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Ove Arup & Partners
奧雅納工程顧問

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Date 8 July 2009

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

By Post and Fax (2565 7638)

www.arup.com

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

ARUP

For the attention of: Mr Raymond Yem

Dear Mr. Yem,

**Low Level Radioactive Waste Storage Facility at Siu A Chau
Verification of Operation Phase EM&A Report No. 12**

We refer to your submission, ref.: ABJV/SP/768/0907046/WY dated 8 July 2009, regarding the captioned report.

We do not have comments and hereby verify the captioned report for your onward submission.

If you require any further information, please do not hesitate to contact the undersigned at 2268 3208 or our Coleman Ng at 2268 3097.

Yours sincerely



Sam Tsoi
Independent Environmental Checker

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ATAL-BELGOPROCESS JOINT VENTURE

Contract No. EP/SP/40/02

**Low Level Radioactive Waste Storage
Facility at Siu A Chau**

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

Version 1.1

November 2008

Certified By



(Environmental Team Leader)

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

This is the second yearly report after the Facility has been operated for 3 years and it presents the results of the radiological monitoring work performed between September 7, 2007 and the dates of sampling for this report. Two samplings were done separately on September 29, 2008 and November 12, 2008.

Some unforeseen delays in measurement of samples were encountered for this year's report. The instability of the γ dose rate-meter has led to the need of a repeated measurement of ambient γ dose rates on July 7, 2009. The malfunctioning of the low-level α/β counting system also led to delay in measurement of some samples, but this does not affect the results.

A transfer of radioactive wastes to the Facility was performed on January 20, 2008. The wastes were collected from:-

1. Education and Manpower Bureau (EMB).
2. Hing Fung goldsmith & Refinery.
3. Wong Tak Engineering and Shipbuilding Co. Ltd.

Overall performance of the Facility is fine and there is no evidence that the operation of the Facility has led to any adverse effect to the environment.

There was a typographical error for the Investigation Level of ambient γ dose rate at Location L given in Table A1.2, which should be 0.30 $\mu\text{Sv/hr}$ instead of 0.25 $\mu\text{Sv/hr}$. This error occurred in all previous reports up to this one but the results have not been affected.

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 were stored in disused air raid tunnels close to Queen's Road East in Wan Chai. Other arisings were 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 for 10 years. 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 also contains facilities for waste reception and repackaging waste, and administering the process. A jetty was 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 twelfth EM&A (Operation Phase) report, which is also the second annual 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 September 7, 2007 to the dates of sampling which were September 29, 2008 and November 12, 2008. Ambient γ dose-rates; soil samples; one of the three sand samples and grass samples were collected on September 29, 2008. Two remaining sediment samples; airborne particulate samples; water samples; sea snails and fish samples were collected on November 12, 2008.
- 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 sand 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.

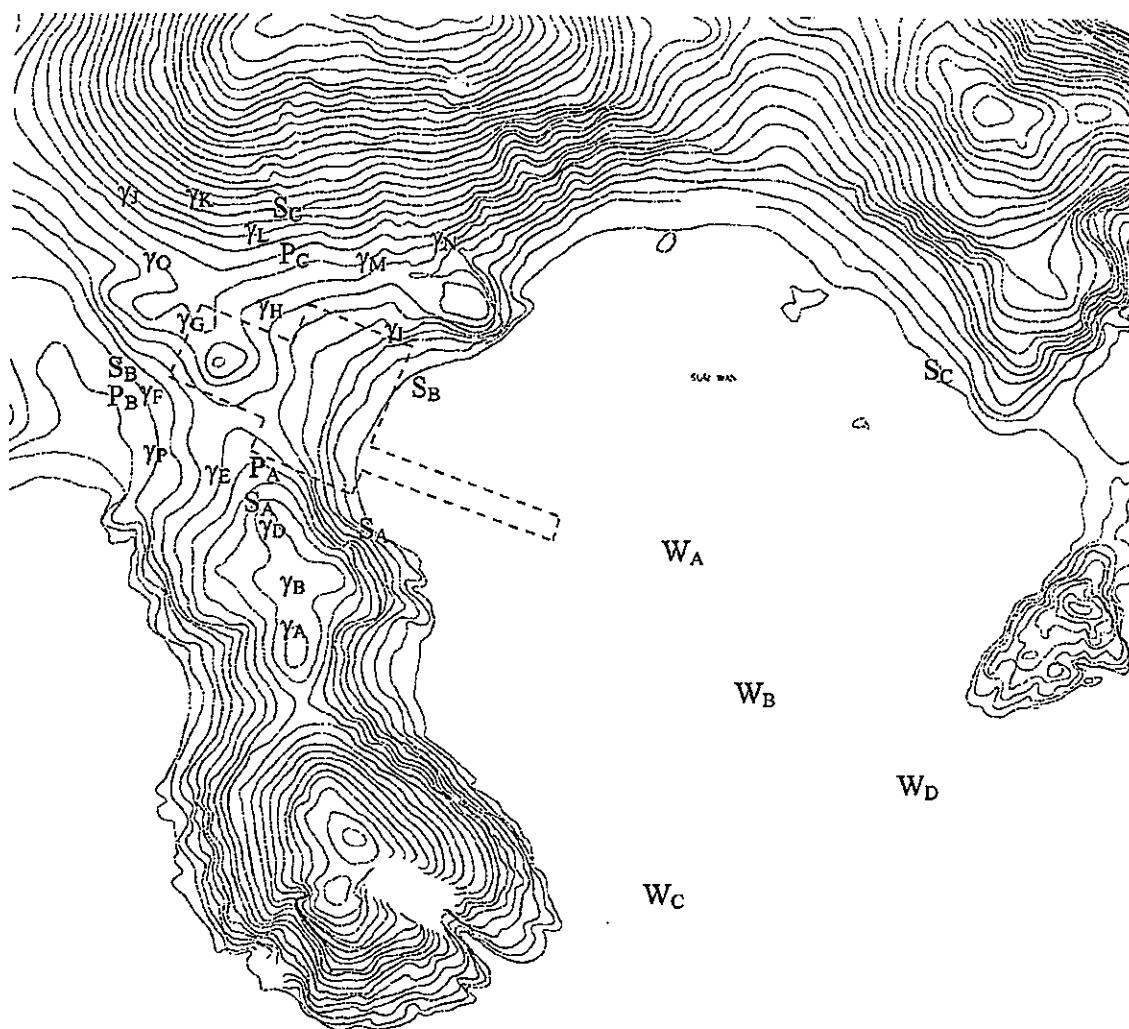


Fig. 2.1 Locations of the Sampling Sites

(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 the last column in Table 2.1(a). The 1st year results are average of all previous results measured within the 1st year. Table 2.1(b) also shows the results of the previous measurements for comparison. 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 ± 1 SD ($\mu\text{Sv h}^{-1}$)			
	Baseline	1 st Year (± 1 SU)	2 nd Year	3 rd Year
Boat	0.07	0.06 ± 0.008	0.06 ± 0.005	0.07 ± 0.006
A	0.21	0.22 ± 0.012	0.21 ± 0.012	0.20 ± 0.011
B	0.22	0.24 ± 0.016	0.25 ± 0.013	0.24 ± 0.012
D	0.23	0.26 ± 0.014	0.26 ± 0.013	0.25 ± 0.013
E	0.25	0.23 ± 0.021	0.22 ± 0.012	0.20 ± 0.011
F	0.24	0.27 ± 0.012	0.29 ± 0.014	0.26 ± 0.013
G	0.23	0.26 ± 0.012	0.26 ± 0.013	0.25 ± 0.013
H	0.27	0.29 ± 0.008	0.30 ± 0.014	0.29 ± 0.014
I	--	0.29 ± 0.016	0.29 ± 0.014	0.27 ± 0.013
J	0.21	0.23 ± 0.017	0.24 ± 0.012	0.22 ± 0.012
K	0.28	0.27 ± 0.020	0.27 ± 0.013	0.26 ± 0.013
L	0.22	0.26 ± 0.018	0.27 ± 0.013	0.25 ± 0.013
M	0.27	0.28 ± 0.022	0.27 ± 0.013	0.30 ± 0.014
N	0.25	0.25 ± 0.020	0.27 ± 0.013	0.25 ± 0.013
O	--	0.22 ± 0.016	0.24 ± 0.012	0.20 ± 0.011
P	--	0.25 ± 0.013	0.27 ± 0.013	0.27 ± 0.013

-- Not measured

- 2.6 Slight exceedances of Investigation Level were observed in a number of sites in this year's measurement done on September 29, 2008. They were Locations B, D, F, G, H, J, M, O and P. Such exceedances were later confirmed to be attributable to the instability of the γ dose rate-meter.
- 2.7 Ambient γ dose rates at all locations were therefore measured again on July 7, 2009 after the γ dose rate probe has been repaired and calibrated. The results are shown in the above Table 2.1(a) in the 3rd Year column.
- 2.8 No exceedance was observed.

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	0.026
2	0.26	0.028
3	0.25	0.022
4	0.25	0.029
5	0.26	0.027
6	0.25	0.024
7	0.26	0.022
8	0.25	0.031
9	0.24	0.031
10	0.25	0.029
11 (2 nd Year)	0.26	0.025
12 (3 rd Year)	0.25	0.031

- 2.9 The overall mean ambient γ dose-rate for this year is the same as those in previous years.

Soil

- 2.10 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	29 Sep 08	36.7	0.5	71.7	0.6	526	3.1	0.20	0.41
B	29 Sep 08	103.0	0.6	103.9	0.8	714	4.0	0.13	0.12
C	29 Sep 08	53.3	0.4	121.6	1.1	279	2.6	0.21	0.08

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
9	52.5	18.6	98.4	16.3	523	307	0.07	0.12
10	50.7	16.1	97.7	9.5	498	282	0.18	0.17
11 (2 nd Year)	52.8	15.7	106.8	16.9	483	253	0.27	0.01
12 (3 rd Year)	64.3	34.5	99.1	25.3	506	218	0.18	0.04

* Not detected

- 2.11 There is a slight exceedance of Investigation Level for ²²⁶Ra activity concentration in soil sample taken from location B.
- 2.12 Since the other radionuclides in the same sample, namely ²²⁸Th series and ⁴⁰K were also on the high side, it is suspected that the exceedance was due to sample-sample variation rather than contaminants originated from the Facility.
- 2.13 Hence no remedial action was recommended.

Sand

2.14 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	29 Sep 08	20.1	0.2	16.9	0.2	390	2.6
B	12 Nov 08	21.1	0.2	18.0	0.3	396	2.6
C	12 Nov 08	12.6	0.2	14.7	0.3	358	2.3

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
9	14.5	1.2	17.3	5.8	380	99.1
10	18.4	1.7	18.5	2.4	377	124
11 (2 nd Year)	17.0	2.4	18.6	4.4	397	71.3
12 (3 rd Year)	18.0	4.7	16.5	1.7	382	20.6

2.15 No exceedance of Investigation Level is observed.

Grass

- 2.16 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	29 Sep 08	0.000 [#]	0.000	0.134	0.004
B	29 Sep 08	0.000 [#]	0.000	0.165	0.004
C	29 Sep 08	0.035	0.004	0.219	0.005

* Bq g⁻¹ refers to dry mass of grass[#] Below minimum detectable activity of 0.006 Bq g⁻¹**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	0.03
2	0.037	0.012	0.25	0.01
3	0.081	0.017	0.30	0.10
4	0.093	0.009	0.26	0.03
5	0.084	0.020	0.23	0.04
6	0.081	0.056	0.22	0.09
7	0.077	0.046	0.25	0.08
8	0.068	0.047	0.28	0.05
9	0.050	0.023	0.29	0.02
10	0.051	0.008	0.40	0.07
11 (2 nd Year)	0.030	0.022	0.27	0.06
12 (3 rd Year)	0.012	0.020	0.17	0.04

- 2.17 No exceedance of Investigation Level is observed.

Sea Water

- 2.18 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).
- 2.19 Similar to grass samples, the γ spectra are not reported. There is no sign of presence of γ emitters.
- 2.20 No exceedance of Investigation Level is observed.

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

Location	Collection Date	Water Depth (m)	α Activity (Bq L ⁻¹)	SD (Bq L ⁻¹)	β Activity (Bq L ⁻¹)	SD (Bq L ⁻¹)
A	12 Nov 08	1	0.00 [#]	0.00	4.04	0.32
		3.5	0.00 [#]	0.00	4.44	0.33
B	12 Nov 08	1	0.00 [#]	0.00	3.18	0.40
		6.5	0.00 [#]	0.00	4.10	0.40
C	12 Nov 08	1	0.00 [#]	0.00	4.50	0.40
		7.5	0.00 [#]	0.00	3.92	0.39
D	12 Nov 08	1	0.00 [#]	0.00	4.36	0.40
		5	0.00 [#]	0.00	4.10	0.39

[#] Below minimum detectable activity of 1.26 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
9	0.32	0.29	5.21	0.38
10	0.70	0.35	8.35	2.19
11 (2 nd Year)	0.00	0.00	2.35	0.21
12 (3 rd Year)	0.00	0.00	4.08	0.42

Marine Organisms

- 2.21 Fishes were caught along the jetty and sea snails were collected randomly along the shores.
- 2.22 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	12 Nov 08	0.000 [#]	0.000	0.067	0.003

* Bq g⁻¹ refers to wet mass of fish flesh.[#] Below minimum detectable activity of 0.007 Bq g⁻¹**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
9	0.0100	0.004	0.062	0.050
10	0.0060	0.005	0.078	0.007
11 (2 nd Year)	0.0003	0.001	0.055	0.012
12 (3 rd Year)	0.0000	0.000	0.067	0.003

- 2.23 No exceedance in Investigation Level is observed.

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	12 Nov 08	0.000 [#]	0.000	0.024	0.002

* Bq g⁻¹ refers to wet mass of sea snail flesh.[#] Below minimum detectable activity of 0.007 Bq g⁻¹**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
9	0.000	0.000	0.023	0.002
10	0.010	0.009	0.045	0.005
11 (2 nd Year)	0.000	0.001	0.043	0.002
12 (3 rd Year)	0.000	0.000	0.024	0.002

2.24 All activities are comparable to the baseline levels.

Airborne Particulates

2.25 The sampling period was from September 7, 2007 to November 12, 2008.

2.26 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	0.80	0.12	4.53	0.28
A1	0.42 [#]	0.23	6.17	0.51
A2	0.10 [#]	0.10	6.18	0.50
B1	0.12 [#]	0.12	5.57	0.49
B2	0.72 [#]	0.24	5.45	0.51
C1	0.00 [#]	0.00	2.65	0.43
C2	0.38 [#]	0.23	3.00	0.46

[#] Below minimum detectable limit of 0.78 cpm.

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
9	0.91	3.03	0.29	1.36	0.09	0.42
10	0.32	1.97	0.11	1.05	0.00	0.03
11 (2 nd Year)	0.35	1.00	0.11	0.04	0.02	1.75
12 (3 rd Year)	0.26	6.18	0.42	5.51	0.19	2.83

2.27 A small amount α and β were detected, but their activities are comparable to the background.

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 is a slight exceedance of Investigation Level for ^{226}Ra activity concentration in soil sample taken from location B. Since the other radionuclides in the same sample, namely ^{228}Th series and ^{40}K were also on the high side, it is suspected that the exceedance was due to sample-sample variation rather than contaminants originated from the Facility. Hence no remedial action was recommended.
- 3.3 No other exceedance was observed.

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 average total radon released during the monitoring period was estimated to be 3.3×10^8 Bq/month, which is below the A/L Levels.
- 4.6 It was noted that the jumbo filters removed on May 15, 2008 (left and right filters); May 27, 2008 (left and right filters); June 16, 2008 (left filter) and July 14, 2008 (left and right filters) exhibited slightly higher activities in the order of 1 or 2 Bq over the background. These activities were very small. After investigation, it was concluded that the filter paper might have been contaminated during the transfer from Siu A Chau to the laboratory. Procedures have been implemented to prevent the contamination and no more unusual activities were recorded after that.
- 4.7 The discharged α and β activities were also below the A/L Levels.
- 4.8 The total airborne effluent discharge was below the A/L Levels.

5. RESULT OF ENVIRONMENTAL COMPLIANCE AUDITS

5.1 No compliant 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 (3/10 th 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 \times 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 Gross β		Occurrence in any quantities

- SD is the standard deviation of a single sample.

- SU is standard uncertainty of the sample group.