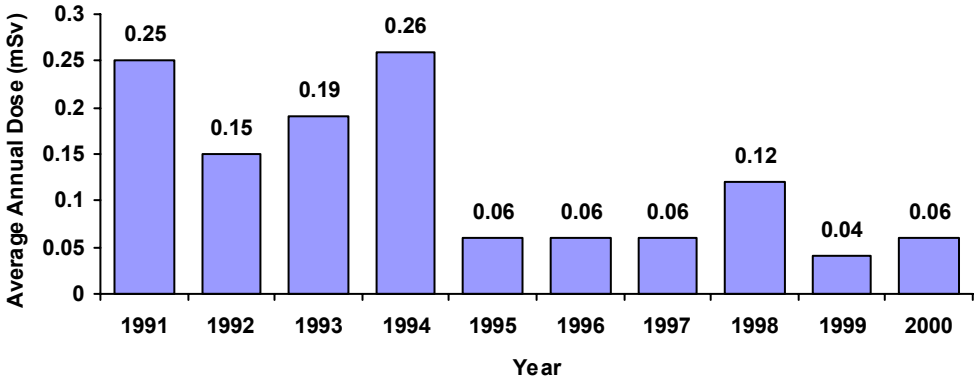


Table 4 (Cont'd)

Veterinarian

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	3764	0.00	0.00
>0-1	178	61.59	0.35
>1-2	6	7.70	1.28
>2-5	2	5.10	2.55
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	3950	74.39	0.02
			Five year period 1996 - 2000
0	4824	0.00	0.00
>0-5	1052	546.17	0.52
>5-25	15	109.90	7.33
>25-100	2	60.90	30.45
>100	0	0.00	0.00
Total	5893	716.97	0.12

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-1.1099
sigma-squared:	0.3099

Sample size: 186
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

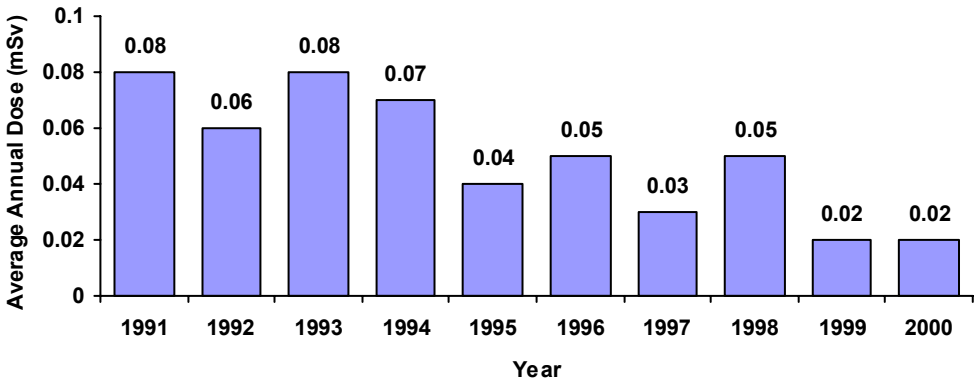


Table 4 (Cont'd)

Veterinary technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1524	0.00	0.00
>0-1	56	20.20	0.36
>1-2	10	13.90	1.39
>2-5	3	9.70	3.23
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1593	43.80	0.03
			Five year period 1996 - 2000
0	1640	0.00	0.00
>0-5	121	77.30	0.64
>5-25	1	13.20	13.20
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	1762	90.50	0.05

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.8380
sigma-squared:	0.6453

Sample size: 69
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

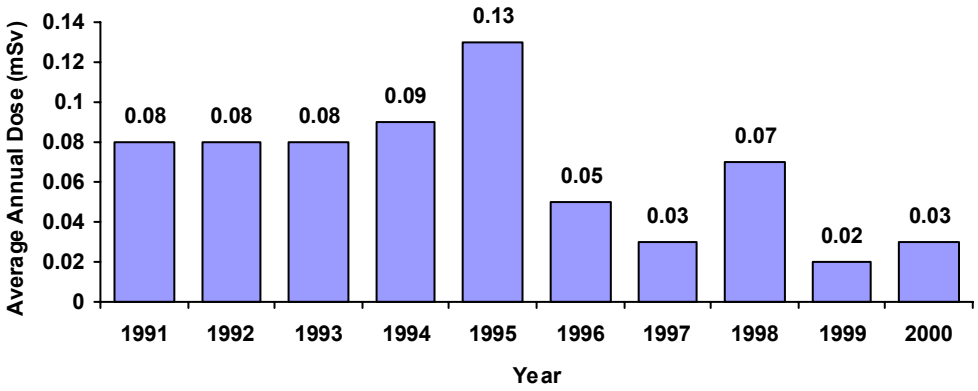


Table 4 (Cont'd)

Ward aid/orderly

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 2000
0	1328	0.00	0.00
>0-1	81	29.40	0.36
>1-2	10	13.80	1.38
>2-5	6	19.80	3.30
>5-20	1	7.20	7.20
>20-50	0	0.00	0.00
>50	1	57.20	57.20
Total	1427	127.40	0.09
			Five year period 1996 - 2000
0	2229	0.00	0.00
>0-5	557	386.00	0.69
>5-25	10	105.90	10.59
>25-100	3	152.20	50.73
>100	0	0.00	0.00
Total	2799	644.10	0.23

Lognormal or hybrid lognormal parameters for positive doses in 2000 :

rho:	n/a
mu:	-0.7871
sigma-squared:	0.9984

Sample size: 99
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

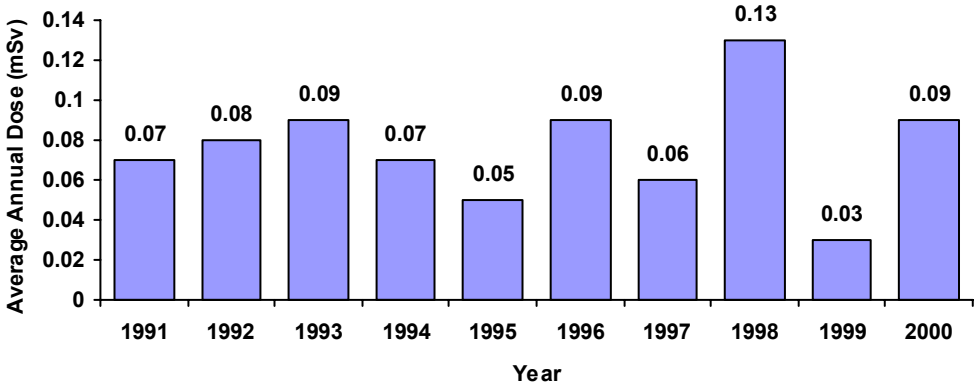


Table 4 (Cont'd)

Reactor - administration

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	3630	0.00	0.00	0
>0-1	531	146.26	0.28	49
>1-2	97	138.12	1.42	47
>2-5	85	274.35	3.23	38
>5-20	34	235.86	6.94	27
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	4377	794.59	0.18	38
				Five year period 1996 - 2000
0	4848	0.00	0.00	0
>0-5	2130	2058.62	0.97	36
>5-25	309	2928.92	9.48	29
>25-100	1	27.18	27.18	47
>100	0	0.00	0.00	0
Total	7288	5014.72	0.69	32

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1570
mu:	-2.7753
sigma-squared:	3.5891

Sample size: 747
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

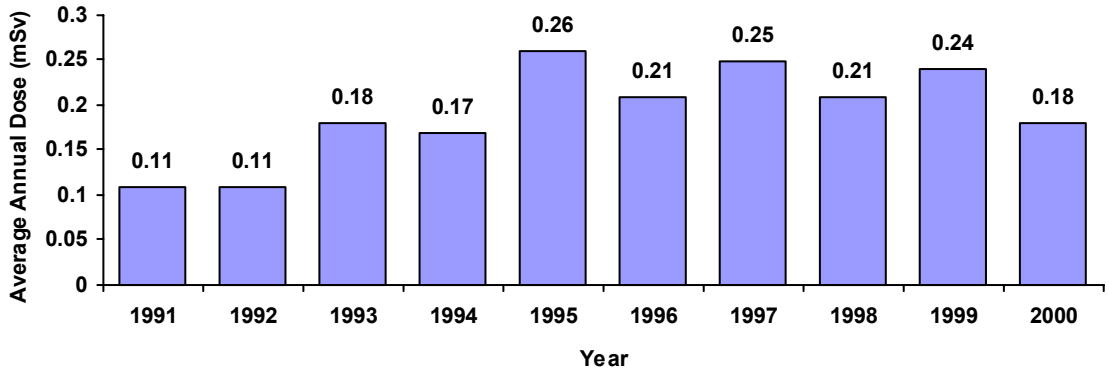


Table 4 (Cont'd)

Reactor - chemical and radiation control

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	105	0.00	0.00	0
>0-1	138	53.86	0.39	48
>1-2	34	47.17	1.39	44
>2-5	42	137.12	3.26	15
>5-20	30	292.33	9.74	12
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	349	530.48	1.52	19
				Five year period 1996 - 2000
0	146	0.00	0.00	0
>0-5	278	425.64	1.53	44
>5-25	99	1109.89	11.21	18
>25-100	34	1483.10	43.62	9
>100	0	0.00	0.00	0
Total	557	3018.63	5.42	17

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1156
mu:	-2.2316
sigma-squared:	4.0361

Sample size: 244
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

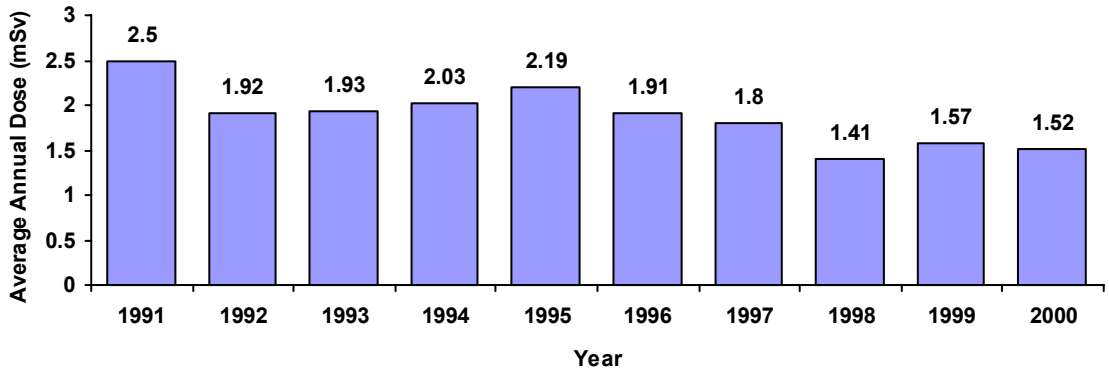


Table 4 (Cont'd)

Reactor - construction

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	923	0.00	0.00	0
>0-1	346	103.36	0.30	28
>1-2	122	186.76	1.53	16
>2-5	203	672.05	3.31	12
>5-20	220	1861.62	8.46	8
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1814	2823.79	1.56	10
				Five year period 1996 - 2000
0	1411	0.00	0.00	0
>0-5	1141	1615.63	1.42	15
>5-25	499	5659.06	11.34	11
>25-100	109	3810.84	34.96	11
>100	0	0.00	0.00	0
Total	3160	11085.53	3.51	12

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.3311
mu:	0.0423
sigma-squared:	8.3948

Sample size: 891
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

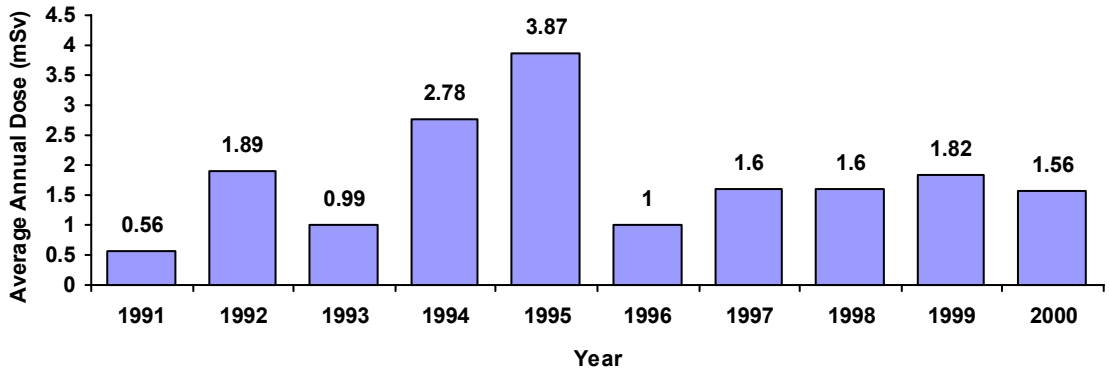


Table 4 (Cont'd)

Reactor - control technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	92	0.00	0.00	0
>0-1	48	19.00	0.40	45
>1-2	14	20.87	1.49	23
>2-5	9	31.33	3.48	23
>5-20	7	67.82	9.69	6
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	170	139.02	0.82	18
				Five year period 1996 - 2000
0	108	0.00	0.00	0
>0-5	93	150.02	1.61	22
>5-25	46	570.99	12.41	15
>25-100	2	53.28	26.64	2
>100	0	0.00	0.00	0
Total	249	774.29	3.11	15

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-0.5361
sigma-squared:	2.9222

Sample size: 78
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

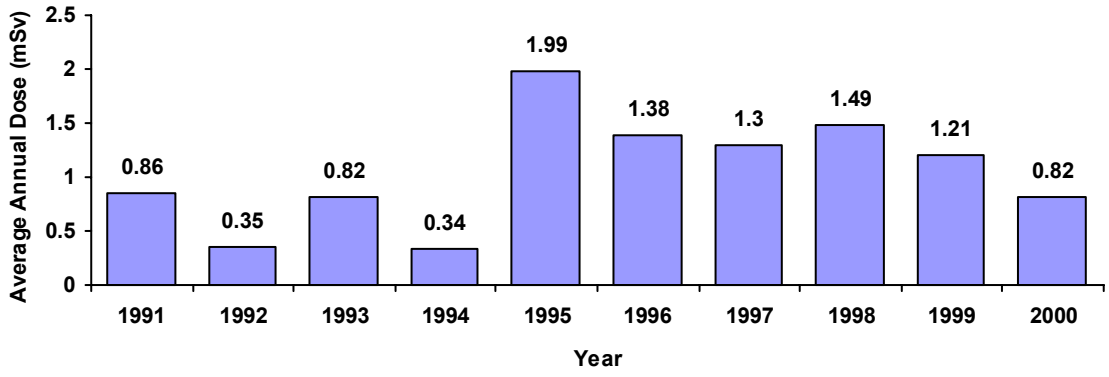


Table 4 (Cont'd)

Reactor - electrical maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	487	0.00	0.00	0
>0-1	294	106.29	0.36	33
>1-2	124	178.14	1.44	23
>2-5	121	365.35	3.02	19
>5-20	38	253.20	6.66	9
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1064	902.98	0.85	19
				Five year period 1996 - 2000
0	400	0.00	0.00	0
>0-5	800	1215.30	1.52	27
>5-25	317	3273.02	10.32	18
>25-100	22	653.13	29.69	13
>100	0	0.00	0.00	0
Total	1539	5141.45	3.34	19

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.4030
mu:	-0.6373
sigma-squared:	4.5936

Sample size: 577
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

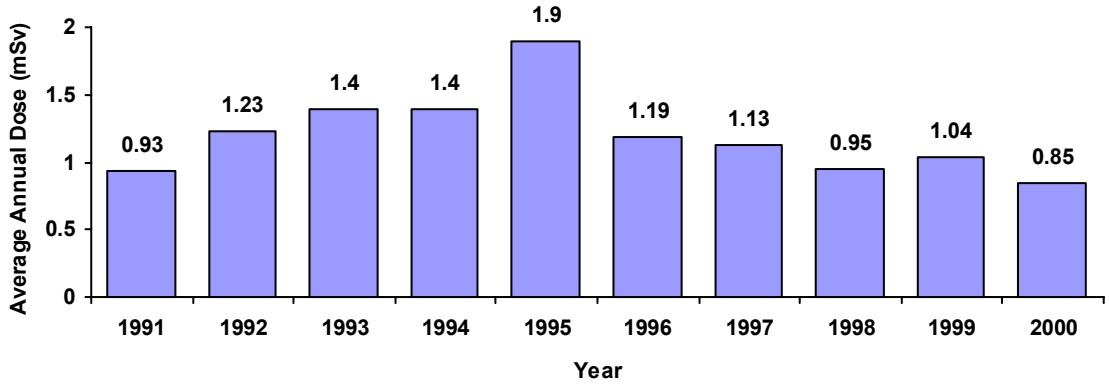


Table 4 (Cont'd)

Reactor - fuel handling

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	4	0.00	0.00	0
>0-1	6	0.84	0.14	32
>1-2	2	3.04	1.52	7
>2-5	11	40.54	3.69	15
>5-20	29	248.90	8.58	20
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	52	293.32	5.64	19
				Five year period 1996 - 2000
0	9	0.00	0.00	0
>0-5	21	38.41	1.83	7
>5-25	35	404.51	11.56	18
>25-100	18	749.22	41.62	23
>100	0	0.00	0.00	0
Total	83	1192.14	14.36	20

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	1.2739
mu:	9.3170
sigma-squared:	37.3309

Sample size: 48
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

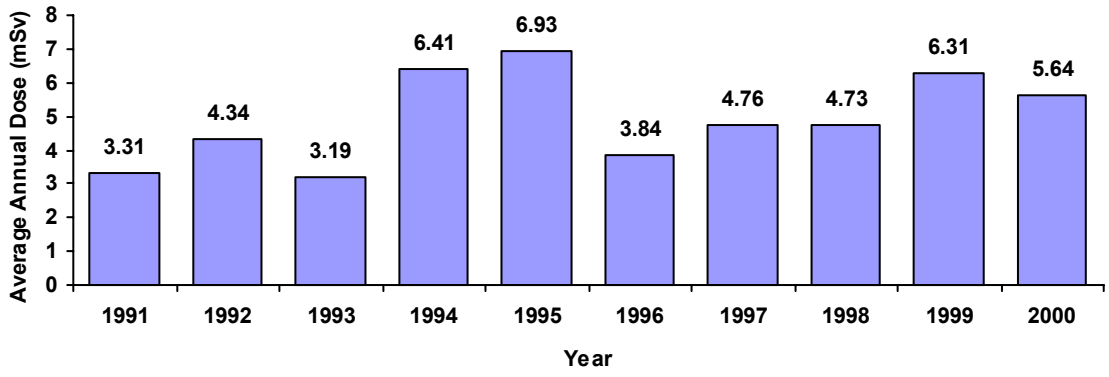


Table 4 (Cont'd)

Reactor - general maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	849	0.00	0.00	0
>0-1	244	76.92	0.32	33
>1-2	80	114.41	1.43	24
>2-5	106	325.49	3.07	25
>5-20	74	645.56	8.72	14
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1353	1162.38	0.86	19
				Five year period 1996 - 2000
0	1364	0.00	0.00	0
>0-5	830	1074.85	1.30	27
>5-25	268	3138.44	11.71	16
>25-100	45	1469.31	32.65	12
>100	0	0.00	0.00	0
Total	2507	5682.60	2.27	17

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1972
mu:	-1.4068
sigma-squared:	5.0861

Sample size: 504
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

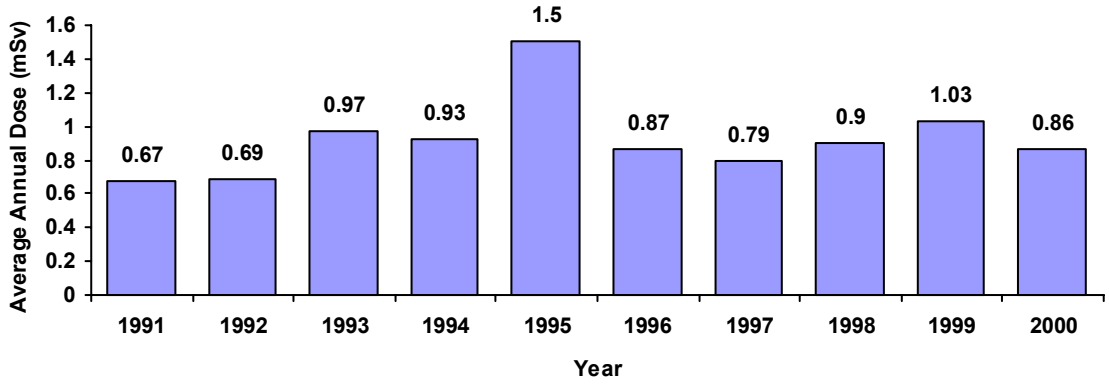


Table 4 (Cont'd)

Reactor - health physics

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	59	0.00	0.00	0
>0-1	13	3.91	0.30	24
>1-2	4	5.77	1.44	21
>2-5	7	19.10	2.73	16
>5-20	1	5.17	5.17	15
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	84	33.95	0.40	18
				Five year period 1996 - 2000
0	109	0.00	0.00	0
>0-5	46	51.44	1.12	23
>5-25	12	119.59	9.97	16
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	167	171.03	1.02	18

Lognormal or hybrid lognormal parameters for positive doses in 2000

rho:	0.7676
mu:	0.3018
sigma-squared:	6.1160

Sample size: 25
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

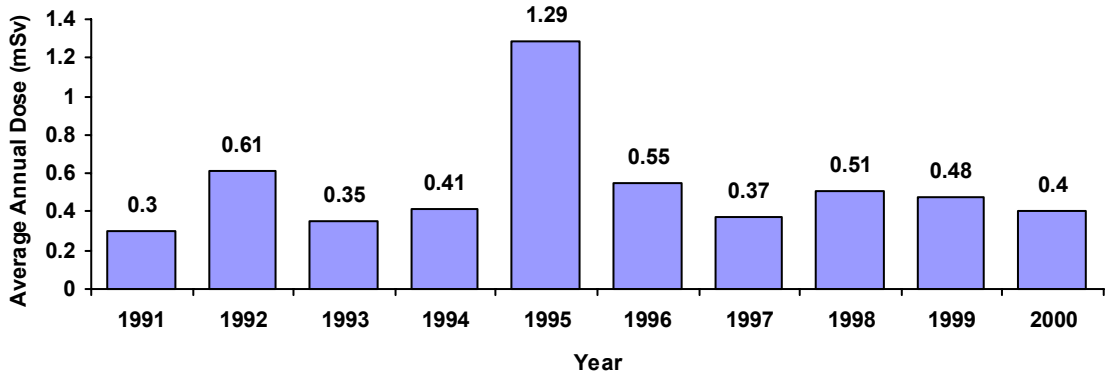


Table 4 (Cont'd)

Reactor - industrial radiographer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	10	0.00	0.00	0
>0-1	12	5.24	0.44	10
>1-2	7	9.08	1.30	9
>2-5	20	69.81	3.49	12
>5-20	8	54.98	6.87	10
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	57	139.11	2.44	11
				Five year period 1996 - 2000
0	14	0.00	0.00	0
>0-5	40	87.18	2.18	10
>5-25	18	170.50	9.47	8
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	72	257.68	3.58	9

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.5167
mu:	1.4533
sigma-squared:	5.5280

Sample size: 47
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

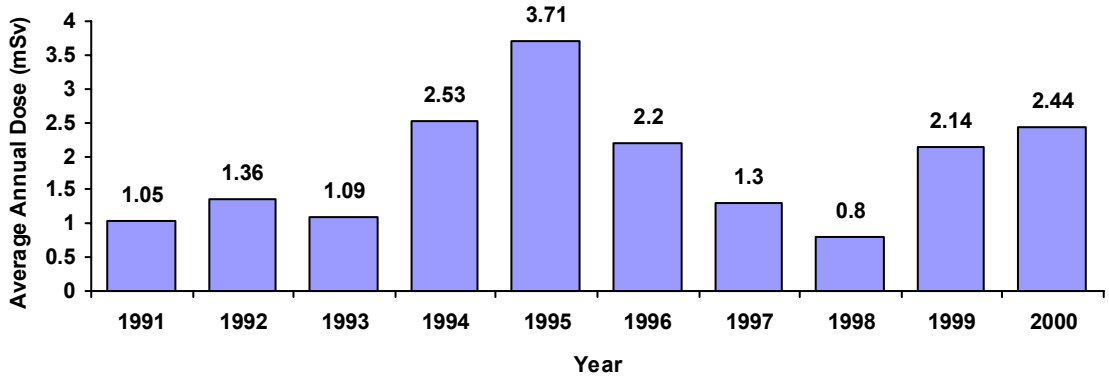


Table 4 (Cont'd)

Reactor - mechanical maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	412	0.00	0.00	0
>0-1	349	127.99	0.37	37
>1-2	130	188.70	1.45	27
>2-5	176	573.75	3.26	19
>5-20	219	1804.72	8.24	13
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1286	2695.16	2.10	16
				Five year period 1996 - 2000
0	616	0.00	0.00	0
>0-5	981	1686.06	1.72	25
>5-25	677	8317.49	12.29	15
>25-100	150	5212.01	34.75	14
>100	0	0.00	0.00	0
Total	2424	15215.56	6.28	16

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.2727
mu:	-0.2576
sigma-squared:	6.2318

Sample size: 874
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

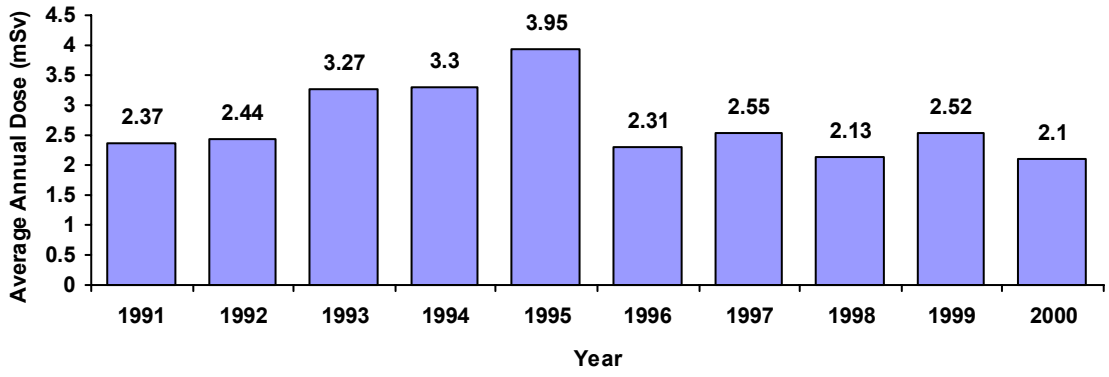


Table 4 (Cont'd)

Reactor - operations

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	711	0.00	0.00	0
>0-1	778	272.10	0.35	52
>1-2	208	303.32	1.46	46
>2-5	171	527.33	3.08	41
>5-20	124	1129.75	9.11	15
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1992	2232.50	1.12	30
				Five year period 1996 - 2000
0	488	0.00	0.00	0
>0-5	1189	1793.24	1.51	44
>5-25	605	6103.89	10.09	39
>25-100	113	4888.70	43.26	13
>100	0	0.00	0.00	0
Total	2395	12785.83	5.34	30

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.0839
mu:	-2.8450
sigma-squared:	3.2272

Sample size: 1281
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

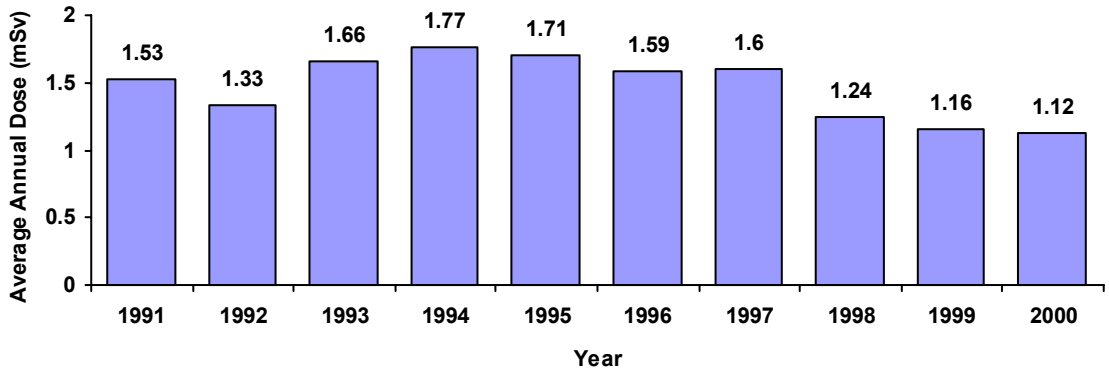


Table 4 (Cont'd)

Reactor - scientific/professional

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	1469	0.00	0.00	0
>0-1	302	95.69	0.32	27
>1-2	81	118.51	1.46	16
>2-5	72	244.55	3.40	12
>5-20	63	492.35	7.82	12
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1987	951.10	0.48	14
				Five year period 1996 - 2000
0	2309	0.00	0.00	0
>0-5	812	787.30	0.97	17
>5-25	203	2191.75	10.80	12
>25-100	42	1476.77	35.16	11
>100	0	0.00	0.00	0
Total	3366	4455.82	1.32	12

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1709
mu:	-1.9891
sigma-squared:	4.4942

Sample size: 518
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

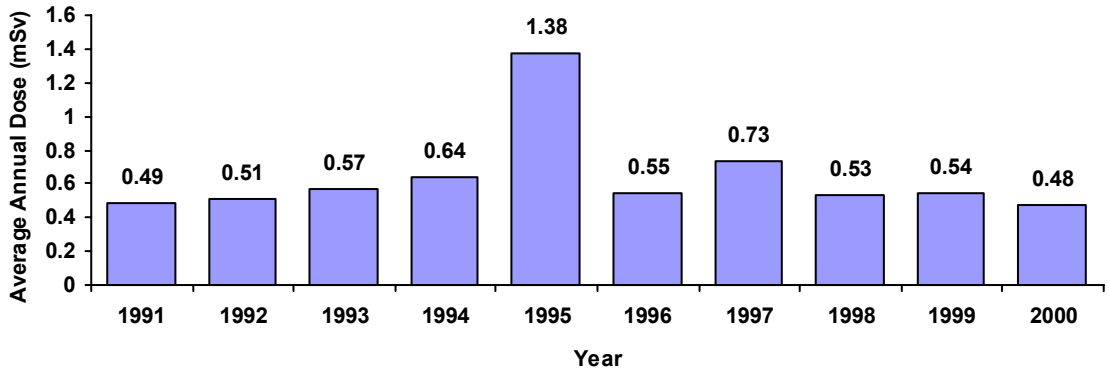


Table 4 (Cont'd)

Reactor - training

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	68	0.00	0.00	0
>0-1	15	5.31	0.35	21
>1-2	5	5.51	1.10	19
>2-5	2	5.45	2.72	21
>5-20	3	23.27	7.76	7
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	93	39.54	0.43	12
				Five year period 1996 - 2000
0	119	0.00	0.00	0
>0-5	42	32.25	0.77	22
>5-25	9	102.67	11.41	11
>25-100	1	47.93	47.93	8
>100	0	0.00	0.00	0
Total	171	182.85	1.07	12

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-0.5658
sigma-squared:	2.5659

Sample size: 25
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

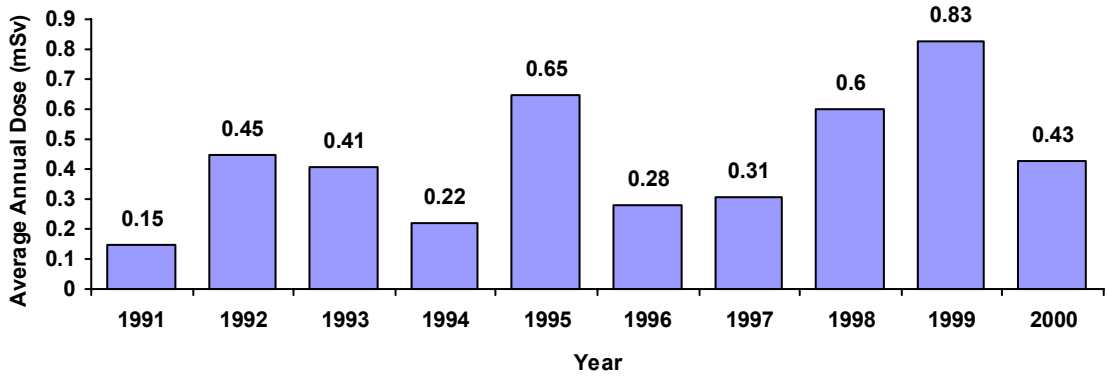


Table 4 (Cont'd)

Reactor - visitor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 2000
0	3171	0.00	0.00	0
>0-1	145	36.06	0.25	26
>1-2	45	64.68	1.44	10
>2-5	40	127.73	3.19	8
>5-20	41	349.86	8.53	8
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	3442	578.33	0.17	9
				Five year period 1996 - 2000
0	4448	0.00	0.00	0
>0-5	464	519.15	1.12	12
>5-25	152	1689.04	11.11	8
>25-100	10	330.15	33.02	10
>100	0	0.00	0.00	0
Total	5074	2538.34	0.50	9

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1744
mu:	-1.9500
sigma-squared:	5.6678

Sample size: 271
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

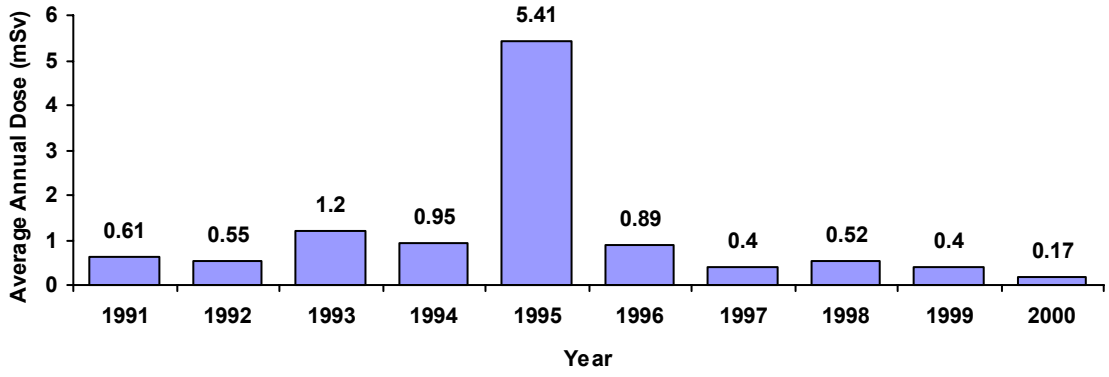


Table 4 (Cont'd)

Uranium mine electrician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	8	0.00	0.00	0
>0-1	2	1.10	0.55	100
>1-2	1	1.05	1.05	100
>2-5	0	0.00	0.00	0
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	11	2.15	0.20	100
				Five year period 1996 - 2000
0	7	0.00	0.00	0
>0-5	15	8.60	0.57	100
>5-25	0	0.00	0.00	0
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	22	8.60	0.39	100

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-0.6332
sigma-squared:	0.8004

Sample size: 3
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

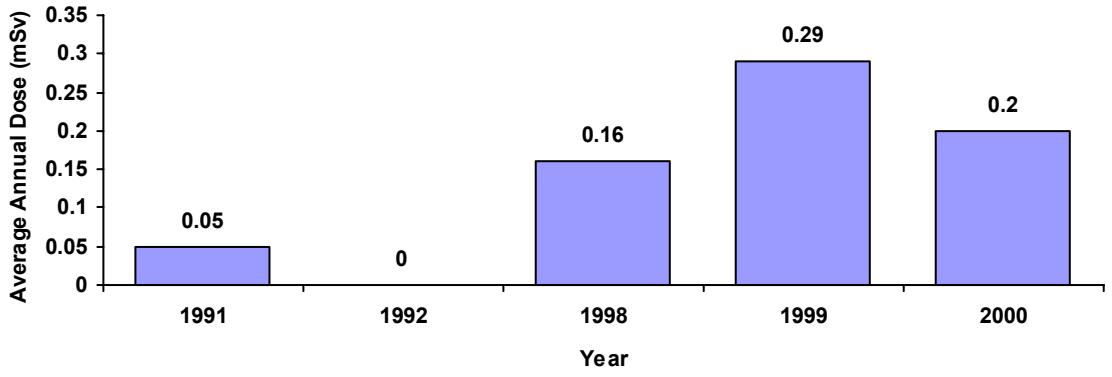


Table 4 (Cont'd)

Uranium mine mill maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	5	0.00	0.00	0
>0-1	64	41.70	0.65	65
>1-2	50	71.15	1.42	61
>2-5	50	150.25	3.00	52
>5-20	6	37.60	6.27	70
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	175	300.70	1.72	58
				Five year period 1996 - 2000
0	26	0.00	0.00	0
>0-5	181	354.20	1.96	70
>5-25	98	1087.85	11.10	41
>25-100	9	277.65	30.85	20
>100	0	0.00	0.00	0
Total	314	1719.70	5.48	44

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1833
mu:	-1.0956
sigma-squared:	1.0926

Sample size: 170
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

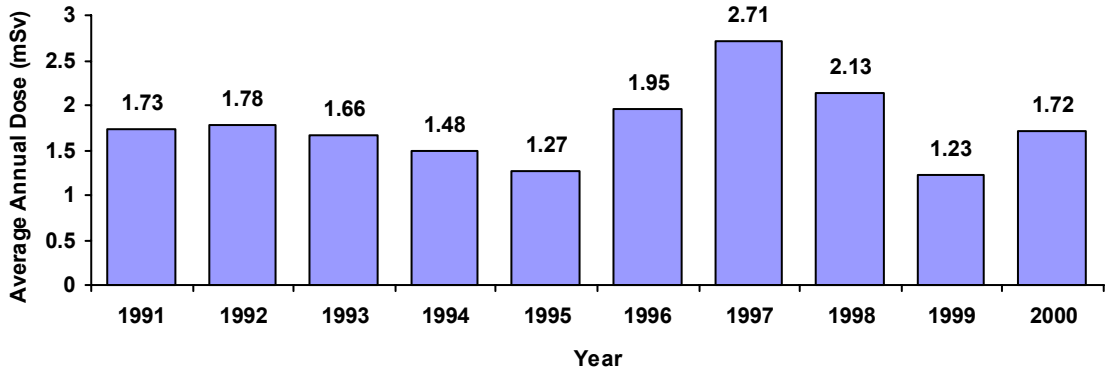


Table 4 (Cont'd)

Uranium mine mill worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	29	0.00	0.00	0
>0-1	72	39.30	0.55	66
>1-2	58	91.30	1.57	62
>2-5	85	277.95	3.27	57
>5-20	23	141.70	6.16	57
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	267	550.25	2.06	58
				Five year period 1996 - 2000
0	35	0.00	0.00	0
>0-5	256	414.80	1.62	59
>5-25	176	1986.70	11.29	45
>25-100	12	349.05	29.09	19
>100	0	0.00	0.00	0
Total	479	2750.55	5.74	44

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.4220
mu:	0.5622
sigma-squared:	2.9170

Sample size: 238
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

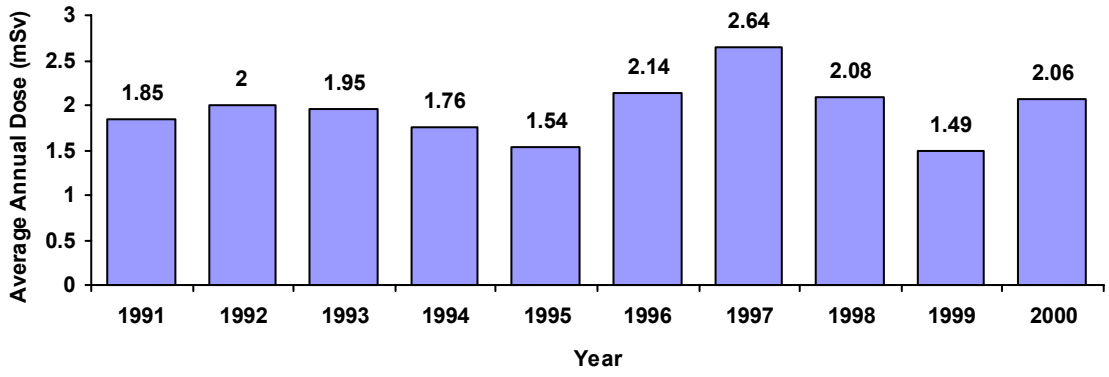


Table 4 (Cont'd)

Uranium mine nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	10	0.00	0.00	0
>0-1	7	1.80	0.26	67
>1-2	0	0.00	0.00	0
>2-5	0	0.00	0.00	0
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	17	1.80	0.11	67
				Five year period 1996 - 2000
0	21	0.00	0.00	0
>0-5	16	10.05	0.63	57
>5-25	0	0.00	0.00	0
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	37	10.05	0.27	57

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-1.7165
sigma-squared:	0.8300

Sample size: 7
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

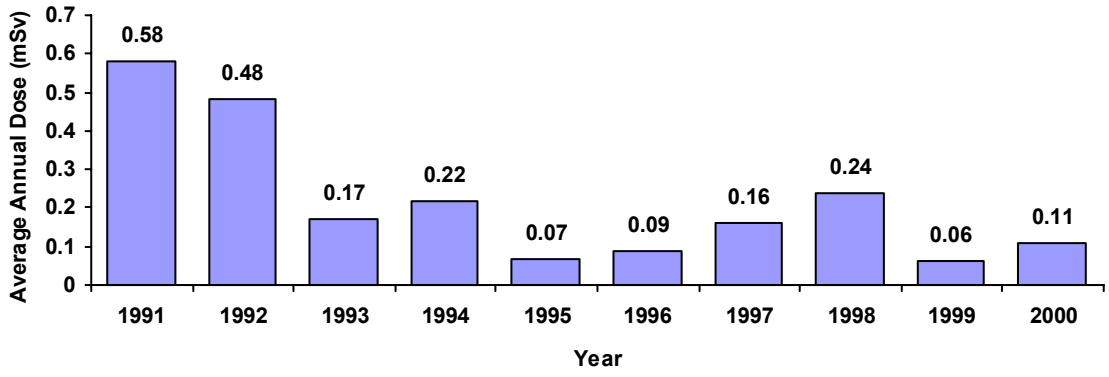


Table 4 (Cont'd)

Uranium mine office staff

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	89	0.00	0.00	0
>0-1	86	29.15	0.34	74
>1-2	2	2.40	1.20	25
>2-5	0	0.00	0.00	0
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	177	31.55	0.18	70
				Five year period 1996 - 2000
0	133	0.00	0.00	0
>0-5	240	182.60	0.76	66
>5-25	0	0.00	0.00	0
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	373	182.60	0.49	66

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	1.9661
mu:	0.0235
sigma-squared:	1.9108

Sample size: 88
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

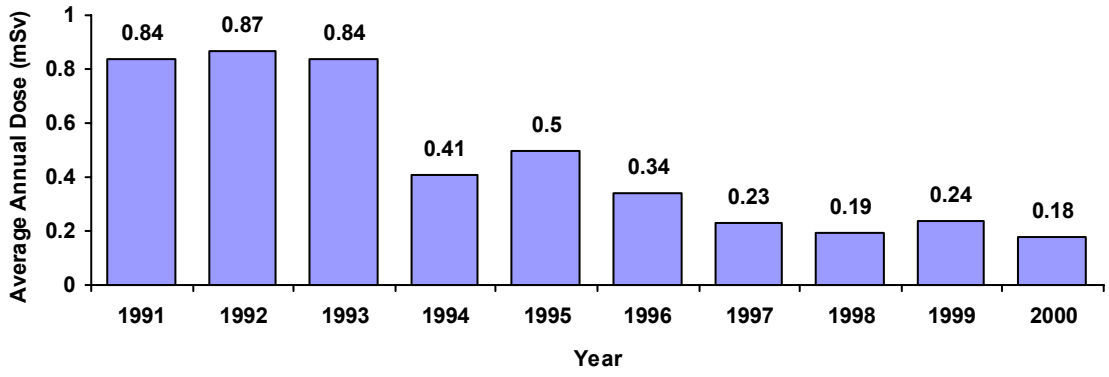


Table 4 (Cont'd)

Uranium mine support worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	37	0.00	0.00	0
>0-1	174	69.65	0.40	80
>1-2	52	75.95	1.46	58
>2-5	55	177.15	3.22	50
>5-20	9	65.05	7.23	28
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	327	387.80	1.19	53
				Five year period 1996 - 2000
0	86	0.00	0.00	0
>0-5	636	800.75	1.26	68
>5-25	124	1290.80	10.41	49
>25-100	12	377.20	31.43	34
>100	0	0.00	0.00	0
Total	858	2468.75	2.88	53

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.1824
mu:	-1.8709
sigma-squared:	2.3894

Sample size: 290
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

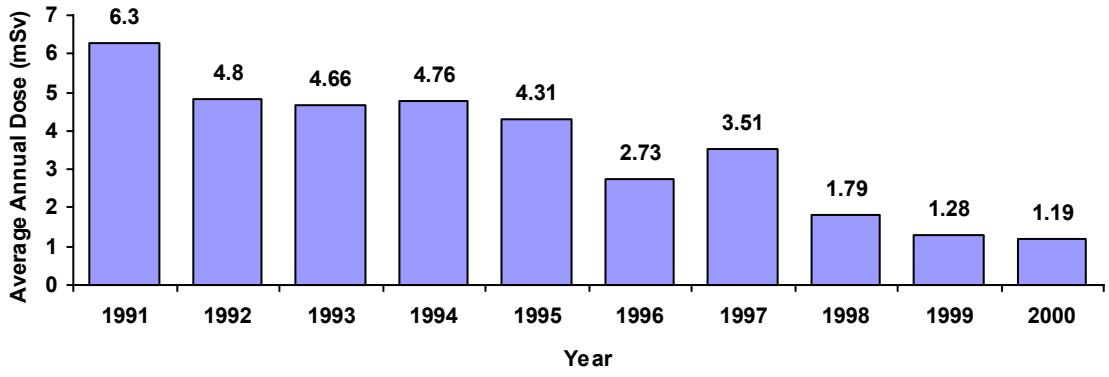


Table 4 (Cont'd)

Uranium mine surface maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	53	0.00	0.00	0
>0-1	98	48.20	0.49	68
>1-2	34	47.60	1.40	39
>2-5	9	28.75	3.19	17
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	194	124.55	0.64	45
				Five year period 1996 - 2000
0	143	0.00	0.00	0
>0-5	430	559.55	1.30	60
>5-25	24	159.55	6.65	35
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	597	719.10	1.20	54

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.4956
mu:	-0.7851
sigma-squared:	1.7483

Sample size: 141
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

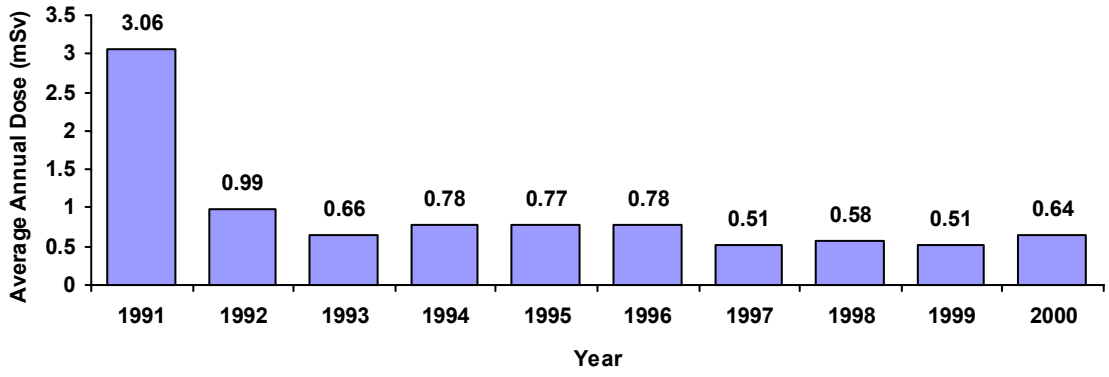


Table 4 (Cont'd)

Uranium mine surface miner

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	6	0.00	0.00	0
>0-1	43	15.50	0.36	59
>1-2	11	15.50	1.41	39
>2-5	29	88.80	3.06	52
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	89	119.80	1.35	52
				Five year period 1996 - 2000
0	57	0.00	0.00	0
>0-5	252	421.20	1.67	42
>5-25	40	282.55	7.06	20
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	349	703.75	2.02	33

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.6418
mu:	0.1865
sigma-squared:	4.5850

Sample size: 83
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

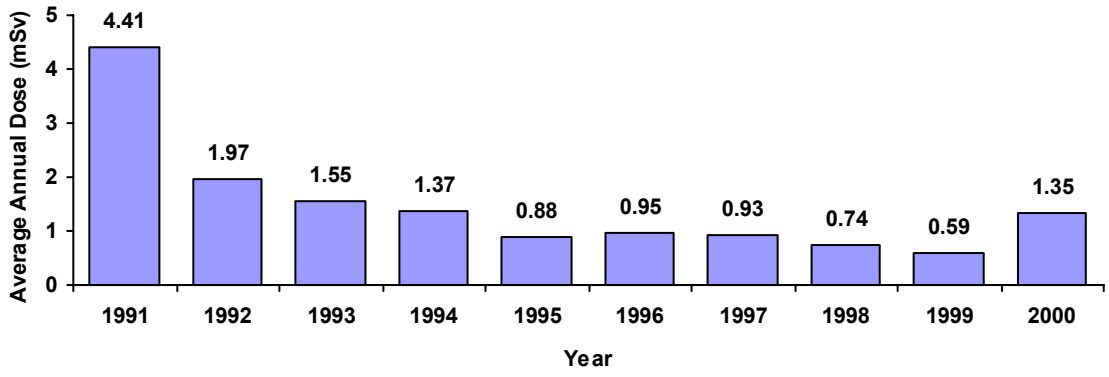


Table 4 (Cont'd)

Uranium mine surface personnel

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	46	0.00	0.00	0
>0-1	94	32.05	0.34	64
>1-2	25	34.05	1.36	74
>2-5	21	52.50	2.50	80
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	186	118.60	0.64	74
				Five year period 1996 - 2000
0	89	0.00	0.00	0
>0-5	264	286.65	1.09	67
>5-25	10	75.70	7.57	43
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	363	362.35	1.00	62

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.4299
mu:	-1.2568
sigma-squared:	2.3964

Sample size: 140
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

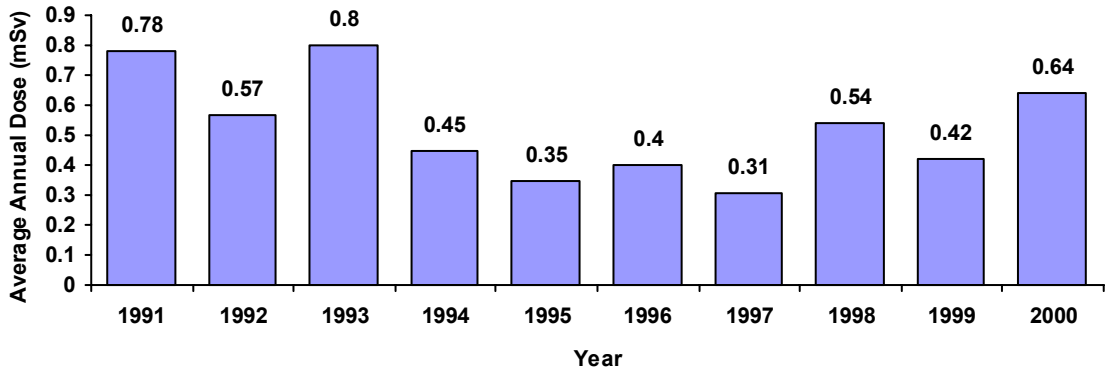


Table 4 (Cont'd)

Uranium mine surface support worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	114	0.00	0.00	0
>0-1	162	58.60	0.36	49
>1-2	8	11.60	1.45	61
>2-5	8	21.20	2.65	54
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	292	91.40	0.31	52
				Five year period 1996 - 2000
0	303	0.00	0.00	0
>0-5	530	536.80	1.01	48
>5-25	31	283.00	9.13	37
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	864	819.80	0.95	44

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-1.1392
sigma-squared:	0.9705

Sample size: 178
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

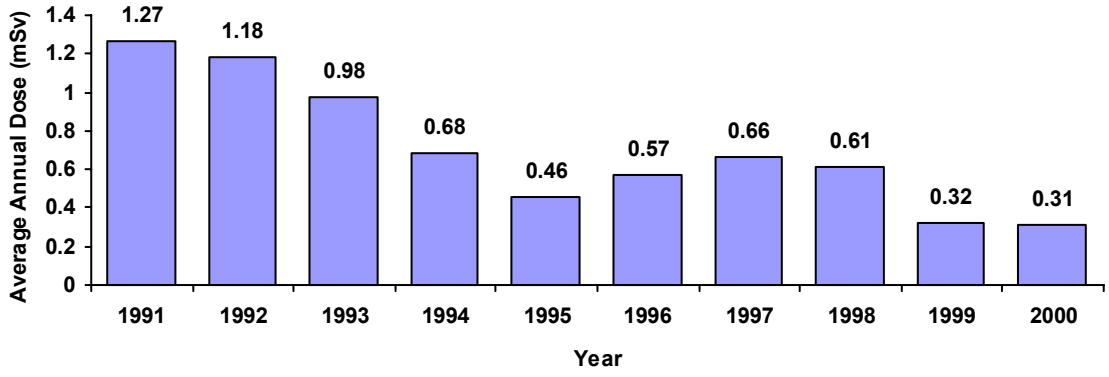


Table 4 (Cont'd)

Uranium mine underground maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	13	0.00	0.00	0
>0-1	134	63.05	0.47	80
>1-2	43	62.00	1.44	64
>2-5	4	11.75	2.94	51
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	194	136.80	0.71	70
				Five year period 1996 - 2000
0	28	0.00	0.00	0
>0-5	324	405.05	1.25	69
>5-25	55	495.30	9.01	59
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	407	900.35	2.21	63

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.9184
mu:	-0.0465
sigma-squared:	2.1985

Sample size: 181
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

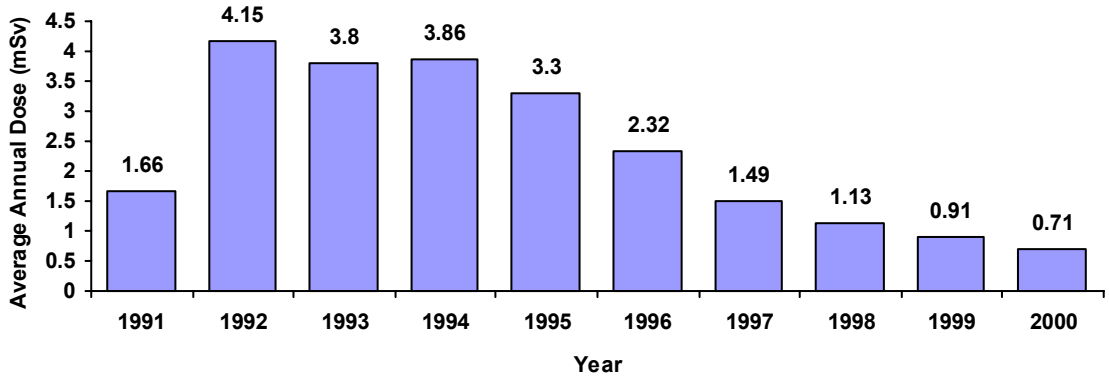


Table 4 (Cont'd)

Uranium mine underground miner

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	26	0.00	0.00	0
>0-1	96	40.20	0.42	84
>1-2	43	65.25	1.52	65
>2-5	71	225.70	3.18	57
>5-20	48	398.65	8.31	22
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	284	729.80	2.57	40
				Five year period 1996 - 2000
0	35	0.00	0.00	0
>0-5	485	864.30	1.78	66
>5-25	311	3366.45	10.82	47
>25-100	101	4101.25	40.61	32
>100	0	0.00	0.00	0
Total	932	8332.00	8.94	41

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	0.2339
mu:	-0.4953
sigma-squared:	4.2386

Sample size: 258
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

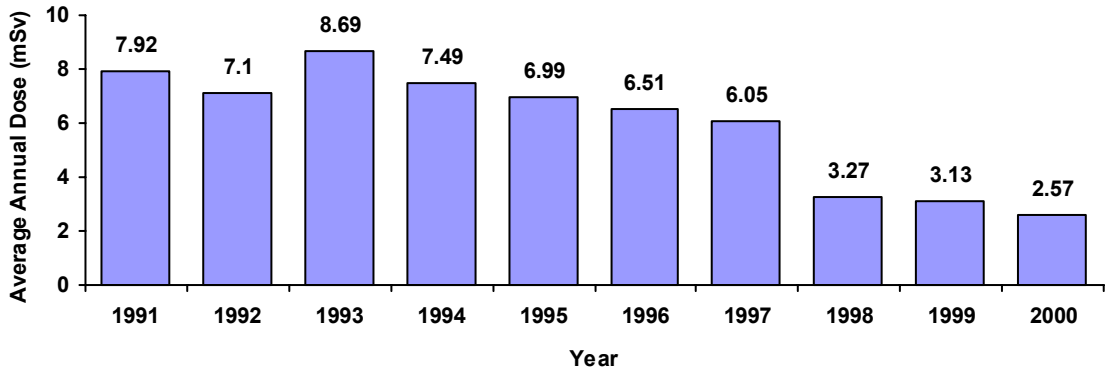


Table 4 (Cont'd)

Uranium mine underground personnel

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	26	0.00	0.00	0
>0-1	52	24.80	0.48	83
>1-2	22	30.40	1.38	65
>2-5	9	28.40	3.16	35
>5-20	2	14.40	7.20	8
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	111	98.00	0.88	53
				Five year period 1996 - 2000
0	267	0.00	0.00	0
>0-5	345	410.10	1.19	58
>5-25	52	529.25	10.18	47
>25-100	2	58.05	29.02	65
>100	0	0.00	0.00	0
Total	666	997.40	1.50	53

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-0.3840
sigma-squared:	1.2302

Sample size: 85
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000

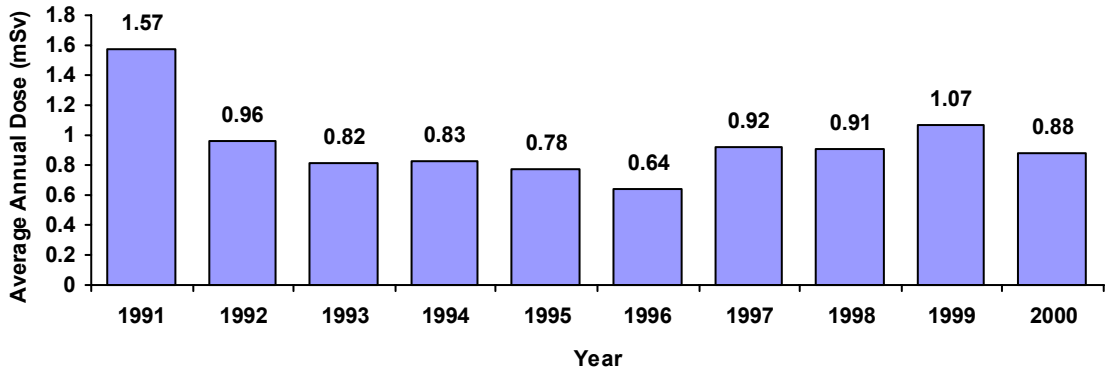


Table 4 (Cont'd)

Uranium mine visitor

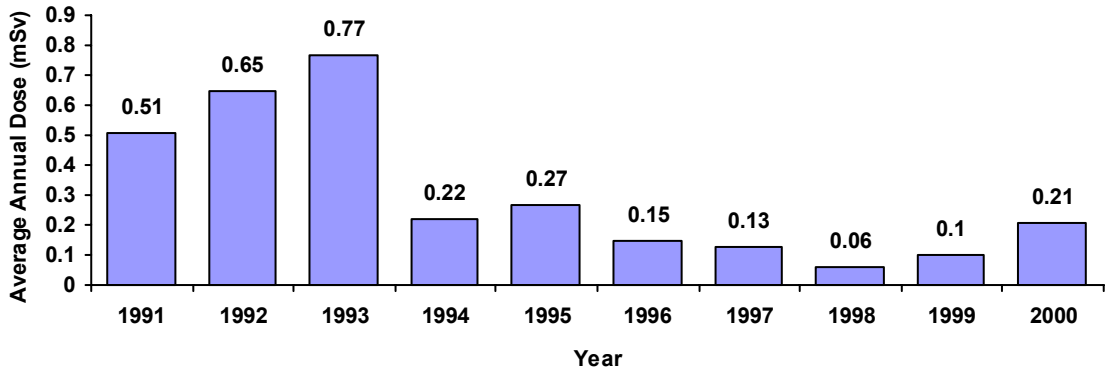
Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon
				Year 2000
0	49	0.00	0.00	0
>0-1	122	28.65	0.23	56
>1-2	0	0.00	0.00	0
>2-5	3	8.65	2.88	38
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	174	37.30	0.21	51
				Five year period 1996 - 2000
0	403	0.00	0.00	0
>0-5	533	163.25	0.31	57
>5-25	0	0.00	0.00	0
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	936	163.25	0.17	57

Lognormal or hybrid lognormal parameters for positive doses in 2000:

rho:	n/a
mu:	-1.8578
sigma-squared:	1.1517

Sample size: 125
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1991 - 2000



Appendix

The lognormal and hybrid lognormal distributions

The appendix explains how the data can be fitted to a statistical distribution, so that: (1) the sample of doses can be described by 3 or 4 quantities (the parameters of the distribution and sample size); and, (2) from these quantities, any dose statistic can be estimated, including any statistic not listed in this report, such as the 9-th decile.

Statistical distributions, such as the lognormal or hybrid lognormal distribution, are defined by a probability density function, containing a variable x, which in our case represents the occupational dose. This function is interpreted as follows:

The probability that a dose value lies between a and b equals

$$\int_a^b f(x)dx \quad ,$$

where f represents the probability density function.

Besides the variable (occupational dose) the probability density function contains a number of parameters, which determine the shape of the function. Only when the parameters have been specified is the statistical model for the occupational dose defined. Parameters are adjusted to fit the data.

The lognormal probability density function f is given by:

$$f(x: \mu,\sigma^2)=(1/x)(2\pi\sigma^2)^{-1/2}\exp(-\ln(x)-\mu)^2/2\sigma^2)$$

The hybrid lognormal probability density function f is given by:

$$f(x: \rho,\mu,\sigma^2)= (\rho+1/x)(2\pi\sigma^2)^{-1/2}\exp(-\ln(\rho x)+\rho x-\mu)^2/2\sigma^2)$$

In these functions, the quantities μ and σ^2 are parameters of the distribution. The hybrid lognormal distribution contains an extra parameter ρ. This distribution was introduced by Kumazawa[9] *et al*, for the purpose of describing a workforce that makes a sustained effort to stay below a regulatory limit. This distribution often gives a better fit than the lognormal distribution for certain high dose occupations, such as nuclear medicine workers. It is similar to a lognormal distribution for low doses and to a normal distribution for high doses.

If the parameters for the probability density function f are known, one can estimate any dose statistic. For example, the mean dose is estimated as

$$\int_0^\infty xf(x)dx$$

(since the dose values x are between 0 and infinity).

The variance of the dose is estimated as:

$$\int_0^\infty (x-\text{mean})^2 f(x)dx$$

and the standard deviation as the square root thereof.

The probability that a dose exceeds, for example, 50 mSv, is estimated as:

$$\int_{50}^\infty f(x)dx \quad .$$

The 95-th percentile is estimated as that dose value v for which:

$$\int_v^\infty f(x)dx = 95/100 \ .$$

The fraction of the collective dose due to doses exceeding 15 mSv is estimated as:

$$\frac{\int_{15}^\infty xf(x)dx}{\int_0^\infty xf(x)dx}$$

The parameters are determined from the actual dose data. They are chosen to give the best "fit" with the sample of observed data, for which purpose there exists a variety of methods. The parameters in Table 4 have been estimated with the Maximum Likelihood method. With this method, dose statistics can be estimated with the formulas given above, with the tabulated parameter values substituted for (ρ,) μ, and σ^2.

Software is available from the authors for the purpose of estimating occupational dose statistics and their confidence intervals. Since the lognormal and hybrid lognormal distribution do not apply to zero doses, as evident from the formulas of their probability density functions, the software will determine parameters based on positive doses only. Estimates for the total of all doses can be derived if the numbers of zero and positive doses in the sample are taken into account. For example, consider a sample in which half the doses are zero. If the parametric estimate is 2 mSv for the mean of the positive doses, then the estimate of the mean of all doses is 1 mSv. Or, if a parametric estimate for the 95-th percentile of all doses is needed, it is calculated as the estimate of the 90-th percentile for the positive doses.