

ATAL-BELGOPROCESS JOINT VENTURE

Contract No. EP/SP/40/02

Low Level Radioactive Waste Storage Facility at Siu A Chau

**Second Environmental Monitoring and Audit Report
(Operation Phase)**

Version 1.1

October 2005

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.

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EXECUTIVE SUMMARY

This report presents the results of the radiological monitoring work performed between August 2005 and September 14, 2005. The sampling was done on September 14, 2005.

The newly reformed land was still covered with nets for growing grass; hence no soil samples or grass samples were taken from those areas.

The beaches on both sides of the jetty are gradually forming. Sediment samples will be collected on those places in the future.

Some samples do show signs of increased activity over the baseline level, but the increase is very small. This could be a result of increase in airborne effluent release from the Facility or just normal fluctuation. A few more sampling times are required to determine whether the radiological levels have been changed.

No non-compliance with the environmental performance requirement was observed, though the airborne effluent discharge has exceeded the action level.

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's 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 second EM&A (Operation Phase) report, which is also the first 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 commencement of operation (August 2005) up to September 14, 2005.
- 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 un-controlled areas of the Facility and the liquid and gaseous effluents.

2. MONITORING RESULTS

- 2.1 The sampling scheme for this and subsequent monitorings is less extensive than the baseline measurement except the measurement of ambient γ dose rates. Ambient γ dose rates will be taken at exactly the same locations every time and therefore they would give a true picture of the variation of the radiation environment if there were any.
- 2.2 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 will not be the same every time.
- 2.3 In this survey, 14 in-situ ambient γ dose rates were measured. 3 soil samples; 3 sand samples; 3 grass samples; 8 seawater samples from 4 locations at two depths; 3 fish; 1 kg of sea snails and 3 airborne particulate samples were collected and analysed.
- 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.

Ambient γ Dose Rates

- 2.5 The ambient γ dose rates at the same locations as the baseline monitoring were measured. The sampling locations and measurement results are given in **Figure 2.1** and **Table 2.1(a) & (b)** respectively.

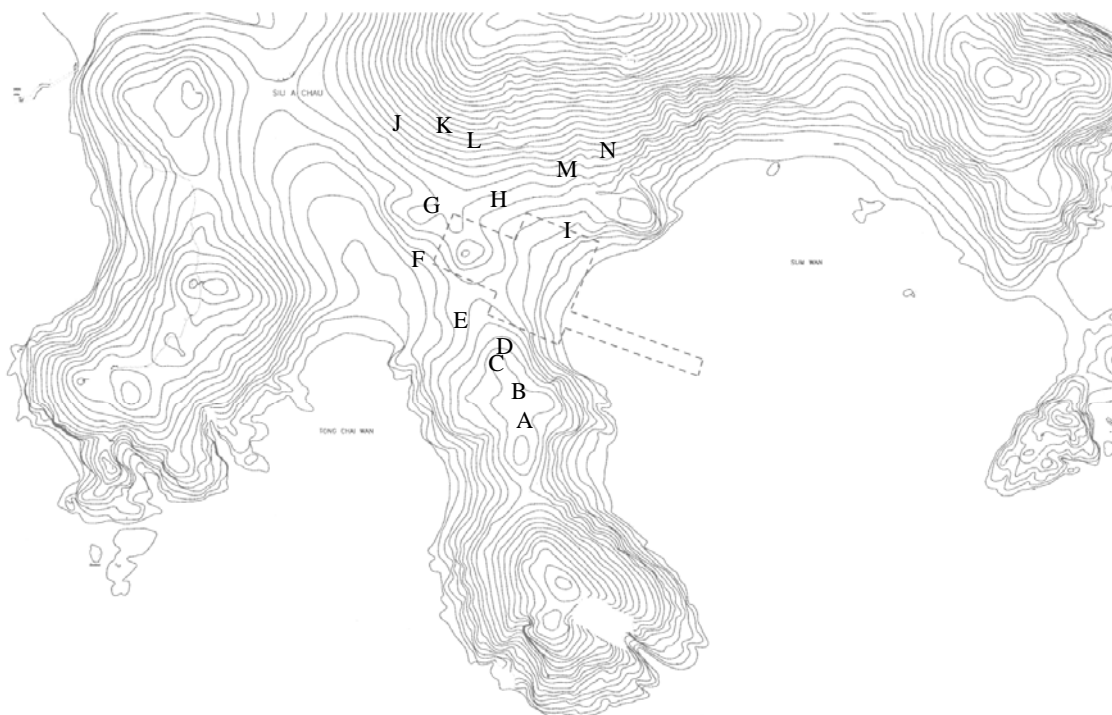


Figure 2.1 Locations for Measuring Ambient γ Dose Rate

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

Location	γ Dose Rate ($\mu\text{Sv h}^{-1}$)	
	1 (Baseline) \pm 1 SD	2 \pm 1 SD
On the boat	0.07 ± 0.006	--
A	0.17 ± 0.010	0.21 ± 0.015
B	0.22 ± 0.012	0.24 ± 0.016
C	0.28 ± 0.014	0.26 ± 0.016
D	0.23 ± 0.012	0.29 ± 0.017
E	0.25 ± 0.013	0.22 ± 0.015
F	0.24 ± 0.012	0.26 ± 0.016
G	0.23 ± 0.012	0.28 ± 0.017
H	0.27 ± 0.013	0.29 ± 0.017
I	0.28 ± 0.013	--
J	0.21 ± 0.011	0.23 ± 0.015
K	0.28 ± 0.013	0.27 ± 0.017
L	0.22 ± 0.011	0.28 ± 0.017
M	0.27 ± 0.013	0.29 ± 0.017
N	0.25 ± 0.013	0.27 ± 0.014

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	0.25	0.03

- 2.6 Table 2.1(a) & (b) also show the results of the baseline measurement for comparison. The header “2” means this second monitoring result. It is noted that the average value has increased slightly but is still well within the range of standard uncertainty.
- 2.7 It is worthwhile to mention that it is the trend at each location that matters, not the overall mean value.
- 2.8 γ dose-rate on the boat was not measured. It need not be measured every time, since the seasonal variation of cosmic ray flux is small. Location I was not measured and will not be measured in the future because it is now located at the fence on a steep slope.

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 sampling locations and measurement results are given in **Figure 2.2** and **Table 2.2(a) & (b)** respectively.

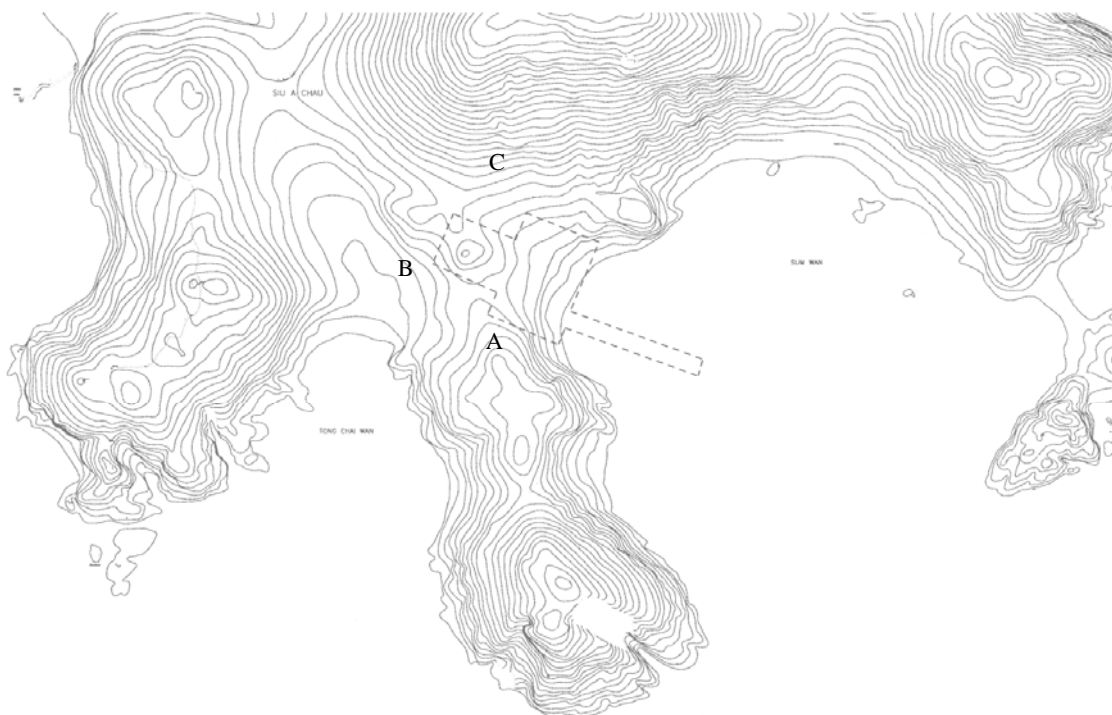


Figure 2.2 Locations for Collecting Soil Samples

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	14 Sep 05	44.3	0.4	41.8	0.5	569	4.8	*	*
B	14 Sep 05	57.3	0.4	82.3	0.6	447.6	4.0	*	*
C	14 Sep 05	23.6	0.3	67.0	0.6	143.7	2.6	*	*

* 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	*	*

Radionuclide contents in sample C are on the low side. This site corresponds to location H in the baseline monitoring which also gave low radionuclide contents.

Sand

2.10 Sand samples partly immersed in water along the shore were collected. A small sandy beach has formed at the southern side of the jetty and sand from the beach was also collected. This was not sampled in the baseline monitoring.

2.11 The sampling locations and measurement results are shown in **Figure 2.3** and **Table 2.3(a) & (b)** respectively.

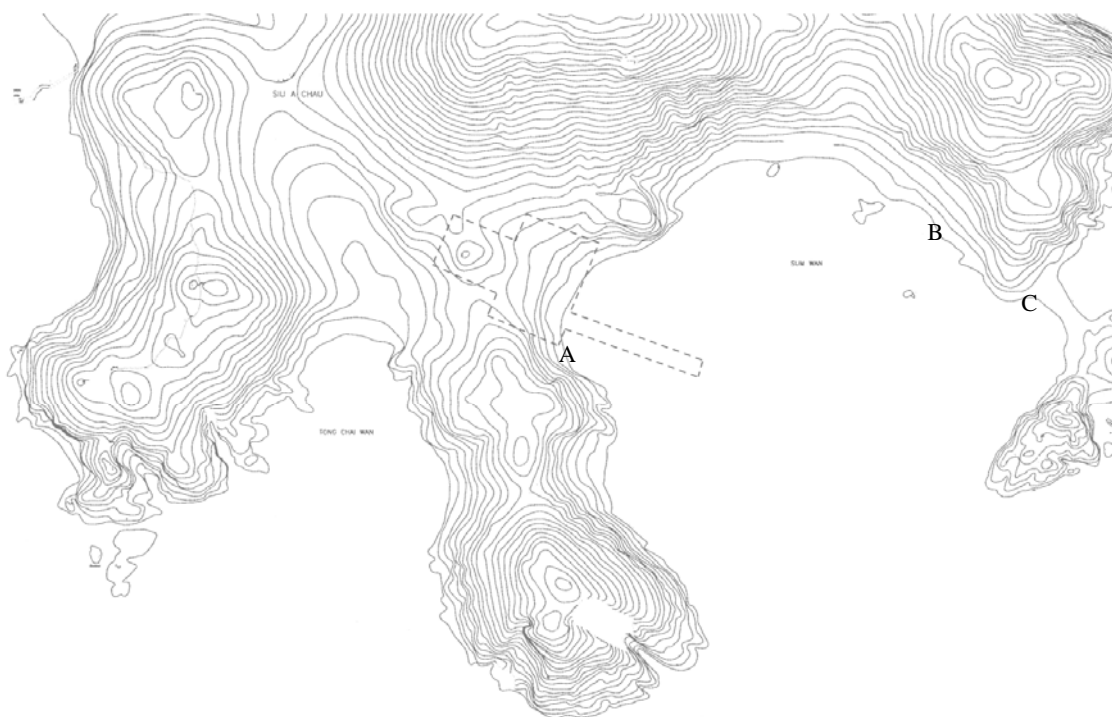


Figure 2.3 Locations for Collecting Sand Samples

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	14 Sep 05	16.1	0.3	20.0	0.4	485	3.9
B	14 Sep 05	11.2	0.3	12.4	0.3	387	3.5
C	14 Sep 05	9.9	0.3	9.3	0.3	272	3.1

2.12 The radionuclide contents in this batch of samples are all lower than those in the baseline samples.

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	356.7	100

Grass

2.13 Grass samples were collected in locations near to the soil samples. The sampling locations and measurement results are given in **Figure 2.4** and **Table 2.4(a) & (b)** respectively. 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.

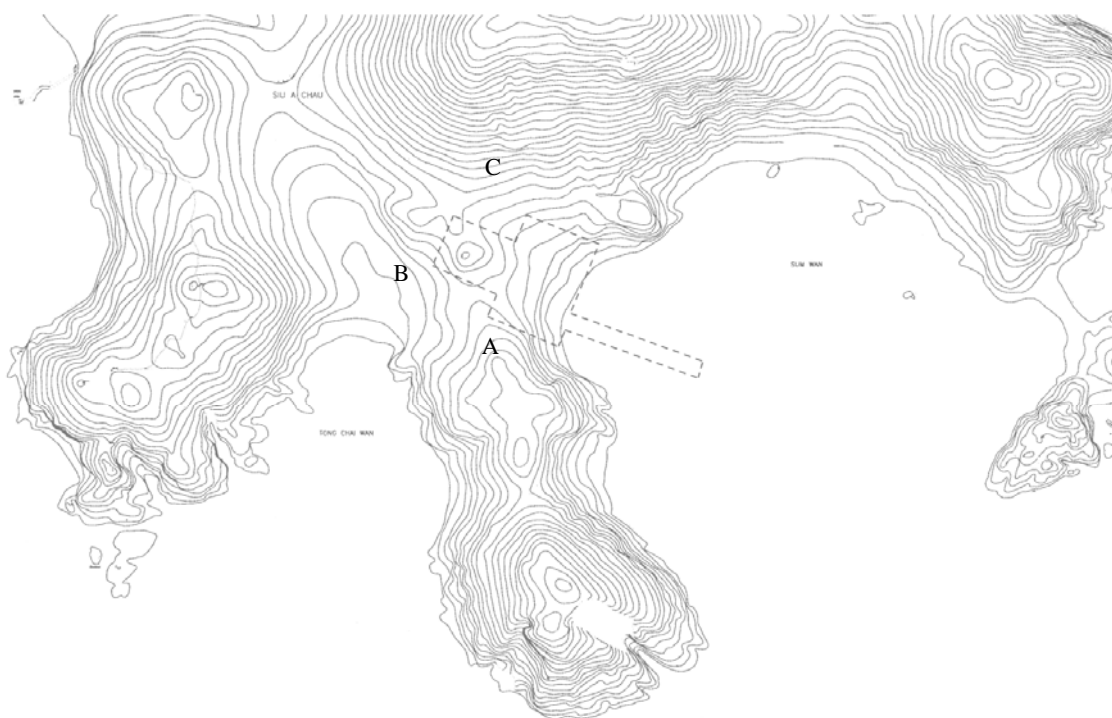


Figure 2.4 Locations for Collecting Grass Samples

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	14 Sep 05	0.046	0.003	0.244	0.005
B	14 Sep 05	0.024	0.002	0.267	0.005
C	14 Sep 05	0.042	0.003	0.243	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

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 locations and measurement results are given in **Figure 2.5** and **Table 2.5(a) & (b)** respectively.

2.16 Similar to grass samples, the γ spectra are not reported. There is no sign of presence of γ emitters.

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	14 Sep 05	Surface	1.25	0.23	5.97	0.23
			Bottom	0.36	0.18	6.89	0.24
B	7.7	14 Sep 05	Surface	0.49	0.20	6.17	0.23
			Bottom	0.00	0.00	6.00	0.23
C	8.9	14 Sep 05	Surface	0.00	0.00	5.28	0.22
			Bottom	0.52	0.19	6.00	0.23
D	11.5	14 Sep 05	Surface	1.12	0.22	6.50	0.24
			Bottom	0.16	0.16	6.02	0.23

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

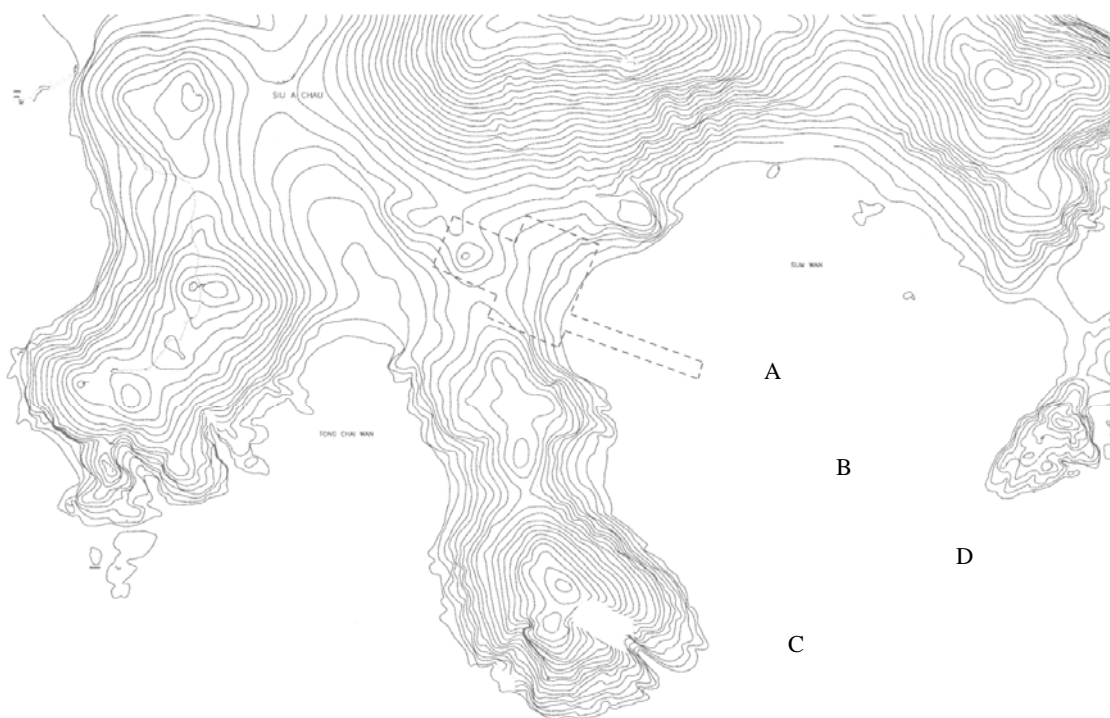
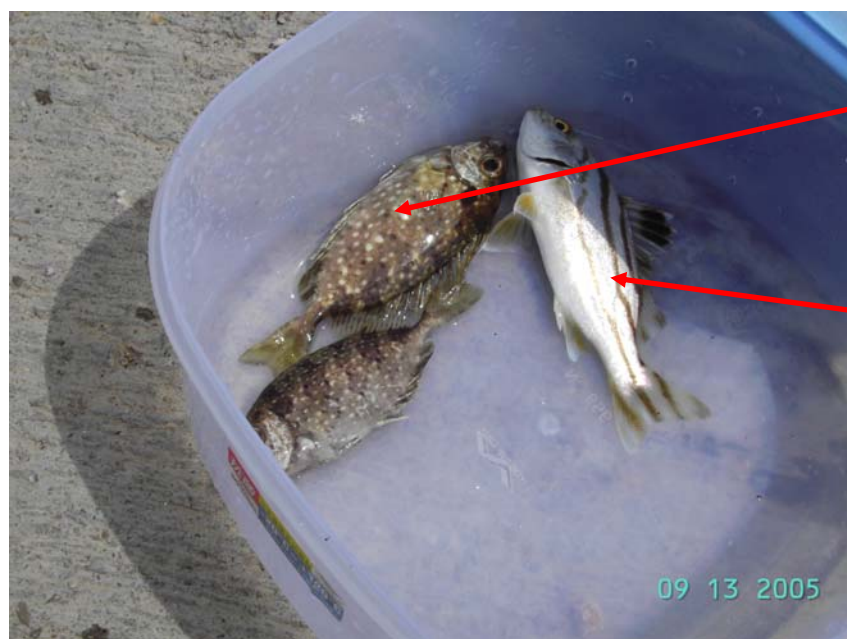


Figure 2.5 Locations for Collecting Water Samples

Marine Organisms

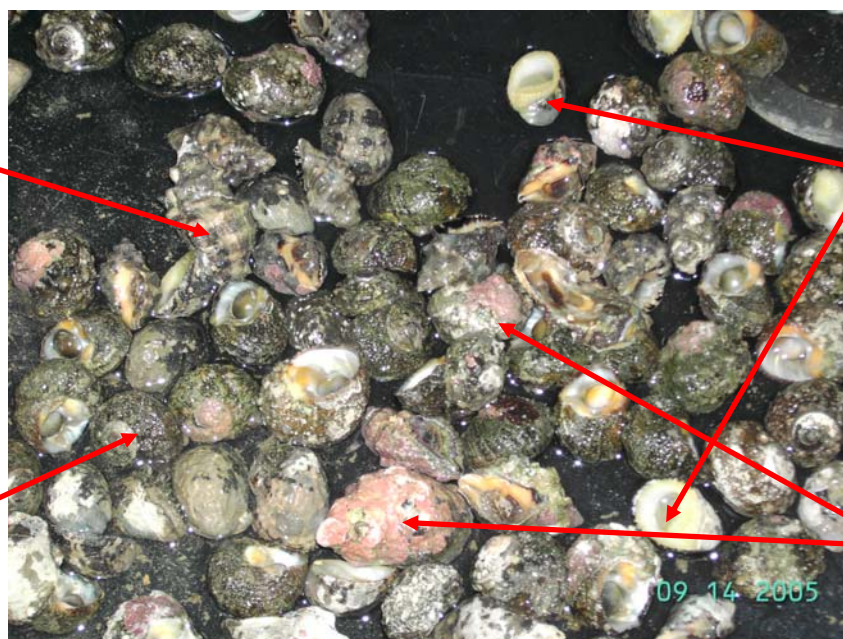
2.17 Three fish were caught at the jetty and sea snails were collected randomly along the shores.

2.18 Two species of fish were caught; they were *Siganus canaliculatus* (White-spotted spinefoot) and *Terapon jarbua* (Jarbua terapon). The sea snails are of various species, some identified ones are *Thais clavigera* (Dog whelk); *Nerita albicilla* (Nerite); *Lunella coronata* (Turban shell) and *Thais luteostoma* (Whelk). They are shown in **Figure 2.6**.



Siganus canaliculatus
(White-spotted spinefoot)

Terapon jarbua
(Jarbua terapon)



Thais clavigera
(Dog whelk)

Nerita albicilla
(Nerite)

Lunella coronata
(Turban shell)

Thais luteostoma
(Whelk)

Figure 2.6 Identity of the fish and sea snails

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	14 Sep 05	0.0028	0.0011	0.339	0.005
2	14 Sep 05	0.0089	0.0014	0.076	0.002
3	14 Sep 05	0.0088	0.0014	0.070	0.002

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

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	0.0025
2	0.0068	0.0035	0.16	0.15

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	14 Sep 05	0.0005	0.0005	0.029	0.002
2	14 Sep 05	0.014	0.002	0.042	0.002
3	14 Sep 05	0.016	0.002	0.032	0.002

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

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	0.0062	0.064	0.004
2	0.010	0.0084	0.034	0.007

Airborne Particulates

2.20 The sampling period was from August 12, 2005 to September 14, 2005.

2.21 Sampling locations and measurement results are given in **Figure 2.7** and **Table 2.8(a) & (b)** respectively.

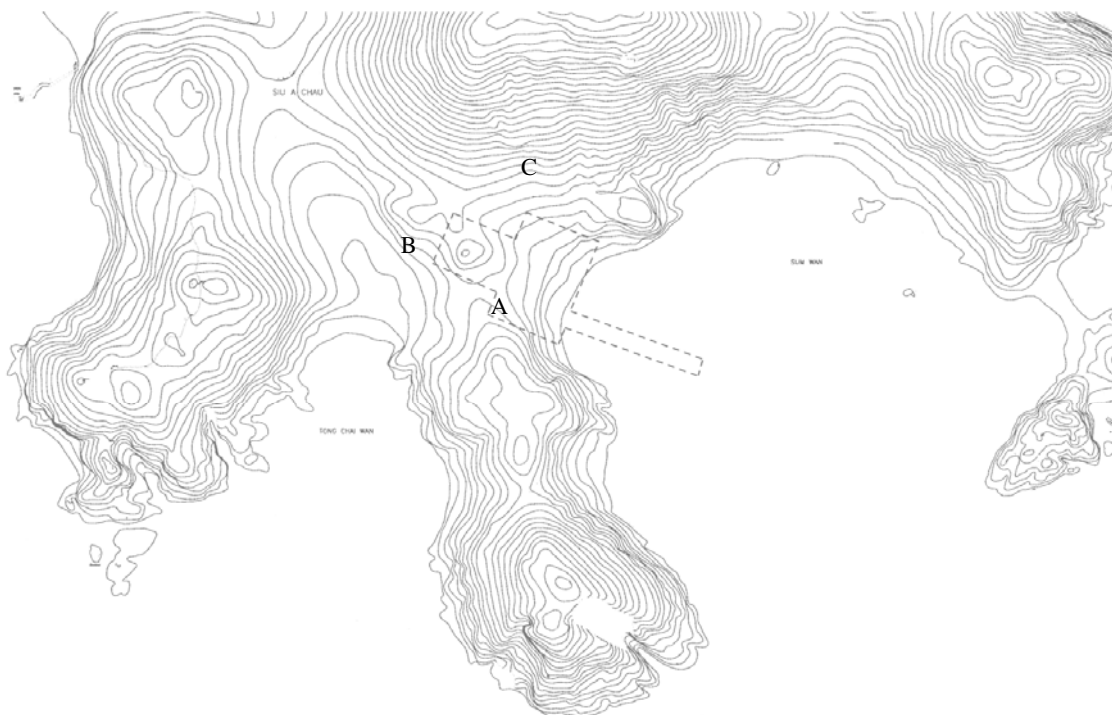


Figure 2.7 Locations of the Passive Airborne Particulate Samplers

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	0.93	0.13	4.30	0.27
A1	0.01	0.01	0.03	0.01
A2	0.00	0.00	0.07	0.02
B1	0.00	0.00	0.00	0.00
B2	0.00	0.00	0.03	0.01
C1	0.00	0.00	0.00	0.00
C2	0.00	0.00	0.00	0.00

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	0.01	0.05	0.00	0.01	0.00	0.00

2.22 Location A seems to have detected a small activity, but they are still much below the background activity of the cloth.

3. REPORT ON ELEVATED RADIATION LEVEL

- 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 The overall ambient γ dose-rate has recorded a 4% increase, which is still within the standard uncertainty of the baseline level. It is uncertain at this moment whether the increase is due to airborne effluent from the Facility.
- 3.3 The other samples do not show any systematic change in the measured activities. One of the fish samples recorded a higher β activity. Unfortunately the species of that fish sample has not been identified. It is worth to note that those fishes were caught at the jetty and there is no way to trace the origin of the fishes and hence to determine whether the higher activity was attributed to the operation of the LRWF.
- 3.4 The passive cloth sampler at location A seems to have recorded a slight airborne activity. But the level is well below the background activity of the cloth itself.
- 3.5 It will need a longer monitoring period to ascertain the effect of the operation of the Facility to the environment.

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 The whole body doses of the workers are monitored by TLDs on a monthly basis. Individual doses for the month of August 2005 and the accumulated individual doses recorded up to and including August 2005 are all below the A/L levels.

Dose Rates at Un-controlled Areas

4.3 The dose-rates were monitored by a portable γ dose ratemeter. No exceedance of A/L levels was observed.

Liquid Effluent Discharge

4.4 No liquid effluent was discharged during the monitoring period.

Airborne Effluent Discharge

4.5 There was some problems with the stack monitor starting at around September 1, 2005 when the recorded α - and β -activities fluctuated widely from low to high values. Investigation has been conducted to rectify the situation.

4.6 Radon concentration in the Storage Vault was monitored by a continuous radon monitor. The result shows an exceedance of the action level but not the limit level.

4.7 The α - and β -activities for the period August 14 to August 30 was considered. After compensating for the presence of radon and its progenies, the released α - and β -activities were below the A/L levels.

5. RESULT OF ENVIRONMENTAL COMPLIANCE AUDITS

- 5.1 The Facility commenced operation on July 28, 2005. It is noticed that the γ radiations emitted from the waste drums are well shielded and the increase in γ dose rate outside the site boundary is negligible.
- 5.2 However with the introduction of some high activity Ra-loaded wastes, the radon concentration increased markedly. Investigation is being done to find out why radon leaks out of those drums at such a high rate.
- 5.3 This incidence shows that the system installed for airborne effluent monitoring is appropriate and it can provide timely response.
- 5.4 The doses received by the workers are reasonably low even though transportation of Batch A wastes was mostly done in August and September.
- 5.5 It is not evidenced from the environmental samples that the marked increase in airborne effluent discharge has led to increased fallout in the vicinity of the Facility.
- 5.6 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 µSv per hour	0.3 µSv 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 ($\mu\text{Sv h}^{-1}$)	A	0.20	3 × SD of individual baseline dose rate
	B	0.25	
	C	0.32	
	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	0.25	
	M	0.31	
	N	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		
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.