AAEC/E375

AAEC/E375

AUSTRALIAN ATOMIC ENERGY COMMISSION

RESEARCH ESTABLISHMENT

LUCAS HEIGHTS

ENVIRONMENTAL SURVEY AT THE AAEC RESEARCH ESTABLISHMENT, LUCAS HEIGHTS - RESULTS FOR 1974

by

D.R. DAVY
A. DUDAITIS

April 1976

Reprinted May 1979

AUSTRALIAN ATOMIC ENERGY COMMISSION
RESEARCH ESTABLISHMENT
LUCAS HEIGHTS

ENVIRONMENTAL SURVEY AT THE AAEC RESEARCH ESTABLISHMENT, LUCAS HEIGHTS - RESULTS FOR 1974

by

D.R. DAVY
A. DUDAITIS

ABSTRACT

This report tabulates the results of the environmental survey at Lucas Heights during 1974 and compares them with derived maximum permissible concentrations appropriate to the local environment.

Possible doses to individual members of the local population as a result of Research Establishment operations are less than those due to weapons test fallout and much less than those due to natural radiation background.

CONTENTS

1. INTRODUCTION

This report gives results obtained from samples collected for the environmental survey program at the Australian Atomic Energy Commission, Research Establishment, Lucas Heights during 1974. The rationale for the program and synopsis of results for the period 1965-1970 have been reported by Watson [1972]. The results for the period 1971-1972 have been reported by Dudaitis [1973, 1974] and those for 1973 by Davy & Dudaitis [1974].

2. SAMPLING PROGRAM

The Woronora estuary receives treated low level aqueous waste from the Research Establishment (RE). Table 1 gives details of the collection and preparation of samples taken from the estuary for the environmental survey program. Figure 1 gives the location of estuary sampling stations. Table 2 gives details of terrestrial samples and their preparation and Figure 2 gives the location of terrestrial sampling stations.

3. TABULATION OF RESULTS

Tables 3 to 7 refer to samples collected from the Woronora estuary. Table 8 refers to radiation dose readings on the bed of the Woronora estuary at the discharge point. Table 9 refers to milk samples from the terrestrial environment. Table 10 refers to samples taken from the closed solid waste burial ground (Station T1, 1.6 km from the RE). Table 11 refers to samples collected near the stormwater outlets outside the RE safety fence.

4. DISCUSSION OF RESULTS

4.1 Woronora Estuary

The results for estuarine water, oysters, fish and beach sand are summarised in Table 12, where the average results for the period are expressed as fractions of the derived maximum permissible concentrations (m.p.c.) listed. The results for 1968 to 1973 are included for comparison.

The isotopes detected were the same as those found in previous years. The levels for tritium in water, zinc-65 in oysters and cobalt-60 in fish were all less than one thousandth of the derived maximum permissible concentrations. Gross alpha and gross beta activities in beach sand samples, attributed to natural activity, were generally the same as in previous years at three thousandths and one thousandth of the derived maximum permissible concentrations. Water samples taken

from Station E3.6 above the discharge point showed no significant changes from previous years.

Zostera (Table 7) showed the same activity concentrations as in previous years with cobalt-60 and manganese-54 gamma emitters detected. This activity is attributed to site operations. No human exposure routes for Zostera have been identified, hence there are no derived maximum permissible concentrations.

4.2 Terrestrial Samples Related to Possible Airborne Waste

Caesium-137 found in milk samples (Table 9) is attributable to the activity from weapons test fallout. The lower limit of detection of iodine-131 in milk (Table 9) is 0.3 pCi g^{-1} fresh weight, at the 95 per cent confidence level. There is no indication in these samples of any deposition of airborne waste from the Research Establishment. The figures are comparable to those of previous years.

4.3 Other Terrestrial Samples

Samples from the closed solid waste burial ground are listed in Table 10. Vegetation taken from the nearest point to the actual buried waste showed the presence of cobalt-60 and short-lived mixed fission products. Water from boreholes in the burial ground showed only trace levels of 0.5 MeV gamma emitters.

Sub-surface water from the burial ground is expected to drain into Mill Creek north of the burial ground (see Figure 2). For this reason, a line of five borehole sampling sites (designated A to E) is maintained just outside the northern perimeter of the burial ground. Water samples from these holes contain alpha activity from a near equilibrium (*i.e.* naturally occurring) uranium series.

The detected radioactivity in the stormwater drains reported in Table 11 is attributed to site operations. The radiological significance of this contamination is minimal.

5. RADIOLOGICAL SIGNIFICANCE OF THE RESULTS

The results have been used to calculate the maximum potential doses to individual members of the local population from ingestion of oysters, fish or milk, or by the other exposure pathways which were taken into account in setting discharge limits. These are given in Table 13.

Maximum whole-body doses from the ingestion of tritium and zinc-65, attributable to operations at the RE are 0.01 and 0.02 millirem per year respectively. The total annual dose for a hypothetical individual who

consumes 70 g each of local oysters and fish, and swims daily at the discharge point, is 0.05 millirem. This is less than one five-thousandth of the maximum permissible dose limits for members of the public [ICRP 1966].

The traces of activity reported in other samples give no exposure to man. The activity in milk is attributable to fallout and the beach sand activity is natural. For comparison, whole-body dose from natural background radiation, internal and external, is of the order of 100 millirem per year.

6. SUMMARY

During 1974, no radioactivity attributable to aerial dispersion from the Research Establishment was detected in the environment.

In the Woronora estuary, a number of radioisotopes were detected other than those that occur naturally, in weapons test fallout, or in quantities in excess of natural or fallout concentrations. These are attributed to low level liquid effluent discharges in the estuary. Those found were tritium (as water), cobalt-60 (in fish and Zostera) and zinc-65 (in oysters).

At the solid waste burial ground, cobalt-60 attributed to buried waste has been detected in vegetation taken near the buried material.

Levels of activity attributable to RE operations were similar to those of previous years and generally of the order of, or less than, one thousandth of the appropriate derived maximum permissible concentrations.

Estimates of possible doses to individual members of the public from RE operations give results less than those due to weapons test fallout and much less than natural radiation background.

7. ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance received from members of Health Physics Research Section and Chemical Technology Division in the collection, processing and chemical and radiochemical analysis of samples.

8. REFERENCES

Cook, J.E. & Dudaitis, A. [1970] - Environmental Survey at the AAEC Research Establishment, Lucas Heights. Results for 1969. AAEC/E151, Supplement No.3.

Davy, D.R. & Dudaitis, A. [1974] - Environmental Survey at the AAEC Research Establishment, Lucas Heights. Results for 1973. AAEC/E335.

Dudaitis, A. [1973] - Environmental Survey at the AAEC Research Establishment, Lucas Heights. Results for 1971. AAEC/E271.

Dudaitis, A. [1974] - Environmental Survey at the AAEC Research Establishment, Lucas Heights. Results for 1972. AAEC/E301.

Fry, R.M. [1966] - A Reformulation of the Lucas Heights Liquid Effluent Discharge Authorisation. AAEC/E156.

ICRP [1966] - Recommendations of the International Commission on Radiological Protection (adopted 17 September 1965). ICRP Publication 9. Pergamon Press, Oxford.

Watson, G.M. [1972] - Environmental Monitoring Program at the AAEC Research Establishment at Lucas Heights. Proc. 4th Int. Conf. on the Peaceful Uses of Atomic Energy, 6-12 September 1971, Geneva. Vol.11, p.341 UN/IAEA, New York and Vienna.

ENVIRONMENTAL SURVEY RESULTS

(1974)

TABLES 1-13

NOTE: Upper limits shown in Tables 3-12 are at the 95 per cent confidence level of the counting statistics. Where an upper limit is given for an average this is the upper limit of the average of all results. Dashes indicate that no activity was detected and blank spaces that no measurement was made.

TABLE 1

DETAILS OF COLLECTION AND PREPARATION OF ESTUARINE SAMPLES

Sample	Stations	Collection Frequency	Collection Details	Special Steps in Preparation
Oysters	E4.4, E5.8 Control	Quarterly	Obtained from commercial leases	Opened by commercial openers. Drained on sieve for 5 minutes. Ashed
Fish	E0.8, E4.0	Quarterly	Caught by seine net	Whole fish ashed
Beach Sand	E0.8, E3.7	Six Monthly	Taken by scoop from top 2 in. in the intertidal region	Fraction between 60 and 120 mesh B.S.S. removed after ashing
Estuary Water	E3.6	Weekly	From surface by bucket	Distilled for tritium
Zostera	E1.0, E1.5 E2.9, E4.4 E5.8	Quarterly	Pulled from bottom by rake or hand	Ashed

TABLE 2

DETAILS OF COLLECTION AND PREPARATION OF TERRESTRIAL SAMPLES

Sample	Stations	Collection Frequency	Collection Details	Special Steps in Preparation
Milk	T3.1	Monthly	Obtained from bulk milk supplies	Gamma spectrometry of whole milk for iodine-131
Vegetation	T1	Six Monthly	Cut by hand clippers	Whole unwashed vegetation is ashed
Ground Water	T1	Six Monthly	Boreholes pumped out, allowed to refill, sample taken from bottom	The water is passed through 200 ml of Amberlite IRC 120 resin, which is then ashed
Creek Water	T0	Six Monthly	Taken in bucket	As for ground water (Distilled for tritium)

TABLE 3

WORONORA SAMPLES - OYSTER FLESH, 1974

Station	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight			K_{-1} ($\mu g\ g^{-1}$)
		Gross Alpha	Gross Beta (less ^{40}K)	^{65}Zn	
E 4.4	12.2	0.20	< 0.60	0.23	3700
	27.5	0.31	< 0.48	0.06	3300
	13.12	0.22	0.11	0.34	3600
Average		0.24	< 0.40	0.21	
E 5.8	12.2	0.19	< 0.64	trace	4000
	20.5	0.44	0.32	0.12	2700
	19.11	0.20	0.10		3500
Average		0.28	< 0.35		
Hawkesbury River (H.R.)	12.2	0.19	< 0.44		2900
	19.11	0.16	0.06		2900
Average		0.18	0.25		
Oyster Shell Composite	12.2-13.12	0.12	0.30		300
		Derived m.p.c.(a)		1000	
E 4.4		Fraction of m.p.c.		$2x10^{-4}$	
E 5.8		"			
H.R.		"			
Oyster Shell Composite		"			

(a) Derived maximum permissible concentrations are taken from Fry (1966)

TABLE 4

WORONORA SAMPLES - WHOLE FISH, 1974

Station	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight			K_{-1} ($\mu g\ g^{-1}$)
		Gross Alpha	Gross Beta (less ^{40}K)	^{60}Co	
E 0.8 Mullet	18.2	0.13	0.48	trace	2700
Mullet	15.8	0.10	< 0.54	trace	3400
Bream	18.2	0.11	0.68	0.18	3300
Average		0.11	0.57		
E 4.0 Mullet	27.2	0.52	< 0.64		3700
Mullet	8.5	0.50	0.15		3400
Mullet	31.10	0.33	< 0.58		3500
Blackfish	27.2	0.48	< 0.64		4100
Blackfish	8.5	0.44	0.16	trace	3500
Blackfish	31.10	0.30	0.44		3200
Average		0.43	< 0.44		
Derived m.p.c.				500	
E 0.8 Fraction of m.p.c.					
E 4.0 Fraction of m.p.c.					

TABLE 5

WORONORA SAMPLES - BEACH SAND, 1974

Station	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight		K ($\mu g\ g^{-1}$)
		Gross Alpha	Gross Beta (less ^{40}K)	
E 0.8	18.2	5.72	1.19	300
	30.7	12.21	1.35	300
Average		8.97	1.27	
E 3.7	17.4	7.36	2.26	800
	2.8	12.79	2.21	600
Average		6.40	2.24	
Derived m.p.c.		3000	2500	
Average fraction of m.p.c.		3×10^{-3}	7×10^{-4}	

TABLE 6

WORONORA SAMPLES - TRITIUM IN SURFACE WATER

AT STATION E 3.6, 1974

Date 1974	Tritium (pCi ml^{-1})	Date 1974	Tritium (pCi ml^{-1})	Date 1974	Tritium (pCi ml^{-1})
4.1	< 1.0	10.5	< 1.0	16.9	< 1.0
11.1	4.3	17.5	5.1	19.9	< 1.0
18.1	< 1.0	24.5	< 1.0	27.9	1.6
25.1	< 1.0	31.5	1.0	3.10	2.0
1.2	< 1.0	7.6	1.2	11.10	2.5
8.2	< 1.0	13.6	1.8	17.10	2.1
15.2	< 1.0	21.6	2.3	24.10	2.0
22.2	< 1.0	28.6	< 1.0	8.11	2.0
1.3	1.7	8.7	< 1.0	15.11	< 1.0
8.3	1.4	11.7	< 1.0	22.11	< 1.0
15.3	< 1.0	19.7	< 1.0	28.11	< 1.0
22.3	2.4	25.7	< 1.0	6.12	< 1.0
29.3	< 1.0	2.8	< 1.0	13.12	< 1.0
5.4	4.6	8.8	< 1.0	20.12	< 1.0
11.4	< 1.0	16.8	< 1.0	31.12	1.7
19.4	< 1.0	22.8	1.8	Average	1.5
29.4	3.1	30.8	< 1.0	Derived m.p.c.=3×10^{4} pCi ml^{-1}	
3.5	2.4	5.9	< 1.0	Average fraction of m.p.c. = 5×10^{-5}	

TABLE 7

WORONORA SAMPLES - ZOSTERA, 1974

Station	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight						
		Gross Alpha	Gross Beta (less ^{40}K)	Gamma Emitters				
				0.5MeV	^{54}Mn	^{95}Zr+^{95}Nb	^{60}Co	^{238}U series
E 0.8	6.2	0.7	0.8	-	1.0	-	4.6	trace
	9.5	0.8	1.2	-	0.6	-	3.1	-
Average		0.7	1.0	-	0.8	-	3.8	-
E 1.0	6.2	1.1	1.1	-	0.9	-	3.9	trace
	9.5	1.0	1.1	-	0.3	-	2.4	-
	8.11	1.4	2.8	0.4	trace	1.0	2.3	trace
Average		1.2	1.7	-	$\lesssim$ 0.4	-	2.9	-
E 1.5	6.2	0.8	0.9	-	0.8	-	2.7	-
	9.5	0.6	0.5	-	0.4	-	1.5	-
	8.11	0.7	1.6	0.3	trace	0.7	2.1	trace
Average		0.7	1.0	-	$\lesssim$ 0.4	-	2.1	-
E 2.9	6.2	3.8	0.8	-	trace	-	0.8	trace
	9.5	2.7	1.4	-	-	-	0.5	-
	8.11	1.4	1.6	0.2	-	0.9	0.5	trace
Average		2.6	1.3	-	-	-	0.6	-
E 4.4	6.2	2.5	1.1	-	-	-	trace	trace
	9.5	1.0	0.6	-	-	-	trace	trace
	8.11	1.5	1.7	0.1	-	0.5	-	trace
Average		1.7	1.1	-	-	-	-	-
E 5.8	9.5	0.7	0.8	-	-	-	-	-
	8.11	1.7	0.9	0.1	-	0.2	-	trace
Average		1.2	0.8	-	-	-	-	-

TABLE 8

RADIATION DOSE READINGS FROM LiF-TEFLON DOSIMETERS ON BED OF WORONORA ESTUARY AT THE DISCHARGE POINT

Location of Dosimeters Figure 3	(a) Dose in rem from 6.12.73 to 23.12.74
No. 1	< 0.01
2	< 0.01
3	< 0.01
4	< 0.01
5	
6	
7	< 0.01
8	< 0.01
9	

Note: Blank spaces indicate dosimeters have been vandalised during the period.

(a) Integrated dose from single dosimeter at specified position.

TABLE 9

TERRESTRIAL SAMPLES - MILK, 1974

Station	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight	
		^{137}Cs	^{131}I
T3 (Menai)	15.1	0.01	-
	14.2	-	-
	26.3	0.01	-
	18.4	0.01	-
	17.5	0.01	-
	21.6	-	-
	19.7	-	-
	16.8	-	-
	17.9	0.03	-
	21.10	-	-
	14.11	0.02	-
	17.12	0.01	-
Average		0.01	

Note: Minimum detectable level for iodine-131 in milk is 0.3 pCi g^{-1} fresh weight (0.3 nCi l^{-1})

TABLE 10

TERRESTRIAL SAMPLES - SOLID WASTE BURIAL GROUND, 1974

Location	Sample	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight			K ($\mu g\ g^{-1}$)
			Gross Alpha	Gross Beta(a)	Gamma Emitters	
Near Trench No. 57	Top Soil	25.9	605	64	27 ^{137}Cs 9 ^{60}Co trace ^{238}U series	3700
Near Trench No. 59	Acacia	25.9	0.6	3.1	0.5 0.5 MeV(c) 1.3 ^{95}Zr + ^{95}Nb	3500
Near Trench No. 68	Top Soil(b)	25.9	80	145	108 ^{60}Co trace ^{238}U series	400
Near Trench No. 71	Grass	25.9	20	47	0.7 0.5 MeV 1.7 ^{95}Zr + ^{95}Nb 6.1 ^{60}Co trace ^{238}U series	3200
	Acacia	25.9	0.4	29	0.3 0.5 MeV 0.9 ^{95}Zr + ^{95}Nb 0.8 ^{60}Co	2100
Near Yellow Peg No. 1	Grass	25.9	1.9	39	0.7 0.5 MeV 1.0 ^{95}Zr + ^{95}Nb 5 ^{60}Co trace ^{238}U series	4100
	Top Soil	25.9	28	26	0.5 ^{60}Co trace ^{238}U series	400

(a) Including ^{40}K for water results; excluding it for vegetation

(b) ^{90}Sr = 33.4 pCi g^{-1}

(c) The gamma-ray peak detected at approximately 0.50 MeV could be either ^{7}Be (0.48 MeV, 53 day half-life), ^{103}Ru (0.50 MeV, 40 day half-life) or ^{106}Ru (0.51 MeV, 1.0 year half-life). The unit pCi g^{-1} refers to the disintegrations per gram emitting a gamma photon of the energy quoted. Beryllium-7 is a cosmic ray produced atmospheric activation product: the remainder are fission products.

TABLE 10 (continued)

TERRESTRIAL SAMPLES - SOLID WASTE BURIAL GROUND, 1974

Location	Sample	Date 1974	Radioactivity, pCi l^{-1}		
			Gross Alpha	Gross Beta(a)	Gamma Emitters
Bore Hole 1	Ground Water	26.2	3.8	4.7	-
2			5.1	4.4	-
3			1.7	4.3	-
4			1.2	2.3	-
5			0.4	1.9	-
6			1.1	3.0	-
10			7.1	18	trace ^{238}U series
OS1			< 1.8	4.4	-
OS2			2.8	5.7	-
OS3			11	76	2.0 0.5 MeV
A			2.4	5.9	trace ^{238}U series
B			6.0	5.1	trace ^{238}U series
C			2.6	3.2	trace ^{238}U series
D			48	26	trace ^{238}U series
E			0.8	5.7	-
Bore Hole 1		25.9	3.0	3.4	-
2			2.6	3.2	-
3			2.8	4.3	-
4			1.8	1.8	-
5			0.5	2.7	-
6			1.9	2.7	-
10			6.5	12	-
OS1			4.3	4.9	-
OS2			7.9	8.7	-
OS3			11	106	trace 0.5 MeV
A			15	13	trace ^{238}U series
B			11	15	trace ^{238}U series
C			13	7.3	trace ^{238}U series
D			80	41	trace ^{238}U series
E			11	7.0	trace ^{238}U series

(a) Including ^{40}K for water results; excluding it for vegetation.

TABLE 11

TERRESTRIAL SAMPLES - MISCELLANEOUS, 1974

Station	Sample	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight				K ($\mu g\ g^{-1}$)
			Gross Alpha	Gross Beta (less ^{40}K)	^{3}H pCi ml^{-1}	Gamma Emitters	
R.E. Stormwater Outlet near South Gate	Sand	24.5	12	8		trace ^{60}Co	1000
	Grass	24.5	0.1	0.1		0.2 0.5 MeV trace ^{137}Cs trace ^{60}Co	3300
	Water	24.5			7		
R.E. Stormwater Outlet near South Gate, 20 metres away from it	Sand	24.5	62	26		0.4 ^{54}Mn 9 ^{137}Cs 18 ^{60}Co	900
	Sand	22.11	47	21		3 ^{137}Cs 1 ^{95}Zr+^{95}Nb 7 ^{60}Co	700
	Grass	22.5	0.1	1.2		0.3 0.5 MeV 0.4 ^{137}Cs 0.7 ^{54}Mn 0.5 ^{60}Co	4600
	Grass	22.11	0.7	18		0.2 0.5 MeV 0.3 ^{137}Cs 0.5 ^{95}Zr+^{95}Nb trace ^{60}Co	5500
	Water	24.5			11		
	Water	22.11			4		
R.E.Stormwater Outlet near South Gate, 380 metres away from it	Sand	22.5	6	0.5			

TABLE 11 (continued)

TERRESTRIAL SAMPLES - MISCELLANEOUS, 1974

Station	Sample	Date 1974	Radioactivity, pCi g^{-1} Fresh Weight				K ($\mu g\ g^{-1}$)
			Gross Alpha	Gross Beta (less ^{40}K)	^{3}H pCi ml^{-1}	Gamma Emitters	
Stormwater outlet outside R.E. safety fence:							
Opp.Strassman Cres.	Sand	14.2	13	14		0.8 ^{137}Cs 2.0 ^{60}Co trace ^{232}Th+dtrs	1100
	Sand	1.8	28	16		5.6 ^{60}Co trace ^{232}Th+dtrs	1100
Opp.Building 23	Sand	14.2	15	22		2.0 ^{137}Cs 2.4 ^{60}Co	1000
	Sand	1.8	15	8		trace ^{232}Th+dtrs	700
	Grass	1.8	6	4		0.6 0.5 MeV 0.5 ^{137}Cs 0.8 ^{60}Co	3400
Opp.Fermi St.	Sand	14.2	7	10		trace 0.5 MeV trace ^{137}Cs trace ^{60}Co	1100
	Sand	1.8	15	10		trace ^{60}Co	1100
	Grass	1.8	1	0.9		0.2 0.5 MeV	7200
	Water	14.2			< 1.0		
	Water	1.8			< 1.0		

TABLE 12

WORONORA SAMPLES - ANNUAL AVERAGES EXPRESSED AS FRACTIONS OF THE DERIVED MAXIMUM PERMISSIBLE CONCENTRATIONS (a)

Sample	Radioisotope and m.p.c.	Fractions of m.p.c.						
		1968	1969	1970	1971	1972	1973	1974
Water	^{3}H, 30 nCi ml^{-1}							
EO		7×10^{-4}	2×10^{-4}	5×10^{-4}				
E1.5		4×10^{-4}	1×10^{-4}	4×10^{-4}				
E3.6		1×10^{-4}	7×10^{-5}	2×10^{-4}	7×10^{-5}	7×10^{-5}	1×10^{-4}	5×10^{-5}
E5.0		7×10^{-5}	3×10^{-5}	1×10^{-4}				
Oyster Flesh	^{65}Zn, 1000 pCi g^{-1}							
E4.4		1×10^{-4}	5×10^{-5}	2×10^{-4}	3×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}
E5.8			4×10^{-5}	8×10^{-5}	1×10^{-4}			
Hawkesbury								
Fish	^{60}Co, 500 pCi g^{-1}	4×10^{-4}	2×10^{-4}			3×10^{-4}	9×10^{-5}	
(Average of	^{90}Sr, 1 pCi g^{-1}	8×10^{-3}	7×10^{-3}	6×10^{-3}				
all samples)	^{137}Cs, 200 pCi g^{-1}	2×10^{-4}	3×10^{-5}			2×10^{-4}		
Beach Sand	Gross Alpha							
(Average of	3000 pCi g^{-1}	2×10^{-3}	3×10^{-3}	3×10^{-3}	3×10^{-3}	1×10^{-3}	2×10^{-3}	3×10^{-3}
all samples)	Gross Beta							
	2500 pCi g^{-1}	8×10^{-4}	$<1\times10^{-3}$	1×10^{-3}	4×10^{-4}	8×10^{-4}	7×10^{-4}	7×10^{-4}

(a) Derived maximum permissible concentrations are taken from Fry (1966)

TABLE 13

POSSIBLE DOSES TO MEMBERS OF THE LOCAL POPULATION

AS A RESULT OF EXPOSURE TO MEASURED CONCENTRATIONS

Sample	Isotope	Exposure Route	Possible Annual Dose (mrem)	Critical Organ
Oyster Flesh	Tritium	Ingestion	< 0.01	Whole Body
	Zinc-65	Ingestion	0.02	Whole Body
Fish	Tritium	Ingestion	< 0.01	Whole Body
	Cobalt-60	Ingestion	trace	Whole Body
	Cobalt-60	Ingestion	trace	Lower Large Intestines
Milk	Caesium-137	Ingestion	0.08	Whole Body
Estuary Water	Tritium	Daily Swimming at Discharge Point	< 0.01	Whole Body
Beach Sand	Gross Beta Activity	Regular Contact	2.1	Skin

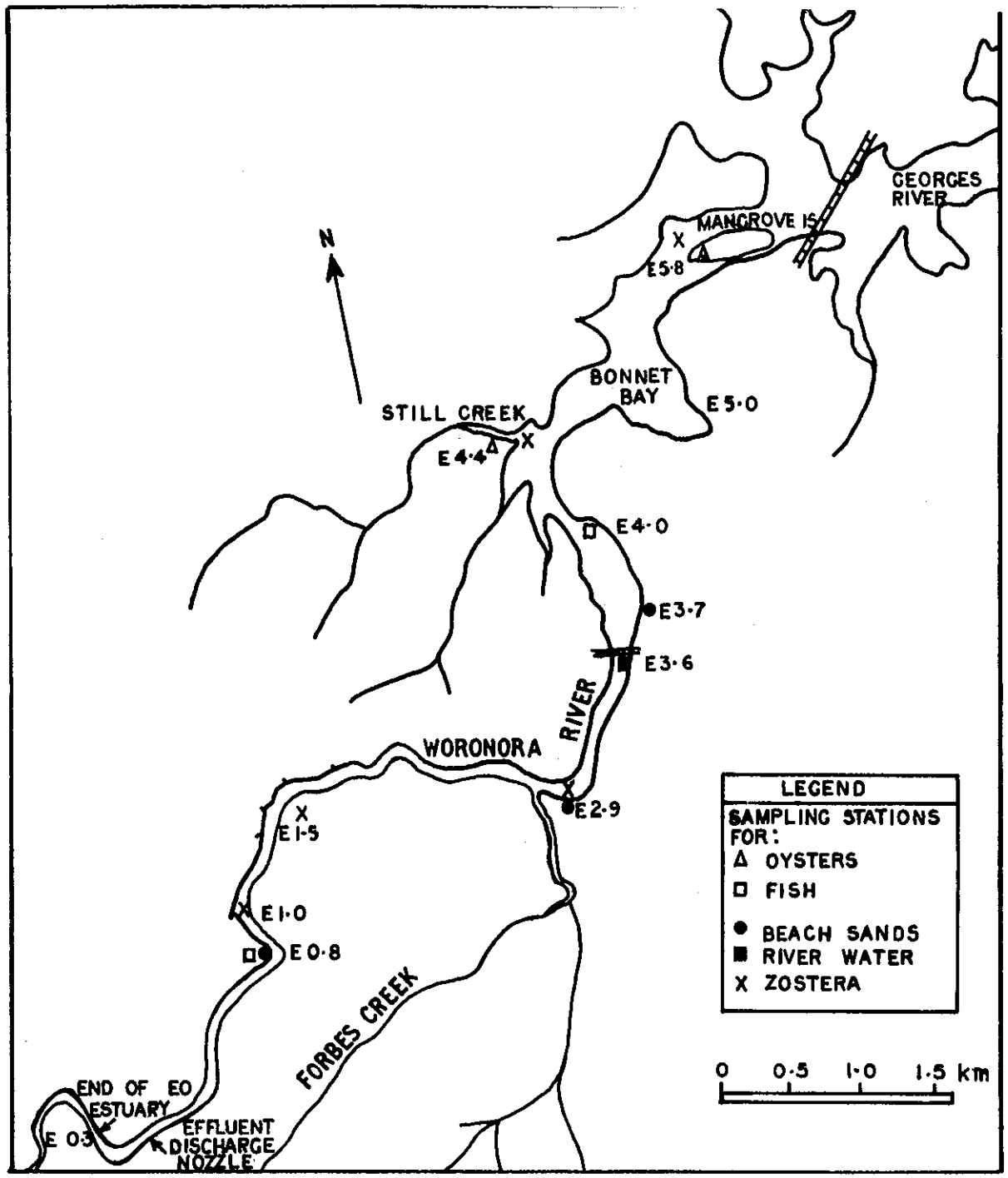

FIGURE 1. WORONORA ESTUARY SAMPLING STATIONS (1974)

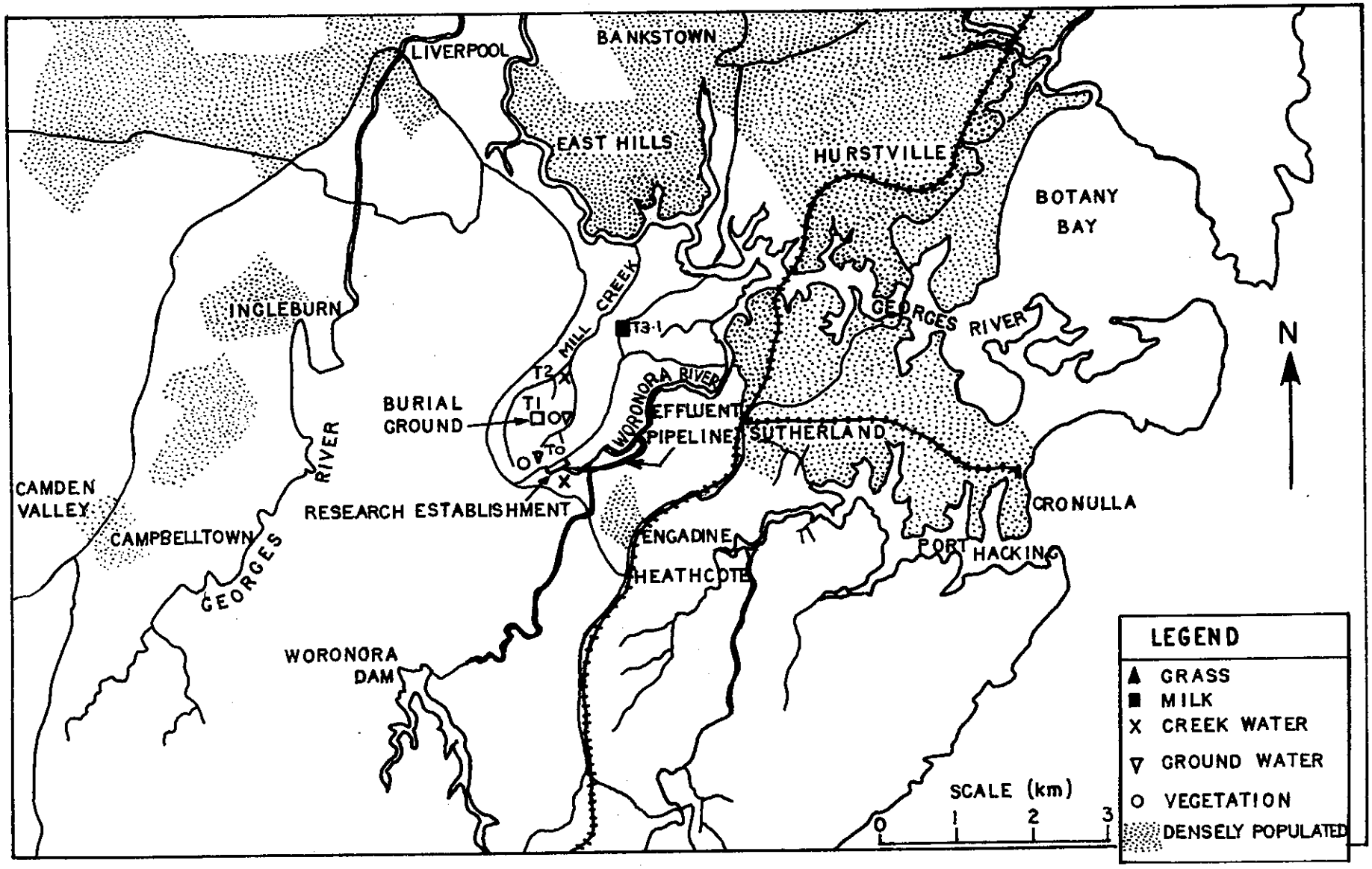

FIGURE 2. TERRESTRIAL SAMPLING STATIONS (1974)

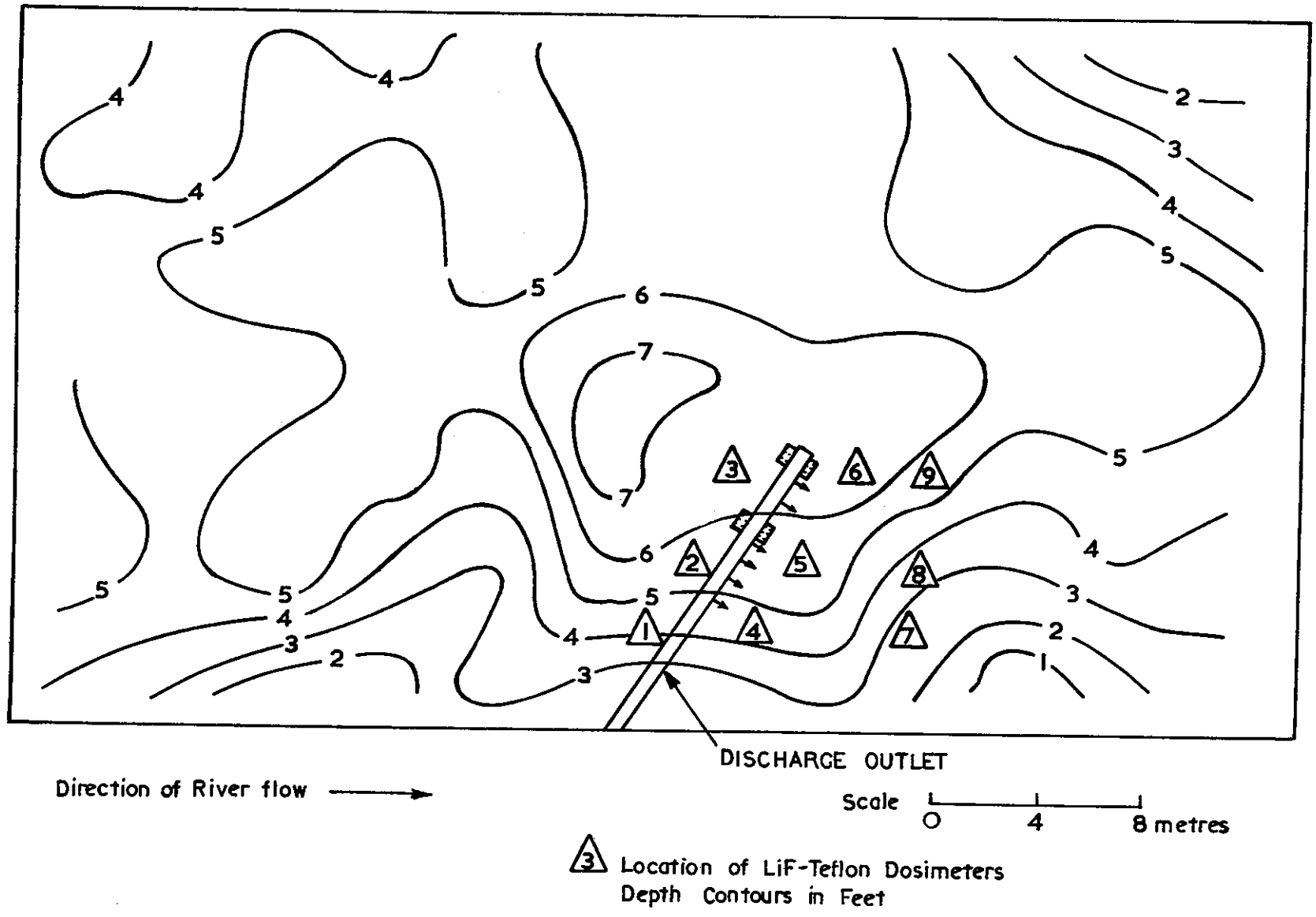

FIGURE 3. LOCATION OF LiF - TEFLON DOSIMETERS ON BED OF WORONORA ESTUARY AT THE DISCHARGE POINT