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CONTENTS

Tritium Surveillance around Nuclear Facilities in Japan

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In order to measure the tritium levels, and consequently to assess the public health significance of tritium in the environmental water around the nuclear facilities, the tritium surveillance program began in 1967 locally at Tsuruga and Mihama districts. Nowadays it has been expanded to the twelve commercial nuclear power stations (Table 1) and five nuclear facilities. Their locations are presented in Figure 1. The data from 1967 to 1976 were reported in "Radioactivity Survey Data in Japan, NIRS-RSD-44 (1978)". In this publication the data from 1977 to 1980 are presented.

Though the frequency of sampling were limited once or twice a year in most cases, the times and the points were managed to fix at each station in order to follow the annual variation of tritium level, taking account of its seasonable variation. Sampling objects of water were selected basically according to following categories.

a) Land water such as rivers, reservoirs or ponds and wells around the nuclear station which are utilized as the sourse of the primary cooling water or the drinking water in the station.
b) Sea water at the inlet or the outlet of the secondary cooling water.
c) Tap water around the station.
d) Land, sea and tap water being remote from the station whose data serve as the baseline to compare with those belong to above categories.

For samples whose tritium concentration is expected less than about 100 pCi/l, they were electrolytically enriched, and then counted by the liquid scintillation counters, Aloka LB 600 or Aloka LB 1. Aloka LSC-LB 1 is designed to use large capacity vials. Its typical counting efficiency of tritium and the background count rate were 12% and 4.5 cpm, respectively for the sample prepared by mixing with 45 ml of water and 55 ml of emulsion scintillator in a 100 ml teflon vial.

The results of each station sampled from the points shown in Figure 2 to 9 are listed in Table 2 to 9, respectively. Certain trends obvious from the data are as follows. Tritium from the effluent was not reflected in all the land water and the tap water around the nuclear power stations and the nuclear facilities.

Tritium concentration in rivers, streams, and reservoirs (pools) decreased exponentially from about 400 pCi/l in 1971 to about 100 pCi/l in 1980 with the halflife of about five years at Fukushima and Ibaragi, in northeastern Japan. In southwestern Japan, Fukui, Shimane, Saga, it decreased exponentially from about 200–300 pCi/l in 1971 to about 60–100 pCi/l in 1979.

Sea water sampled at the intake of the station or on the seashore far from the outlet was regarded not to be influenced by the effluent from the nuclear reactors or facilities. Tritium concentration in these coastal waters decreased from 30–70 pCi/l in 1971 to 20–30 pCi/l in 1979 with the half-life of about six years.

Tritium concentration of tap water around the nuclear power stations was lower or same as the river.

Figure 1 Location of Nuclear Power Stations and Nuclear Facilities

Nuclear Power Station

1. TEPCO Fukushima
2. JAPCO Tokai
3. JAERI Tokai
4. PNC Tokai
5. JAERI Oharai
6. CBEPCO Hamaoka
7. JAPCO Tsuruga
8. KEPCO Mihama
9. KEPCO Ohi
10. KEPCO Takahama
11. CGEPCO Kashima
12. SEPCO Ikata
13. KYEPCO Genkai
14. KYEPCO Sendai (under construction)

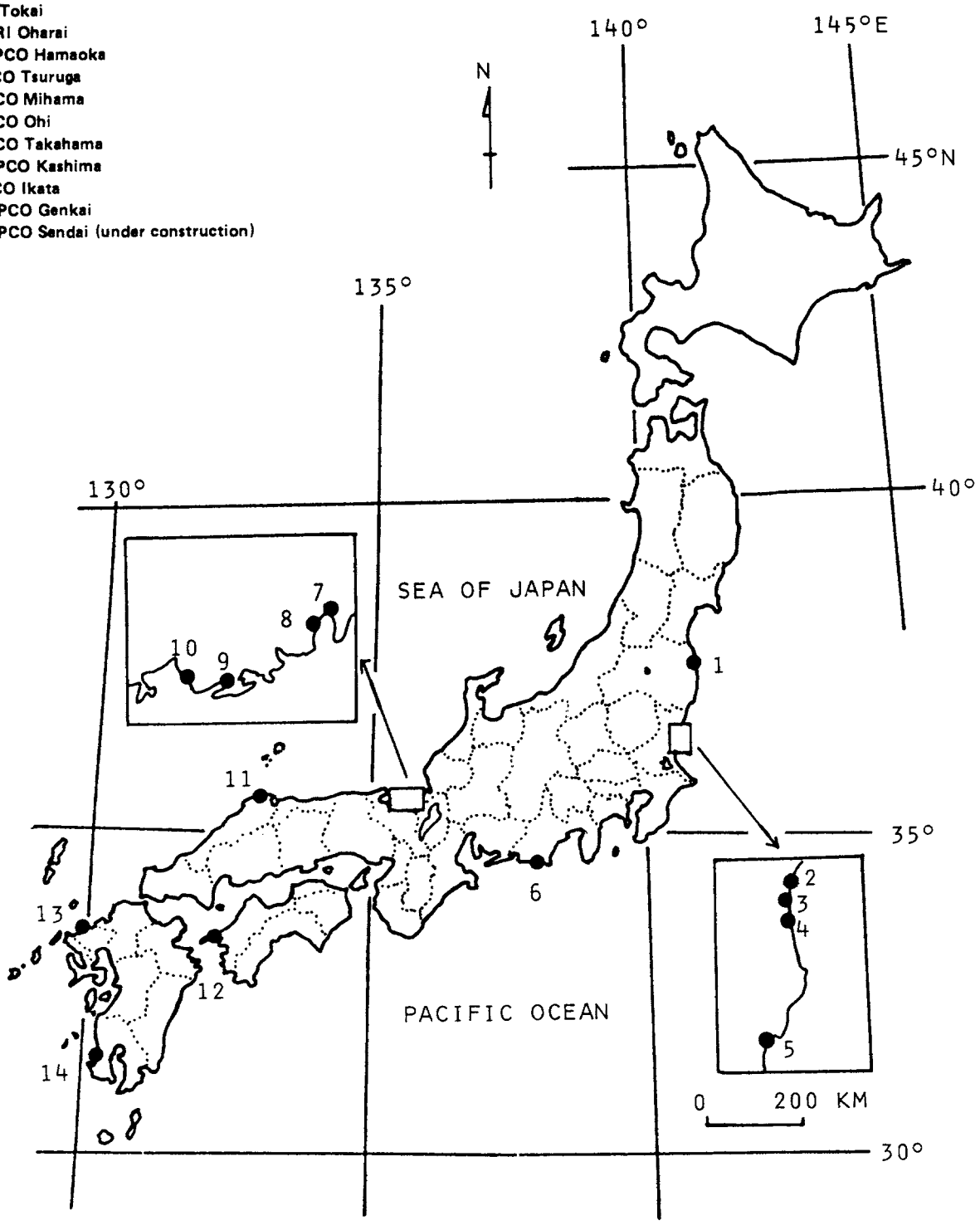


Table 1 Nuclear Power Facilities in Japan (as of Oct. 1979)

Name of Organization	Abbre-viation	Location: Town and PREFECTURE	Name of Nuclear Power Plant		Type of Reactor	Power (MWe)	Date of Beginning of Operation
Tokyo Electric Power Co.	TEPCO	Ohkuma, FUKUSHIMA	Fukushima Dai-Ichi				
				Unit-1	BWR	460	Mar. 26, 1971
				Unit-2	BWR	784	Jul. 18, 1974
				Unit-3	BWR	784	Mar. 27, 1976
				Unit-4	BWR	784	Oct. 2, 1978
				Unit-5	BWR	784	Apr. 18, 1978
				Unit-6	BWR	1,100	Oct. 24, 1979
		Tomioka, FUKUSHIMA	Fukushima Dai-Ni				
				Unit-1	BWR	1,100	(May, 1982)*1
				Unit-2	BWR	1,100	(Aug. 1983)*1
The Japan Atomic Power Co.	JAPCO	Tokai, IBARAGI	Tokai	Unit-1	GCR	166	Jul. 25, 1966
				Unit-2	BWR	1,100	Nov. 28, 1978
		Myojin, FUKUI	Tsuruga	Unit-1	BWR	357	Mar. 14, 1970
Japan Atomic Energy Research Institute	JAERI	Tokai, IBARAGI	Tokai	JRR-2	Research Reactor	*2 10	Oct. 1, 1960
				JRR-3	〃	*3 10	Sept. 12, 1962
				JRR-4	〃	*4 1	Jan. 28, 1965
				JPDR	BWR	47	Aug. 22, 1963
		Oharai IBARAGI	Oharai	JMTR	Research Reactor	*4 50	Mar. 30, 1968
Power Reactor and Nuclear Fuel Co.	PNC	Tokai, IBARAGI	Fuel Reprocessing				Sept. 22, 1977
		Oharai, IBARAGI	Oharai Engineering Center		FBR	100	Apr. 24, 1977
		Myojin, FUKUI	Tsuruga		ATR	165	Mar. 20, 1978
Chubu Electric Power Co.	CBEPCO	Hamaoka, SHIZUOKA	Hamaoka	Unit-1	BWR	540	Mar. 17, 1976
				Unit-2	BWR	840	Nov. 29, 1978
Kansai Electric Power Co.	KEPCO	Mihama, FUKUI	Mihama	Unit-1	PWR	340	Nov. 28, 1970
				Unit-2	PWR	500	Jul. 25, 1972
				Unit-3	PWR	826	Dec. 1, 1976
		Ohi, FUKUI	Ohi	Unit-1	PWR	1,175	Mar. 27, 1979
				Unit-2	PWR	1,175	Dec. 5, 1979
		Takahama, FUKUI	Takahama	Unit-1	PWR	826	Nov. 14, 1974
				Unit-2	PWR	826	Nov. 14, 1975
Chugoku Electric Power Co.	CGEPCO	Kashima, SHIMANE	Shimane	Unit-1	BWR	460	Mar. 29, 1974
Shikoku Electric Power Co.	SEPCO	Ikata, EHIME	Ikata	Unit-1	PWR	566	Sept. 30, 1977
				Unit-2	PWR	566	Mar. 1982)*1
Kyushu Electric Power Co.	KYEPCO	Genkai, SAGA	Genkai	Unit-1	PWR	559	Oct. 15, 1975
				Unit-2	PWR	559	(Mar. 1981)*1
		Sendai, KAGOSHIMA	Sendai	Unit-1	PWR	890	(Jul. 1984)*1

*1 : Under Construction
*2 : Enriched uranium–heavy water moderated reactor
*3 : Natural uranium–heavy water moderated reactor
*4 : Enriched uranium–light water moderated reactor

Figure 2 Sampling Points around TEPCO FUKUSHIMA Nuclear Power Station.

Numbers #1 ~ #6 in Figure indicate the number of reactors, respectively.

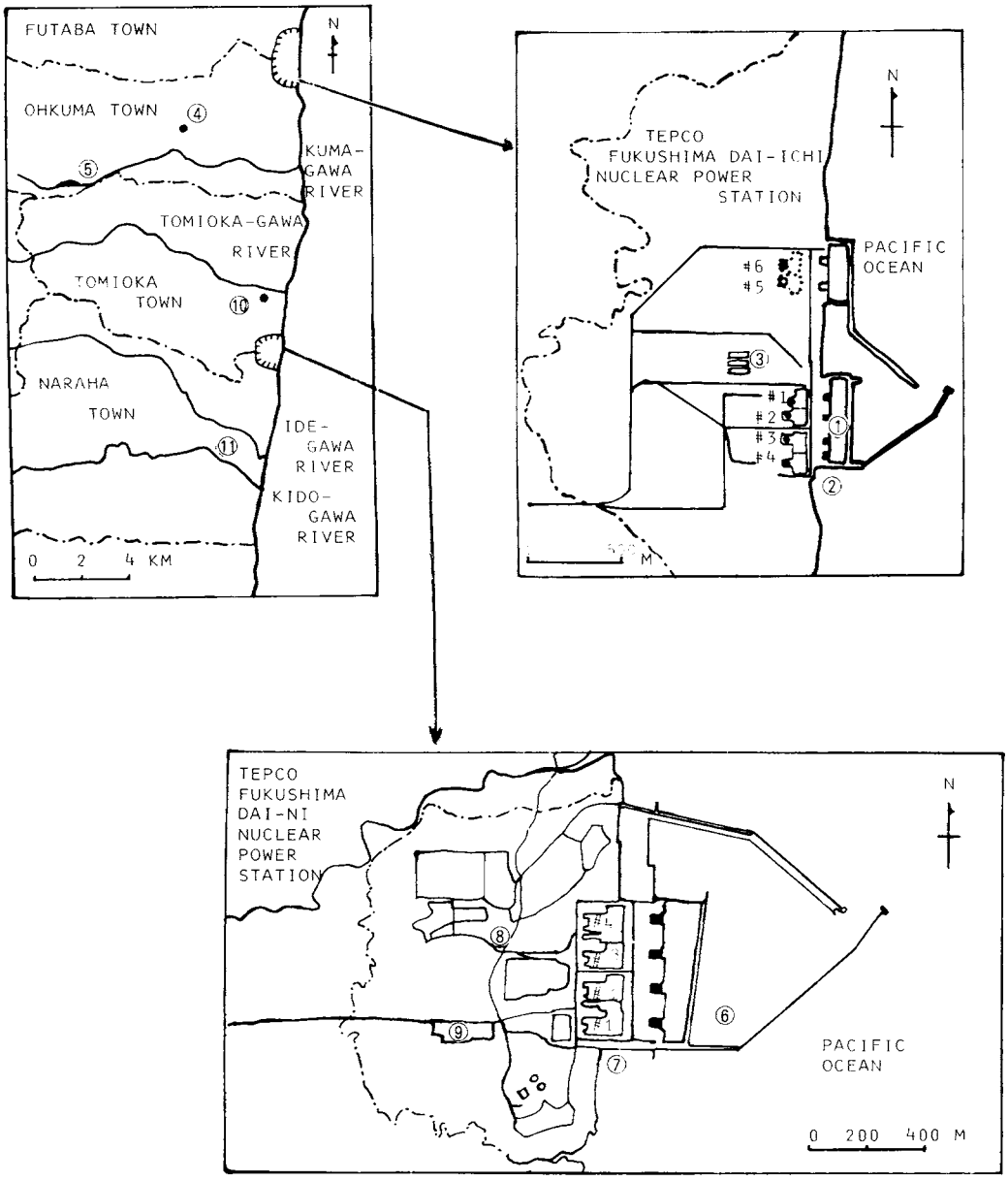


Table 2 FUKUSHIMA PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.		
			Mar. 29 1979	Oct. 18 1979	Mar. 13 1980
	TEPCO FUKUSHIMA DAI-ICHI POWER STATION				
1	Inlet of secondary cooling water	sea	11 ± 5	–	23 ± 3
2	Outlet of secondary cooling water	sea	10 ± 5	–	10 ± 3
3	Tap water of TEPCO	stream	59 ± 32	–	53 ± 4
4	Tap water at Ohokuma	stream	110 ± 25	–	91 ± 4
5	Sakashita dam	stream	76 ± 21	–	93 ± 5
	TEPCO FUKUSHIMA DAI-NI POWER STATION				
6	Inlet of secondary cooling water	sea	29 ± 3	–	35 ± 3
7	Outlet of secondary cooling water	sea	16 ± 3	–	29 ± 3
8	Well No. 1	groundwater	9 ± 5	–	12 ± 5
9	Tap water of TEPCO	groundwater + stream	0 ± 2	64 ± 6	68 ± 3
10	Tap water at Tomioka	stream	76 ± 32	–	79 ± 5
11	Kidogawa river	stream	86 ± 6	–	65 ± 4

Figure 3 Sampling Points around JAPCO, JAERI and PNC at TOKAI and OHARAI.

Nuclear Facilities at TOKAI in Figure 3.

A.	JAPCO Nuclear Power Reactors
B.	JAERI NSRR
C.	JPDR
D.	Waste Disposal Plant
E.	JRR-1
F.	JRR-2
G.	JRR-3
H.	JRR-4
I.	PNC Nuclear Fuel Reprocessing Plant

Numbers #1, #2 and #3 in Figure indicate the number of drains of JAERI, respectively.

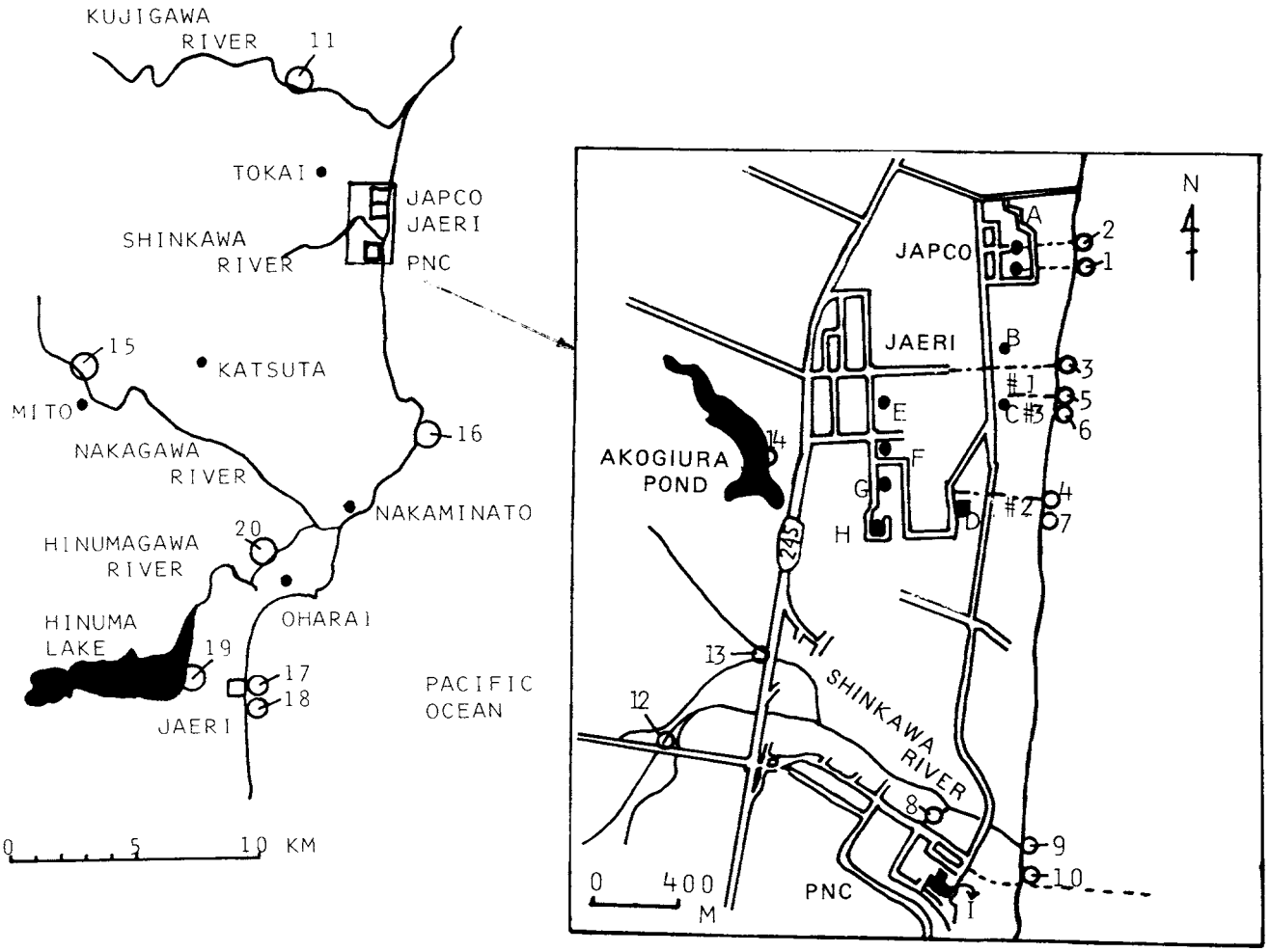


Table 3 IBARAKI PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.						
			Jul. 19 1977	Dec. 12 1977	Jul. 18 1978	Dec. 11 1978	Jul. 11 1979	Dec. 10 1979	Jul. 22 1980
	JAPCO TOKAI POWER STATION								
1	Outlet of secondary cooling water No. 1	sea	24 ± 7	31 ± 6	35 ± 5	17 ± 3	12 ± 3	26 ± 3	–
2	Outlet of secondary cooling water No. 2	sea	–	–	50 ± 4	18 ± 4	26 ± 3	26 ± 5	–
	JAERI at TOKAI								
3	Outlet of Drain No. 1		405 ± 14	251 ± 5	166 ± 22	145 ± 28	137 ± 23	123 ± 6	–
4	Outlet of Drain No. 2		1350 ± 50	108 ± 29	344 ± 27	209 ± 25	197 ± 24	271 ± 31	91 ± 16
5	Outlet of Drain No. 3		20 ± 3	43 ± 3	15 ± 3	12 ± 2	16 ± 3	21 ± 4	–
6	Seashore near the outlet of Drain No. 1	sea	44 ± 7	60 ± 4	83 ± 7	21 ± 4	23 ± 3	24 ± 4	–
7	Seashore near the outlet of Drain No. 2	sea	–	49 ± 3	32 ± 3	21 ± 3	25 ± 3	33 ± 5	–
	PNC at TOKAI								
8	1st waste channel		202 ± 8	105 ± 4	114 ± 28	105 ± 25	111 ± 23	125 ± 28	–
9	Estuary of Shinkawa river	stream/sea	162 ± 5	219 ± 7	115 ± 4	95 ± 25	137 ± 25	128 ± 5	–
10	Seashore at PNC	sea	38 ± 7	26 ± 3	32 ± 4	23 ± 4	11 ± 3	36 ± 2	36 ± 4
	TOKAI village								
11	Sakakibashi Bridge: Kujigawa river	stream	134 ± 4	159 ± 6	86 ± 5	148 ± 25	74 ± 21	113 ± 31	51 ± 17
12	Kikanba: A branch of Shinkawa river	stream	166 ± 6	136 ± 5	109 ± 4	151 ± 25	68 ± 22	115 ± 27	–
13	Miyamaebashi Bridge: Shinkawa river	stream	247 ± 7	202 ± 6	224 ± 33	113 ± 29	157 ± 25	137 ± 24	–
14	Akogiura pond	reservoir	119 ± 44	143 ± 6	81 ± 4	140 ± 25	83 ± 21	110 ± 31	64 ± 15
	MITO city and NAKAMINATO city								
15	Nakagouchi: Nakagawa river	stream	137 ± 6	198 ± 6	164 ± 32	132 ± 25	88 ± 4	99 ± 21	94 ± 17
16	Seashore at Nakaminato	sea	21 ± 7	34 ± 6	32 ± 3	26 ± 3	13 ± 3	186 ± 7	29 ± 4
	JAERI at OHARAI								
17	Outlet of dischange channel		107 ± 11	73 ± 4	157 ± 5	81 ± 5	63 ± 4	49 ± 5	–
18	Seashore near the outlet of discharge channel	sea	30 ± 7	34 ± 3	67 ± 4	31 ± 4	28 ± 4	112 ± 6	–
	OHARAI town								
19	Kitamatsugawa: Hinuma lake	stream/sea	88 ± 4	98 ± 5	90 ± 26	140 ± 35	35 ± 3	59 ± 4	–
20	Hinumabashi Bridge: Hinuma river	stream/sea	110 ± 4	44 ± 4	68 ± 5	57 ± 5	53 ± 3	145 ± 6	–

Figure 4 Sampling Points around CBEPCO HAMAOKA Nuclear Power Station.

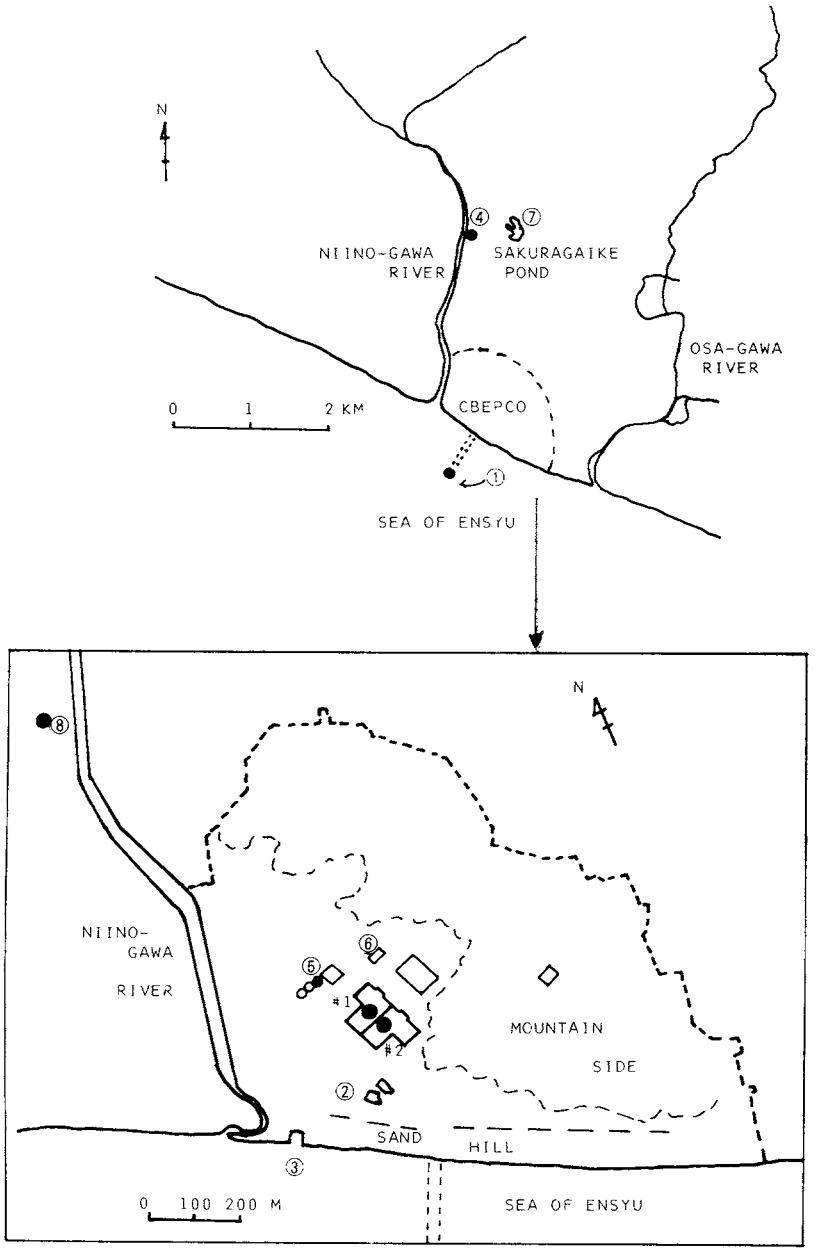


Table 4 SHIZUOKA PREFECTURE

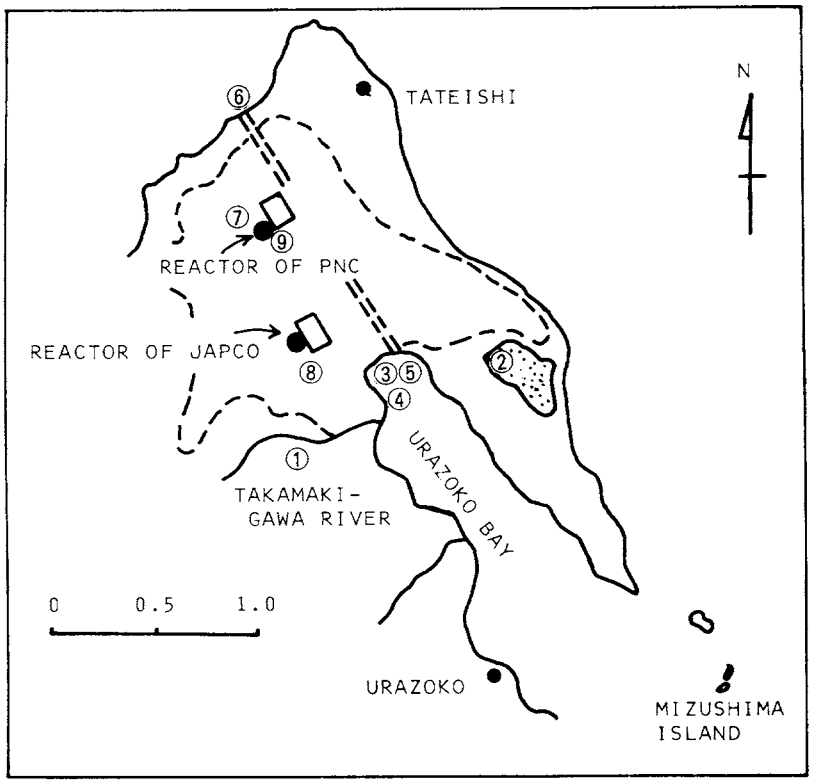
Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D. Nov. 2 1978	Nov. 14 1978
	CBEPCO HAMAOKA POWER STATION			
1	Intake tower of secondary cooling water 600 meter from sand hill	sea	15 ± 5	–
2	Intake reservoir of secondary cooling water of Reactor No. 1	sea	24 ± 4	–
3	Outlet of secondary cooling water	sea	21 ± 3	17 ± 3
4	Ni-inogawa river	stream	68 ± 30	–
5	Tank for primary cooling water of Reactor No. 1	groundwater	60 ± 3	–
6	Tap of CBEPCO	stream	40 ± 6	–
7	Sakuragaike Pond	reservoir	42 ± 5	–
8	Well of Pumping house	stream	66 ± 32	–

Table 5 FUKUI PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.		
			Oct. 3, 4 1977	Dec. 4, 5 1978	Nov. 26, 27 1979
	JAPCO and PNC TSURUGA POWER STATION				
1	Takamakigawa river	stream	75 ± 4	75 ± 25	135 ± 37
2	Inogaike pond	reservoir	57 ± 5	83 ± 23	60 ± 3
3	Inlet of JAPCO secondary cooling water	sea	48 ± 4	12 ± 6	30 ± 5
4	Outlet of JAPCO secondary cooling water	seat	18 ± 3	13 ± 7	34 ± 5
5	Inlet of PNC secondary cooling water	sea	—	26 ± 6	40 ± 7
6	Outlet of PNC secondary cooling water	sea	19 ± 4	6 ± 6	31 ± 8
7	Reservoir of drinking water of PNC	stream	—	73 ± 29	—
8	Tap of JAPCO	stream	107 ± 6	78 ± 23	90 ± 6
9	Tap of PNC	stream	75 ± 5	—	95 ± 5

Figure 5-1 Sampling Points around JAPCO and PNC TSURUGA Nuclear Power Station.

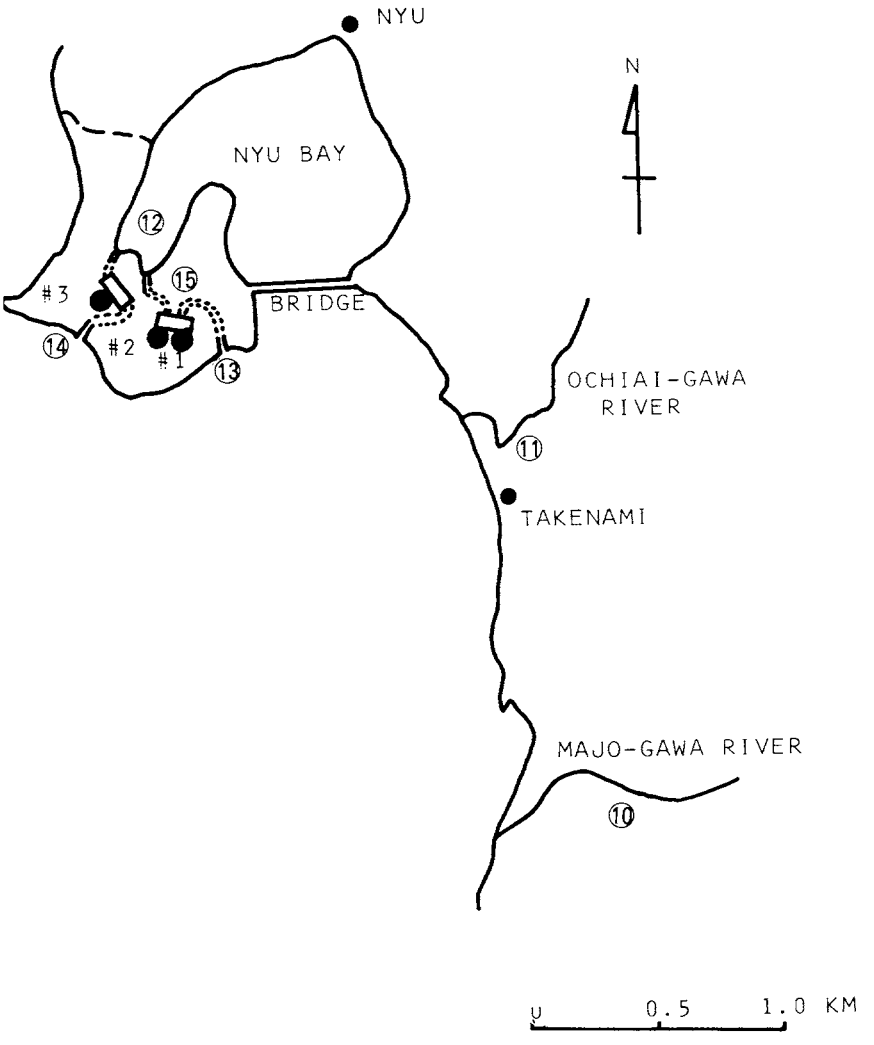
1. **Takamakigawa river.**
2. **Inogaike pond.**
3. **Inlet of secondary cooling water of JAPCO.**
4. **Outlet of secondary cooling water of JAPCO.**
5. **Inlet of secondary cooling water of PNC.**
6. **Outlet of secondary cooling water of PNC.**
7. **Reservoir of drinking water of PNC.**
8. **Tap of JAPCO.**
9. **Tap of PNC.**



Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D. Oct. 3, 4 1977	Dec. 4, 5 1978	Nov. 26, 27 1979
	KEPCO MIHAMA POWER STATION				
10	Majogawa river	stream	89 ± 4	94 ± 4	89 ± 6
11	Ochiaigawa river	stream	86 ± 3	74 ± 25	100 ± 6
12	Inlet of secondary cooling water	sea	124 ± 5	33 ± 6	63 ± 7
13	Outlet of secondary cooling water of Reactor I and II	sea	45 ± 3	16 ± 6	33 ± 7
14	Outlet of secondary cooling water of Reactor III	sea	42 ± 3	22 ± 8	29 ± 8
15	Tap of KEPCO	stream	72 ± 7	91 ± 5	78 ± 25

Figure 5-2 Sampling Points around KEPCO MIHAMA Nuclear Power Plant.

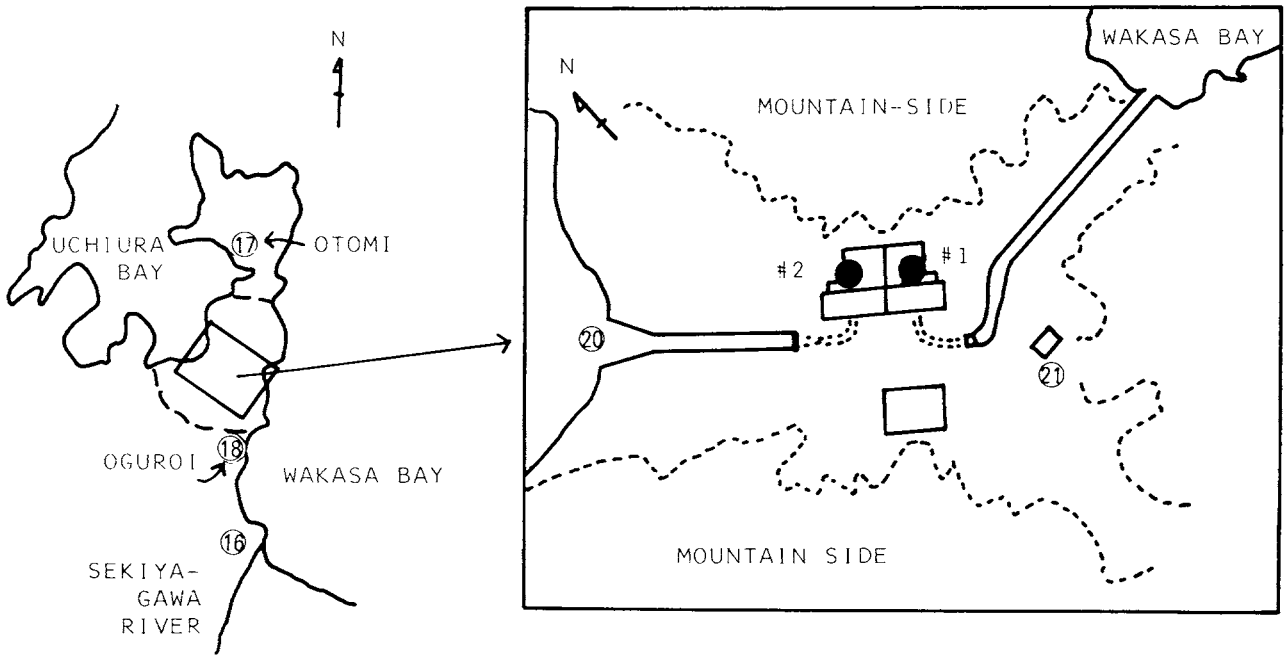
10. Majo-gawa river.
11. Ochiai-gawa river.
12. Inlet of secondary cooling water.
13. Outlet of secondary cooling water of Reactor #1 and #2.
14. Outlet of secondary cooling water of Reactor #3.
15. Tap of KEPCO.



Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.		
			Oct. 3, 4 1977	Dec. 4, 5 1978	Nov. 26, 27 1979
	KEPCO TAKAHAMA POWER STATION				
16	Sekiyagawa river	stream	81 ± 5	63 ± 23	80 ± 4
17	Tap water at Otomi	groundwater	117 ± 6	67 ± 26	69 ± 5
18	Tap water at Oguroi	groundwater	98 ± 6	75 ± 5	65 ± 21
19	Inlet of secondary cooling water	sea	29 ± 4	16 ± 6	32 ± 5
20	Outlet of secondary cooling water	sea	19 ± 3	19 ± 3	24 ± 5
21	Tap of KEPCO	stream	98 ± 6	73 ± 4	92 ± 6

Figure 5-3 Sampling Points around KEPCO TAKAHAMA Nuclear Power Plant.

16. Sekiya-gawa river.
17. Tap of Otomi.
18. Tap of Oguroi.
19. Inlet of secondary cooling water.
20. Outlet of secondary cooling water.
21. Tap of KEPCO.



Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.		
			Oct. 3, 4 1977	Dec. 4, 5 1978	Nov. 26, 27 1979
	DEPCO OHI POWER STATION				
22	Inlet of secondary cooling water	sea	24 ± 3	35 ± 3	34 ± 5
23	Outlet of secondary cooling water	sea	24 ± 3	28 ± 4	26 ± 5
24	Pool of drinking water of KEPCO	stream	174 ± 8	88 ± 24	52 ± 23
25	Tap of KEPCO	stream	49 ± 5	42 ± 5	61 ± 5

Figure 5-4 Sampling Points in the Site of KEPCO OHI Nuclear Power Plant.

22. Inlet of secondary cooling water.
23. Outlet of secondary cooling water.
24. Pool of drinking water.
25. Tap of KEPCO.

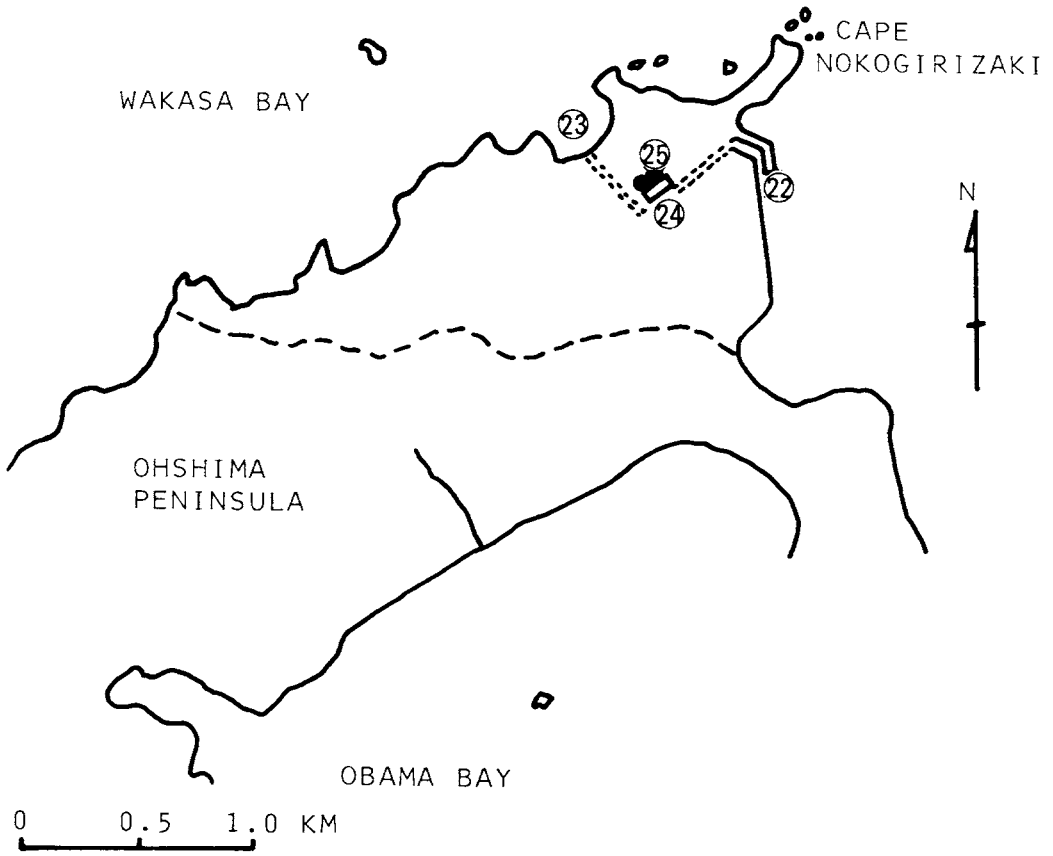


Figure 6-1 Sampling Points in Site of CGEPCO KASHIMA Power Station.

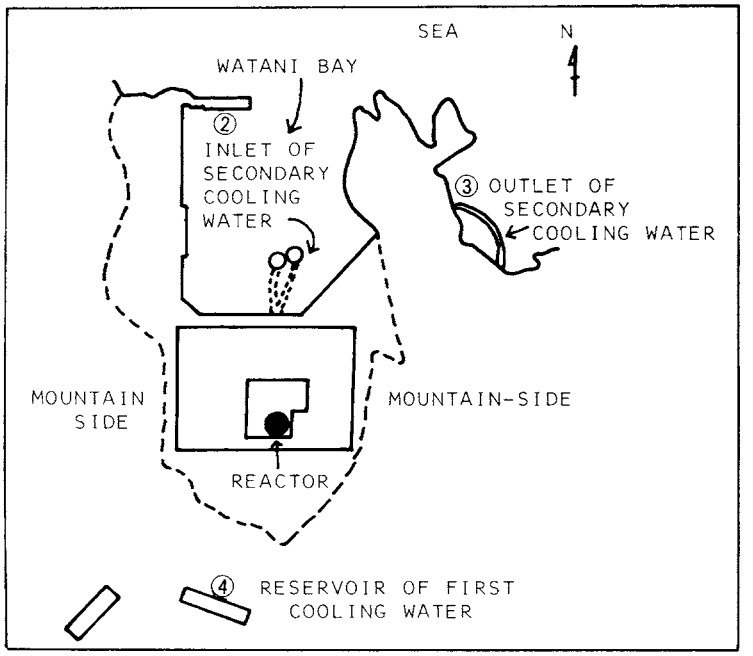


Figure 6-2 Sampling Points around CGEPCO in Shimane Prefecture.

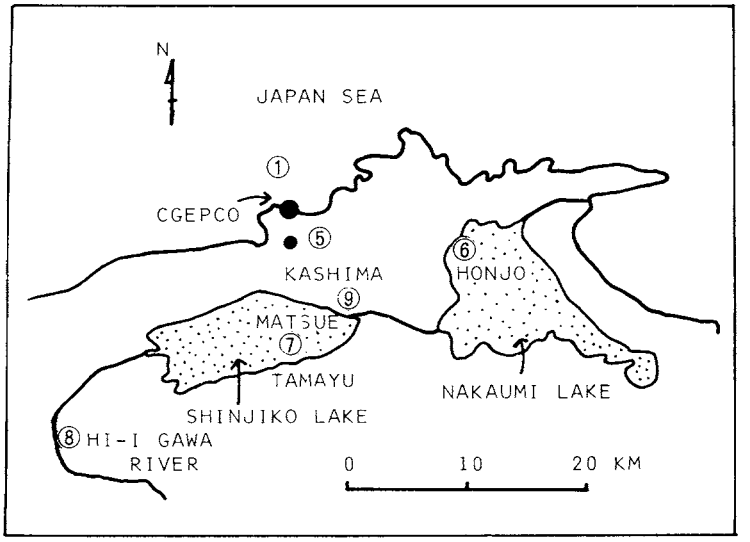


Table 6 SHIMANE PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.				
			Jan. 14, 15 Jul. 1 ~ 28 1977	Dec. 1 ~ 22 1977 or Jan. 20 1978	Jun. 1 ~ 16 1978	Dec. 1 ~ 25 1978	Jun. 4 ~ 27 1979
	CGEPCO KASHIMA POWER STATION						
1	Offshore water at CGEPCO	sea	18 ± 6	19 ± 3	5 ± 3	18 ± 4	11 ± 4
2	Inlet of secondary cooling water	sea	34 ± 4	23 ± 3	16 ± 4	23 ± 3	37 ± 5
3	Outlet of secondary cooling water	sea	27 ± 3	19 ± 3	12 ± 4	43 ± 4	38 ± 4
4	Reservoir for drinking and primary cooling	stream	114 ± 6	121 ± 5	68 ± 28	56 ± 22	95 ± 5
	Southern district of CGEPCO						
5	Public water supply of Kashima town	stream	93 ± 6	74 ± 3	87 ± 30	78 ± 23	86 ± 7
6	Nakaumi lake at Honjyo town	stream/sea	46 ± 4	67 ± 6	39 ± 4	38 ± 4	39 ± 5
7	Shinjiko lake at Tamayu town	stream/sea	93 ± 6	86 ± 5	57 ± 28	107 ± 37	61 ± 8
8	Hi-igawa river	stream	112 ± 5	109 ± 4	82 ± 28	80 ± 5	135 ± 5
9	Matsue spa	hot spring	–	2.6 ± 2.4	3.2±3.1	2.7±3.2	10.2±7.8

Table 7 EHIME PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.	
			Mar. 8 1978	Mar. 25 1980
	SEPCO IKATA POWER STATION			
1	Inlet of secondary cooling water	sea	4 ± 3	18 ± 4
2	Outlet of secondary cooling water	sea	17 ± 3	35 ± 4
3	Desalted sea water	sea	32 ± 4	27 ± 2
4	Tap of SEPCO	stream	141 ± 5	75 ± 5
5	Tap water at Ikata town	stream	74 ± 3	134 ± 7

Figure 7 Sampling Points around SEPCO IKATA Nuclear Power Station.

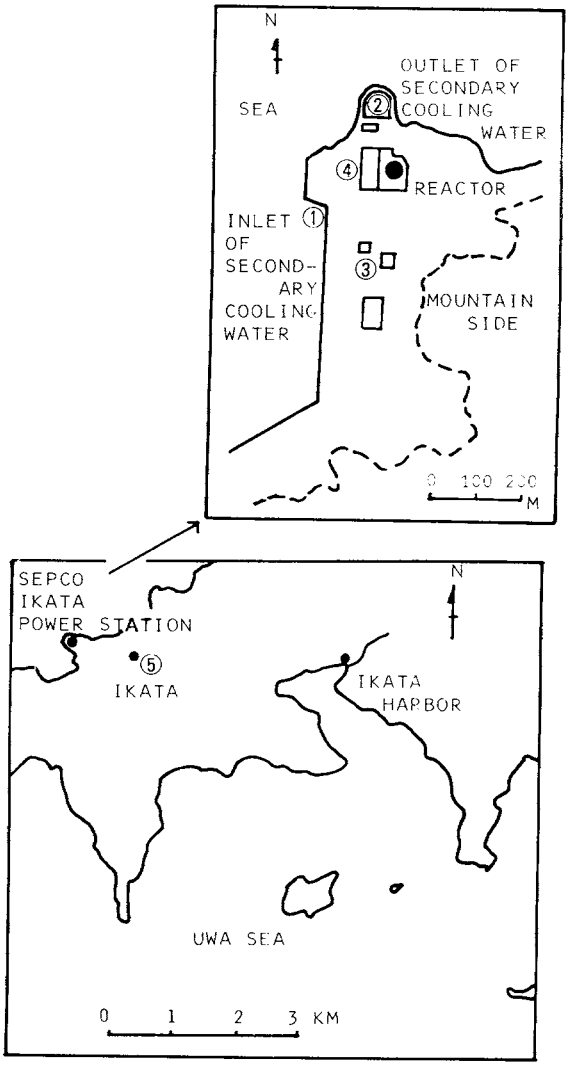


Table 8 SAGA PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D.			
			Mar. 9 1978	Mar. 29 1979	Apr. 10 1979	Mar. 26 1980
	KYEPCO GENKAI POWER STATION					
1	Inlet of secondary cooling water	sea	60 ± 5	16 ± 3	22 ±± 4	105 ± 6
2	Outlet of secondary cooling water	sea	20 ± 4	22 ± 3	12 ± 4	12 ± 3
3	Reservoir of drinking and primary cooling water (Dam of Hatsuta river)	stream	98 ± 7	–	60 ± 27	68 ± 5
4	Shimobatameike Pond	reservoir	96 ± 4	–	40 ± 6	60 ± 4
5	Tap of KYEPCO	stream	83 ± 4	104 ± 7	82 ± 32	51 ± 3
6	A branch of Shiregawa river	stream	97 ± 4	–	–	–

Figure 8 Sampling Points around KYEPCO GENKAI Nuclear Power Station.

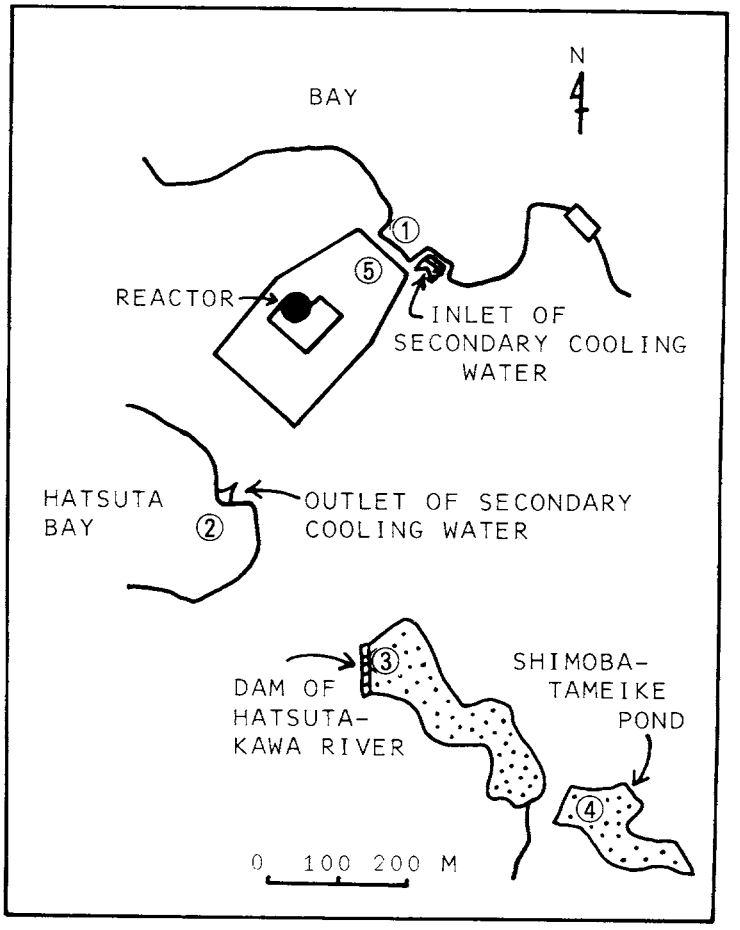


Table 9 KAGOSHIMA PREFECTURE

Sample No.	Sampling Points around the Nuclear Power Station	Water Source	Tritium Concentration, pCi/ℓ ± 2 S.D. Nov. 19 1974	Tritium Concentration, pCi/ℓ ± 2 S.D. Mar. 10 1978
	KYEPCO SENDAI POWER STATION (under construction)			
1	Seashore at Sendai	sea	–	8.9 ± 3.8
2	Tenjinbashi Bridge: Todorokigawa river	stream	94 ± 7	54 ± 5
3	Miyayamaike Pond	reservoir	103 ± 9	121 ± 5
4	Kuranoura: Sendaigawa river	stream	52 ± 10	–
5	Public water supply at Nakago: Sendai river	stream	125 ± 10	51 ± 6
6	Tap water at Yorita elementary school	groundwater	122 ± 8	111 ± 6
7	Tap water at Gumizaki branch of city office	groundwater	86 ± 8	35 ± 4
8	Tap water at Takae branch of city office	groundwater	8 ± 6	0 ± 4

Figure 9 Sampling Points around KYEPCO SENDAI Nuclear Power Station (under construction).