

Ove Arup & Partners
奧雅納工程顧問

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Level 5, Festival Walk
80 Tat Chee Avenue
Kowloon Tong, Kowloon
Hong Kong
Tel +852 2528 3031
Fax +852 2268 3950
Direct Tel +852 2268 3208
sam.tsoi@arup.com

www.arup.com

ATAL Belgoprocess Joint Venture Limited
17/F Java Commercial Centre
128 Java Road
North Point
Hong Kong

For the attention of: Mr Barry Lee

ARUP

Dear Mr Lee

Contract No. EP/SP/40/02
Low Level Radioactive Waste Storage Facility at Siu A Chau
Operation Phase EM&A Report No. 8 to 10

We refer to the EM&A 8th to 10th reports of the captioned project, and have no comment and hereby verify the reports.

Should you require any further information, please do not hesitate to contact the undersigned or Coleman Ng at 2268-3097.

Yours sincerely



Sam Tsoi
Independent Environmental Checker

ATAL-BELGOPROCESS JOINT VENTURE

Contract No. EP/SP/40/02

Low Level Radioactive Waste Storage Facility at Siu A Chau

Eighth Environmental Monitoring and Audit Report (Operation Phase)

Version 1.0

May 2006

Certified By



(Environmental Team Leader)

REMARKS:

The information supplied and contained within this report is, to the best of our knowledge, correct at the time of printing.

The Environmental Team Leader accepts no responsibility for changes made to this report by third parties.

Dr. John K.C. Leung
Department of Physics, The University of Hong Kong
Pokfulam Road, Hong Kong.
Tel: +852 2859 2858 Fax: +852 2471 8888
E-mail: jkcleung@hku.hk

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EXECUTIVE SUMMARY

After reviewing the results of first six monthly Environmental Monitoring & Audit Reports, it was decided to continue the monitoring for a further period of six months, so that data for a full year can be collected which will facilitate the study of seasonal variation in the radioactivity levels, if there were any.

This is the first report after the initial 6 monthly EM&A Reports and it presents the results of the radiological monitoring work performed between February 17, 2006 and May 10, 2006. The sampling was done on May 10, 2006.

Indeed, it is observed in this report that the radioactivity in soil sample C has returned to the baseline level which was obtained a year ago. During the winter months, its activity was substantially higher than the baseline level.

It is noted that the γ dose rates at Location L always exceed the Investigation Level. Location L is not on a flat surface and this will cause a larger error of measurement when placing the detector above the exact location. The average dose rate since the first EM&A is about 0.26 $\mu\text{Sv/h}$ compared to the baseline value of 0.22 $\mu\text{Sv/h}$. To give a more realistic picture of exceedance, the baseline value will be changed to 0.26 $\mu\text{Sv/h}$ from this report onward. The corresponding Investigation Level will be changed to 0.30.

There is a fairly large variation in the collected fish samples, in terms of the species, the size and the number. In view of these and the fact that fish is not a good bio-indicator as they do not live in Siu A Chau, the measured activities will not be compared directly with the Investigation Level to report exceedance but rather considered individually to determine whether investigation is required.

1. INTRODUCTION

Background

- 1.1 Various industrial, educational and medical facilities in Hong Kong have, for a number of years, used radioactive materials and generated radioactive waste. Most of the existing waste arisings are stored in disused air raid tunnels close to Queen Road East in Wan Chai. Other arisings are stored temporarily (although in some cases for several years) at the point of use in educational institutions or hospitals.
- 1.2 A consultancy study in 1995 concluded that Siu A Chau was a suitable location for a purpose-built storage facility to which all waste will be transported, placed in stainless steel drums and stored.
- 1.3 In July 2003 ATAL-Belgoprocess Joint Venture Limited (ABJV) was awarded a contract to design, construct, and operate the LRWF at Siu A Chau. Thereafter, the ABJV will transfer the waste management skills for this Facility to Hong Kong.
- 1.4 The LRWF was designed to have a storage vault that can initially store 260 drums of waste, each drum of 275 litres net capacity. The building will also contain facilities for waste reception and repackaging waste, and administering the process. A jetty will be built to provide marine access to the Facility.
- 1.5 The Facility is equipped with various radiation monitors inside the building specially installed for detecting all possible leakage of effluents from the building.
- 1.6 However, it is possible that minute activities may escape from detection and enter the biosphere, or an unexpected incidence would have resulted in a significant release of radionuclide from the Facility. It is one of the objectives of this environmental monitoring scheme to monitor whether in the long-term, the operation of the Facility will cause deterioration to the environment.

Purpose of the Report

- 1.7 This is the eighth EM&A (Operation Phase) report, which is also the seventh report on measurement results of environmental samples taken after the commencement of operation of the LRWF on July 28, 2005. This report covers the monitoring period from February 17 to May 10, 2006.
- 1.8 The requirements of the operation phase monitoring and audit; monitoring scheme and monitoring equipment and procedures have been fully described in the First EM&A (Operation Phase) Report. Please refer to that report for reference.
- 1.9 This report also covers the monitoring of personnel doses, the non-active areas of the Facility and the liquid and gaseous effluents.

2. MONITORING RESULTS

- 2.1 The sampling scheme remained unchanged. 15 in-situ ambient γ dose rates were measured. 3 soil samples; 3 sea sediment samples; 3 grass samples; 8 seawater samples from 4 locations at two depths; 1 kg of sea snails; a few fish and 3 airborne particulate samples were collected and analysed as in previous monitoring. **Figure 2.1** shows the locations for taking various samples.
- 2.2 Ambient γ dose rates were taken at exactly the same locations and would give a true picture of the variation of the radiation environment if there were any.
- 2.3 Soil and grass samples were collected at more or less the same place as for the baseline. Since we need fresh surface soils that would have stored information of fallout since the commencement of the operation, the sampling sites shifted a little bit every time.
- 2.4 The uncertainties of the measurement results are given as standard deviation (SD) or standard uncertainty (SU). SD is given for individual sample and is calculated according to the number of counts recorded and assuming a normal distribution for the counts. SU is reported for each group of samples and it takes into account of the variance between samples. Please refer to the First EM&A Report (Operation Phase) for details.

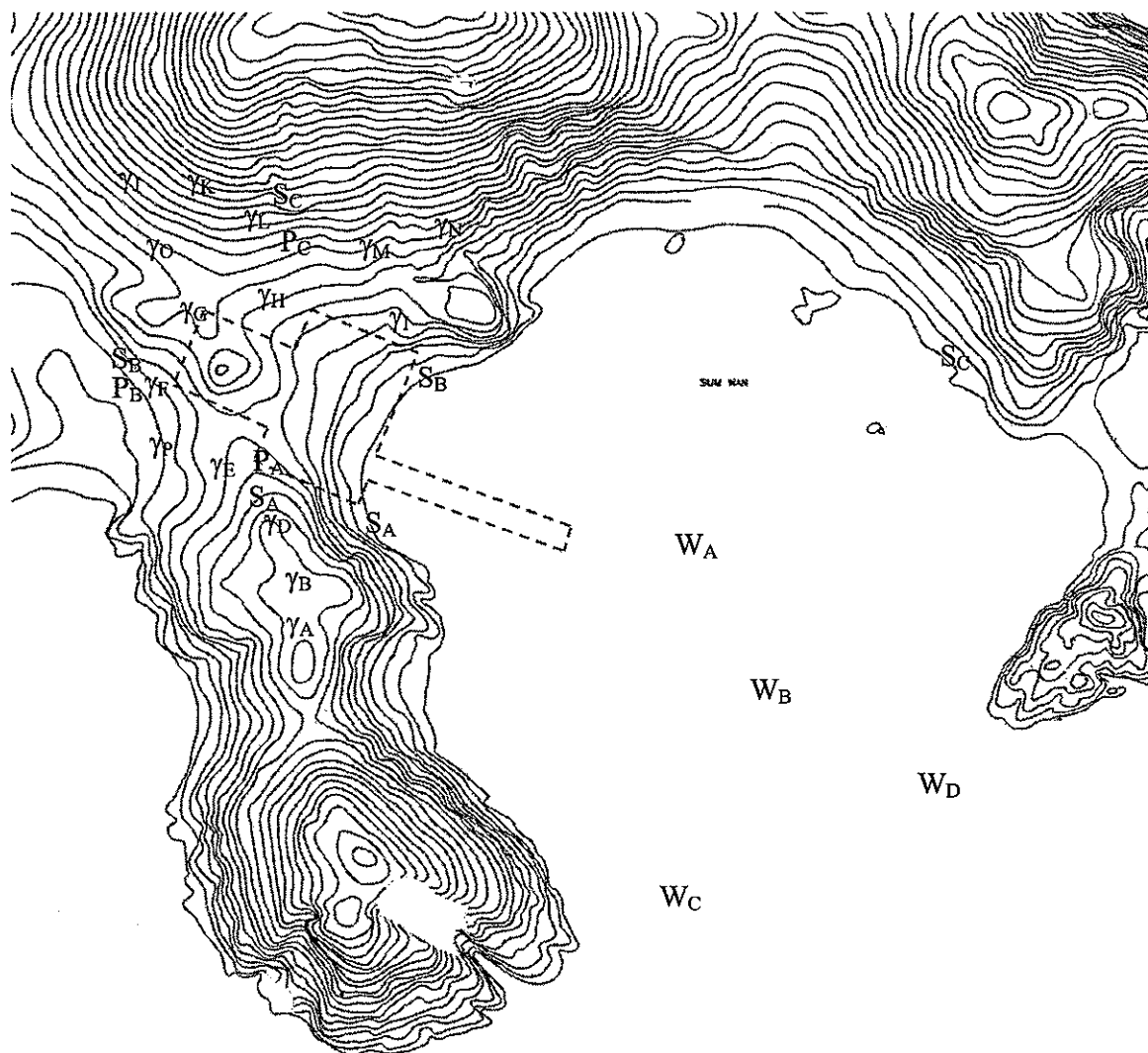


Fig. 2.1 Locations of the Sampling Sites

(γ: Ambient gamma dose rate; S: Soil or Sand; W: Water; P: Air particulates)
(Grass sampling sites are the same as soil sampling sites)

Ambient γ Dose Rates

- 2.5 The measurement results are given in Table 2.1(a). Table 2.1(b) also shows the results of the previous measurements for comparison. The header ? ? means the result of this monitoring. It is noted that the overall average value has not changed during the monitoring period.

Table 2.1(a) Ambient γ Dose Rates at 1 m above Ground

Location	γ Dose Rate ($\mu\text{Sv h}^{-1}$)							
	1 (Baseline) ± 1 SD	2	3	4	5	6	7	8 ± 1 SD
Boat	0.07 ± 0.006	--	--	0.06	0.06	0.06	0.08	0.06 ± 0.005
A	0.21 ± 0.010	0.21	0.24	0.21	0.22	0.23	0.22	0.21 ± 0.011
B	0.22 ± 0.012	0.24	0.25	0.26	0.21	0.24	0.26	0.23 ± 0.012
C	0.28 ± 0.014	0.26	--	--	--	--	--	--
D	0.23 ± 0.012	0.29	0.25	0.26	0.26	0.25	0.27	0.26 ± 0.013
E	0.25 ± 0.013	0.22	0.26	0.24	0.26	0.23	0.25	0.21 ± 0.011
F	0.24 ± 0.012	0.26	0.25	0.25	0.28	0.26	0.28	0.27 ± 0.013
G	0.23 ± 0.012	0.28	0.24	0.26	0.27	0.26	0.27	0.25 ± 0.013
H	0.27 ± 0.013	0.29	0.28	0.30	0.30	0.29	0.29	0.30 ± 0.014
I	0.28 ± 0.013	--	--	--	--	--	--	--
New I	--	--	0.26	0.29	0.31	0.28	0.30	0.28 ± 0.013
J	0.21 ± 0.011	0.23	0.20	0.23	0.24	0.23	0.23	0.26 ± 0.013
K	0.28 ± 0.013	0.27	0.26	0.24	0.26	0.26	0.29	0.29 ± 0.014
L	0.22 ± 0.011	0.28	0.27	0.22	0.28	0.26	0.26	0.25 ± 0.013
M	0.27 ± 0.013	0.29	0.28	0.30	0.26	0.28	0.26	0.29 ± 0.014
N	0.25 ± 0.013	0.27	0.25	0.25	0.27	0.23	0.26	0.24 ± 0.012
O	--	--	0.21	0.21	0.24	0.20	0.24	0.20 ± 0.011
P	--	--	0.25	0.24	0.25	0.24	0.27	0.26 ± 0.013

-- Not measured

- 2.6 Exceedance of the Investigation Level was observed in Location J.

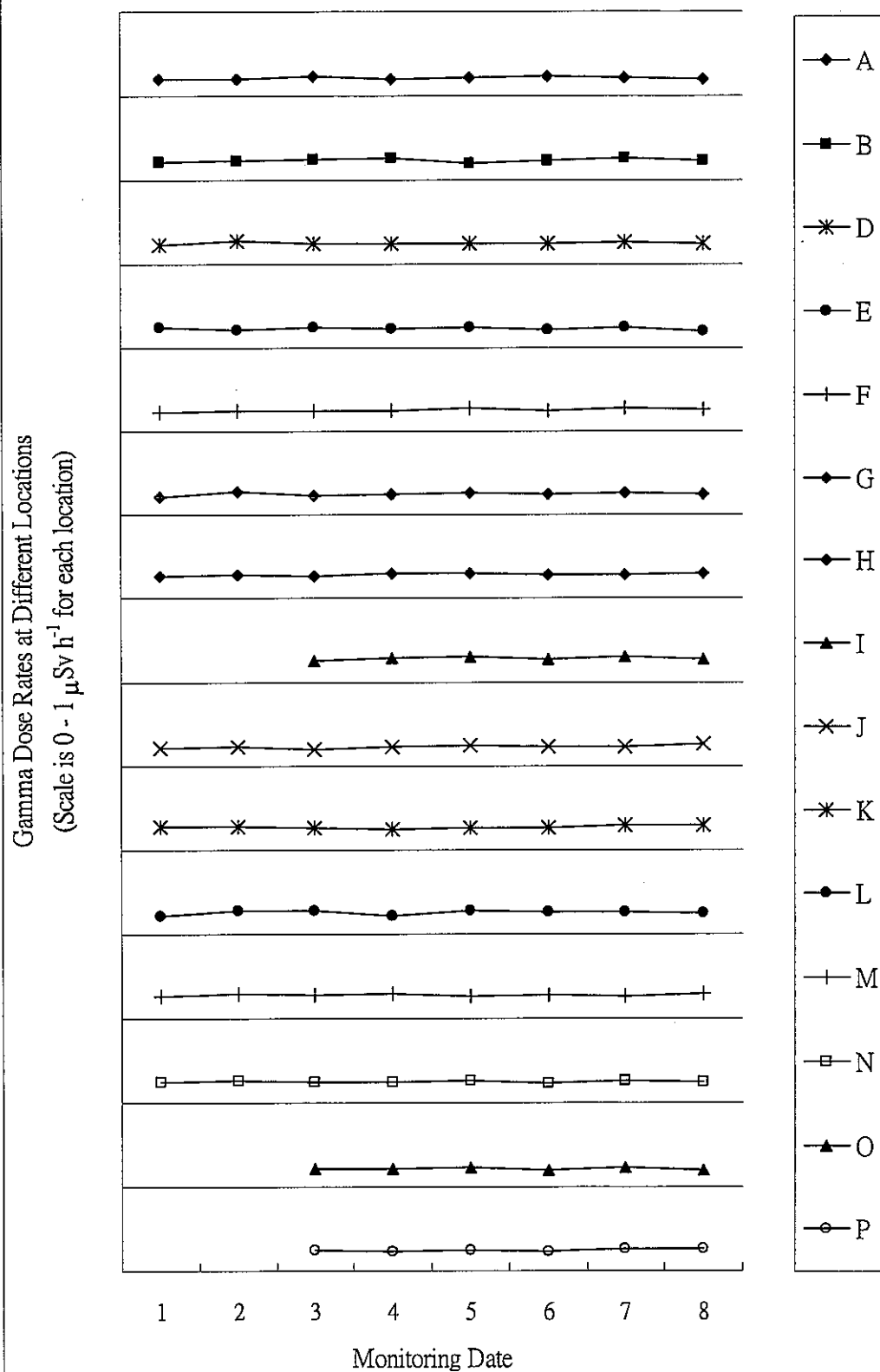
Table 2.1(b) Comparison of Ambient γ Dose Rates with Previous Results

EM&A Report No.	Mean γ Dose Rate ($\mu\text{Sv h}^{-1}$)	SU
1 (Baseline)	0.24	0.03
2	0.26	0.03
3	0.25	0.02
4	0.25	0.03
5	0.26	0.03
6	0.25	0.02
7	0.26	0.02
8	0.25	0.03

2.7 **Figure 2.2** shows the change in ambient γ dose rate with time at the various monitoring locations.

2.8 The overall ambient γ dose-rate remained unchanged.

Fig. 2.2 Variations in Ambient Gamma Dose Rates with Time



Soil

- 2.9 Soil samples were collected at 3 locations only, all from the undisturbed areas. These locations correspond to the passive air sampler locations which aim to detect dispersion of effluent leakages, if any, in the prevailing wind directions. The measurement results are given in Table 2.2(a) & (b).

Table 2.2(a) Activity Concentration of Some Major Radionuclides in Soil Samples

Location	Collection Date	Activity Concentration (Bq kg ⁻¹)							
		²²⁶ Ra	SD	²²⁸ Th	SD	⁴⁰ K	SD	¹³⁷ Cs	SD
A	10 May 06	57.0	0.5	85.2	0.7	708	5.1	0.29	0.07
B	10 May 06	66.4	0.5	112	0.8	457	4.4	*	*
C	10 May 06	32.4	0.4	87.7	0.7	182	3.0	0.29	0.07

* Not detected

Table 2.2(b) Comparison of Activities in Soil Samples with Previous Results

EM&A Report No.	Mean Activity Concentration (Bq kg ⁻¹)							
	²²⁶ Ra	SU	²²⁸ Th	SU	⁴⁰ K	SU	¹³⁷ Cs	SU
1 (Baseline)	50.0	13.9	80.2	16.1	606	297	0.25	0.37
2	41.7	17.0	63.7	20.5	387	219	*	*
3	41.8	15.4	75.6	20.1	423	237	*	*
4	45.3	7.1	104.5	11.4	574	319	0.25	0.43
5	57.8	17.7	95.8	4.2	535	294	0.41	0.42
6	59.9	19.0	103.9	14.3	479	277	0.25	0.23
7	60.8	22.4	102.9	16.2	464	258	0.36	0.33
8	51.9	17.6	95.0	14.8	449	263	0.19	0.17

* Not detected

- 2.10 No exceedance of Investigation Level is observed.

Sand

2.11 The measurement results are shown in Table 2.3(a) & (b).

Table 2.3(a) Activity Concentration of Some Major Radionuclides in Sand Samples

Location	Collection Date	Activity Concentration (Bq kg ⁻¹)					
		²²⁶ Ra	SD	²²⁸ Th	SD	⁴⁰ K	SD
A	10 May 06	20.3	0.3	17.2	0.4	277	3.4
B	10 May 06	11.2	0.3	10.7	0.3	216	3.1
C	10 May 06	14.7	0.3	18.4	0.4	246	3.2

Table 2.3(b) Comparison of Activities in Sand Samples with Previous Results

EM&A Report No.	Mean Activity Concentration (Bq kg ⁻¹)					
	²²⁶ Ra	SU	²²⁸ Th	SU	⁴⁰ K	SU
1 (Baseline)	18.8	4.4	21.6	5.5	576	106
2	11.1	3.8	12.8	5.0	357	100
3	11.4	3.2	13.2	4.4	382	141
4	28.3	22.8	24.5	17.4	360	165
5	23.3	12.7	25.6	17.9	323	117
6	20.8	8.0	25.8	18.0	329	95.7
7	30.2	24.8	24.3	17.0	320	173
8	15.4	4.6	15.4	4.1	246	30.5

2.12 No exceedance of Investigation Level is observed.

Grass

- 2.13 Grass samples were collected in locations near to the soil samples. The measurement results are given in Table 2.4(a) & (b). The γ -spectra are identical to the background of the γ spectrometer and do not reveal the presence of any significant γ -emitting radionuclides, hence they are not reported here.

Table 2.4(a) Activity Concentration of Gross α and β Emitters in Grass Samples

Location	Collection Date	α Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)	β Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)
A	10 May 06	0.060	0.004	0.273	0.005
B	10 May 06	0.025	0.003	0.237	0.005
C	10 May 06	0.118	0.005	0.334	0.005

* Bq g⁻¹ refers to dry mass of grass

Table 2.4(b) Comparison of α/β Activities in Grass with Previous Results

EM&A Report No.	Mean α Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)	Mean β Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)
1 (Baseline)	0.083	0.044	0.33	0.033
2	0.037	0.012	0.25	0.014
3	0.081	0.017	0.30	0.098
4	0.093	0.009	0.26	0.034
5	0.084	0.020	0.23	0.036
6	0.081	0.056	0.22	0.091
7	0.077	0.046	0.25	0.079
8	0.068	0.047	0.28	0.049

- 2.14 All activities are within the normal fluctuation of the baseline values.

Sea Water

- 2.15 The same 4 locations were chosen to collect the water samples at 2 depths. The measurement results are given in Table 2.5(a) & (b).
- 2.16 Similar to grass samples, the γ spectra are not reported. There is no sign of presence of γ emitters.
- 2.17 All activities are comparable to the baseline levels and no exceedance of Investigation Level is observed.

Table 2-5(a) Activity Concentration of Gross α/β Emitters in Sea Water Samples

Location	Total Depth(m)	Collection Date	Water Level	α Activity (Bq L ⁻¹)	SD (Bq L ⁻¹)	β Activity (Bq L ⁻¹)	SD (Bq L ⁻¹)
A	6.6	10 May 06	Surface	#0.00	0.00	4.34	0.20
			Bottom	#0.00	0.00	6.02	0.23
B	7.7	10 May 06	Surface	#0.00	0.00	4.56	0.21
			Bottom	#0.00	0.00	6.95	0.24
C	8.9	10 May 06	Surface	#0.43	0.24	5.52	0.23
			Bottom	#0.13	0.13	7.43	0.25
D	11.5	10 May 06	Surface	#0.43	0.23	4.40	0.21
			Bottom	#0.52	0.24	7.48	0.25

These activities are below the minimum detectable activity of 0.77 Bq L⁻¹.

Table 2.5(b) Comparison of α/β Activities in Sea Water with Previous Results

EM&A Report No.	Mean α Activity (Bq L ⁻¹)	SU (Bq L ⁻¹)	Mean β Activity (Bq L ⁻¹)	SU (Bq L ⁻¹)
1 (Baseline)	0.77	0.25	7.20	0.70
2	0.49	0.47	6.10	0.46
3	0.57	0.21	7.43	0.80
4	0.71	0.50	7.00	0.81
5	0.92	0.44	6.15	0.64
6	0.63	0.28	6.99	0.37
7	0.25	0.28	6.30	0.45
8	0.19	0.23	5.84	1.34

Marine Organisms

- 2.18 Fishes were caught along the jetty and sea snails were collected randomly along the shores.
- 2.19 The measurement results are given in Table 2.6(a) & (b) and Table 2.7(a) & (b) for the gross α/β activities in fish and sea snails respectively.

Table 2.6(a) Activity Concentration of Gross α/β Emitters in Fish Samples

Sample	Collection Date	α Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)	β Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)
1	10 May 06	0.004	0.001	0.069	0.002
2	10 May 06	0.006	0.001	0.073	0.002
3	10 May 06	0.001	0.001	0.081	0.002

* Bq g⁻¹ refers to wet mass of fish flesh.

Table 2.6(b) Comparison of α/β Activities in Fish Samples with Previous Results

EM&A Report No.	Mean α Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)	Mean β Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)
1 (Baseline)	0.0093	0.004	0.068	0.003
2	0.0068	0.004	0.16	0.15
3	0.0116	0.005	0.026	0.006
4	0.0066	0.004	0.065	0.005
5	0.0040	0.004	0.056	0.010
6	0.0069	0.002	0.063	0.002
7	0.0120	0.021	0.047	0.035
8	0.0037	0.002	0.074	0.006

- 2.20 Activities in all fish samples are considered as normal even though the β activity in fish sample 3 is slightly higher than the Investigation Level.

Table 2.7(a) Activity Concentration of Gross α/β Emitters in Sea Snail Samples

Sample	Collection Date	α Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)	β Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)
1	10 May 06	0.005	0.001	0.043	0.002
2	10 May 06	0.006	0.002	0.036	0.002
3	10 May 06	0.006	0.001	0.006	0.002

* Bq g⁻¹ refers to wet mass of sea snail flesh.

Table 2.7(b) Comparison of α/β Activities in Sea Snails with Previous Results

EM&A Report No.	Mean α Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)	Mean β Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)
1 (Baseline)	0.029	0.006	0.064	0.004
2	0.010	0.008	0.034	0.007
3	0.009	0.002	0.032	0.002
4	0.032	0.011	0.050	0.002
5	0.004	0.005	0.045	0.007
6	0.007	0.005	0.042	0.006
7	0.014	0.006	0.063	0.008
8	0.005	0.001	0.040	0.004

2.21 All activities are comparable to the baseline levels.

Airborne Particulates

2.22 The sampling period was from February 17, 2006 to May 10, 2006, about 3 months.

2.23 Measurement results are given in Table 2.8(a) & (b).

Table 2.8(a) Net Gross α/β Counts in Airborne Particulate Samples

Location	α Count-rate (cpm)	SD	β Count-rate (cpm)	SD
Blank	0.45	0.09	3.12	0.23
A1	0.87	0.17	4.25	0.45
A2	0.80	0.17	5.48	0.46
B1	0.35	0.14	2.10	0.39
B2	0.13	0.13	1.17	0.36
C1	0.12	0.12	1.35	0.37
C2	0.05	0.05	2.33	0.38

Table 2.8(b) Comparison of α/β in Airborne Particulate Samples with Previous Results

EM&A Report No.	A		B		C	
	α (cpm)	β (cpm)	α (cpm)	β (cpm)	α (cpm)	β (cpm)
1 (Baseline)	0.00	0.00	0.00	0.00	0.00	1.17
2	0.09	1.38	0.00	0.39	0.00	0.00
3	0.04	0.45	0.00	1.18	0.13	0.86
4	0.12	1.75	0.65	2.18	0.00	0.28
5	0.35	0.94	0.24	0.66	0.07	0.83
6	0.18	0.33	0.00	0.02	0.00	0.00
7	0.16	0.75	0.16	0.09	0.20	0.00
8	0.84	4.87	0.24	1.64	0.09	1.84

2.24 A small amount α and β were detected, but they were all below the background activity of the cloth itself.

3. REPORT ON ELEVATED ENVIRONMENTAL RADIATION BACKGROUND

- 3.1 The Investigation Levels for environmental samples have been established and they are given in Appendix 1. The relevant action plan is given in the First EM&A Report (Operation Phase).
- 3.2 There was a slight exceedance of the Investigation Level for the ambient γ dose-rate at Location J. Nearby locations, namely G, K and O did not show an increase in dose-rate, hence this exceedance was not attributable to deposition of γ -emitters originated from the Facility. The reason for this exceedance is not known.
- 3.3 The radioactivities in sand samples C collected since November 2005 have exceeded the Investigation Level. This was suspected to be due to change in prevailing wind direction which caused soil samples to deposit along the shore. The sand samples collected in this exercise showed that the sand radioactivities have returned to the baseline level which was measured a year ago.

4. REPORT ON NON-COMPLIANCE

- 4.1 The Action Level and Limit Level (A/L Levels) for non-compliance have been established and they are given in Appendix 1 for easy reference. The relevant Event and Action Plan have been developed. Please refer to the First EM&A Report (Operation Phase) for details.

Dose for Radiation Workers

- 4.2 There was no record of exceeding the A/L Levels as recorded by TLDs.

Dose Rates at Un-controlled Areas

- 4.3 No exceedance of the A/L Levels was observed.

Liquid Effluent Discharge

- 4.4 There was no liquid effluent discharged during the monitoring period.

Airborne Effluent Discharge

- 4.5 The total radon released during the monitoring period was estimated to be on average 6.7×10^8 Bq/month, which is below the A/L Levels.
- 4.6 The discharged α and β activities were also below the A/L Levels.
- 4.7 The total airborne effluent discharge was below the A/L Levels.

5. RESULT OF ENVIRONMENTAL COMPLIANCE AUDITS

- 5.1 The radon emission is under control though the high radon leakage from some of the waste drums has not yet been rectified. A plan has been devised to do a survey of radon leakage of the drums by covering each suspected leaking drum with a special container and then measure the radon emission rate from the drum. Confirmed leaking drums will be reprocessed.
- 5.2 A compliance audit was conducted on May 10, 2006 and no non-compliance was noted.
- 5.3 No complaint was received during the period.

APPENDIX 1**Limit Level and Action Level**

The Limit Levels for non-compliance with the Environmental Performance Requirements during the Operation are shown in **Table A1-1**.

Table A1-1 Limit Levels for Non-compliance and Action Levels

Environmental Performance Requirements	Limit Levels	Action Levels (3/10th of Limit Levels)
Dose for radiation workers	1.67 mSv per month	0.5 mSv per month
Dose rate at un-controlled areas	1 μ Sv per hour	0.3 μ Sv per hour
Liquid effluent discharge	10 ALI per month	3 ALI per month
Airborne effluent discharge	10 ALI per month	3 ALI per month

Investigation Level

With the help of all the internal monitoring, it is unlikely that the effluents will cause any observable increase in the radiation levels in the vicinity of the Facility under normal operation. It is also not anticipated that any significant quantity of the radioactive wastes would be released to the environment under even the most severe natural disasters. Nevertheless when the environmental samples are found to have radioactivities higher than the normal fluctuation of the established baseline levels, some investigation has to be initiated. The levels that trigger the investigation are called investigation levels and they are given in **Table A1.2**.

Table A1.2 Investigation Levels for Environmental Samples

Environmental Samples		Investigation Levels	
Ambient γ dose rate (μ Sv h ⁻¹)	A	0.23	3 \times SD of individual baseline dose rate
	B	0.25	
	D	0.27	
	E	0.29	
	F	0.28	
	G	0.27	
	H	0.31	
	I	0.32	
	J	0.24	
	K	0.32	

	L	0.30	
	M	0.31	
	N	0.29	
	O	0.24	
	P	0.29	
Soil (Bq kg ⁻¹)	²²⁶ Ra	91.7	3 × SU of baseline samples
	²²⁸ Th	128.5	
	⁴⁰ K	1497	
	¹³⁷ Cs	1.36	
	Other γ emitters		Occurrence in any quantities
Sand (Bq kg ⁻¹)	²²⁶ Ra	32.0	3 × SU of baseline samples
	²²⁸ Th	38.1	
	⁴⁰ K	894	
	Other γ emitters		Occurrence in any quantities
Grass (Bq g ⁻¹)	Gross α	0.22	3 × SU of baseline samples
	Gross β	0.43	
	γ emitters not found in baseline		Occurrence in any quantities
Sea water (Bq L ⁻¹)	Gross α	1.52	3 × SU of baseline samples
	Gross β	9.3	
	γ emitters not found in baseline		Occurrence in any quantities
Fish (Bq g ⁻¹)	Gross α	0.021	3 × SU of baseline samples
	Gross β	0.076	
Sea snails (Bq g ⁻¹)	Gross α	0.048	3 × SU of baseline samples
	Gross β	0.076	
Airborne particulates (cpm)	Gross α		Occurrence in any quantities
	Gross β		

- SD is the standard deviation of a single sample.

- SU is standard uncertainty of the sample group.