Our ref 23898/1.1/7.11/ST/CN/wl-27688

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ARUP

By Fax (2565 7638) & Post

ATAL Belgoprocess Joint Venture Limited
13/F, Island Place Tower,
No. 510 King's Road,
North Point, Hong Kong

For the attention of Mr Barry Lee

BDL/RY/AW

Level 5 Festival Walk
80 Tat Chee Avenue
Kowloon Tong
Kowloon
Hong Kong
t +852 25283031
f +852 28656493
sam.tsoi@arup.com
www.arup.com

12 June 2012

Dear Mr Lee

Low Level Radioactive Waste Storage Facility at Siu A Chau
Verification of Operation Phase EM&A Report No. 15

We refer to your submission, ref.: ABJV/SP/768/1205004/AW dated 1 May 2012, 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 faithfully

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

Fifteenth Environmental Monitoring and Audit Report (Operation Phase)

September 2011

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

This is the fifth yearly report after the Facility has been operated for 6 years and it presents the results of the radiological monitoring work performed between September 2010 and the date of sampling, which is August 25, 2011.

The Facility was operating smoothly over the years and there is no indication that the operation of the Facility has risen or will raise the environmental radiation level around the Facility. There is also no indication that the environment has been affected by the nuclear accident that occurred in Japan on March 2011.

Soil sample taken at Location A exhibits an extraordinarily low radionuclide content for all three elements under investigation, namely ^{226}Ra, ^{228}Th and ^{40}K. Gamma dose-rates around the soil sampling point (say at gamma Location D & E) do not show a drop in dose-rate when compared to previous years' readings, suggesting that the top soil in that area might have been contaminated over the last year. No action is recommended.

There is no air-borne particulate sample this year due to either the damaged or missing cloth samplers. This has never happened before and therefore is not due to design fault, but rather due to human error in mounting the samplers or a deliberate damage by unauthorized persons. The operators have been instructed on how to mount the samplers correctly and that they will check the sampler on a regular basis.

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 fifteenth EM&A (Operation Phase) report, which is also the fifth 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 9, 2010 to the date of sampling which was August 25, 2011.

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.

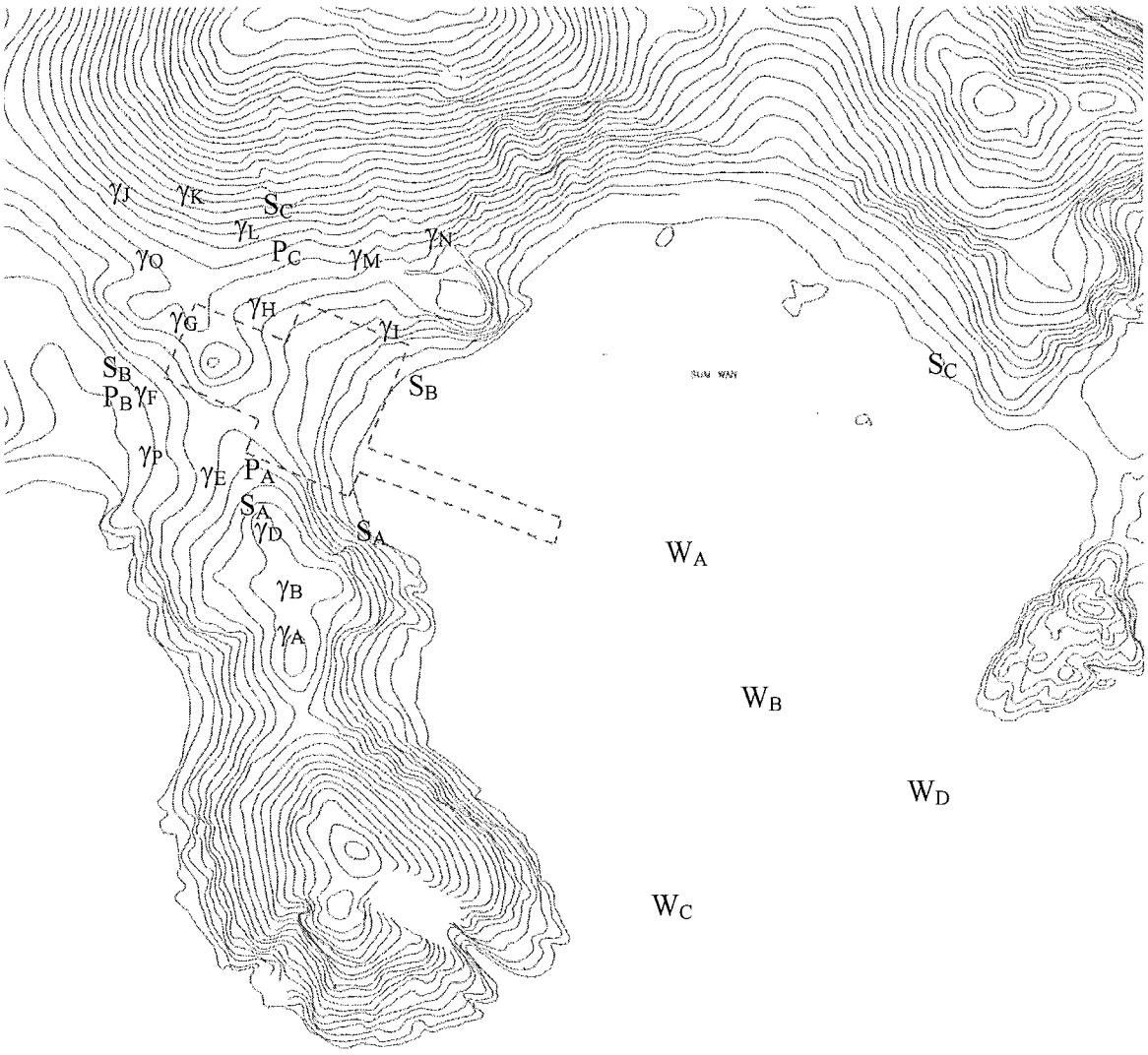

Fig. 2.1 Locations of the Sampling Sites

(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 (μSv h^{-1})						
	Baseline (2005)	2006	2007	2008	2009	2010	2011
Boat	0.07	0.06	0.06	0.07	0.06	0.07	0.07±0.01
A	0.21	0.22	0.21	0.20	0.19	0.21	0.23±0.01
B	0.22	0.24	0.25	0.24	0.23	0.25	0.24±0.01
D	0.23	0.26	0.26	0.25	0.25	0.26	0.27±0.01
E	0.25	0.23	0.22	0.20	0.20	0.22	0.22±0.01
F	0.24	0.27	0.29	0.26	0.25	0.23	0.26±0.01
G	0.23	0.26	0.26	0.25	0.25	0.27	0.25±0.01
H	0.27	0.29	0.30	0.29	0.30	0.25	0.32±0.01
I	--	0.29	0.29	0.27	0.27	0.26	0.24±0.01
J	0.21	0.23	0.24	0.22	0.24	0.25	0.25±0.01
K	0.28	0.27	0.27	0.26	0.27	0.25	0.28±0.01
L	0.22	0.26	0.27	0.25	0.26	0.25	0.28±0.01
M	0.27	0.28	0.27	0.30	0.26	0.31	0.25±0.01
N	0.25	0.25	0.27	0.25	0.24	0.28	0.23±0.01
O	--	0.22	0.24	0.20	0.22	0.22	0.24±0.01
P	--	0.25	0.27	0.27	0.25	0.29	0.28±0.01

-- Not measured

2.6 Locations H and J have a slight exceedance of Investigation Level which are 0.31 and 0.24 μSv h^{-1} respectively.

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

EM&A Report No.	Mean γ Dose Rate ($\mu Sv\ h^{-1}$)	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 (2007)	0.26	0.025
12 (2008)	0.25	0.031
13 (2009)	0.25	0.028
14 (2010)	0.25	0.027
15 (2011)	0.26	0.026

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

Soil

2.8 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	25 Aug 11	23.2	0.9	28.3	0.8	442	4.7	0.3	0.03
B	25 Aug 11	84.0	1.8	81.7	1.6	778	8.4	*	*
C	25 Aug 11	39.4	1.0	47.4	1.2	291	3.9	*	*

* 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
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 (2007)	52.8	15.7	106.8	16.9	483	253	0.27	0.01
12 (2008)	64.3	34.5	99.1	25.3	506	218	0.18	0.04
13 (2009)	59.3	12.0	116.0	12.0	474	199	*	*
14 (2010)	58.7	9.7	105.[illegible]	23.2	626	290	*	*
15 (2011)	48.9	31.5	52.5	27.1	504	249	0.1	0.03

* Not detected

2.9 No exceedance of Investigation Level is observed.

Sand

2.10 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	25 Aug 11	17.0	0.8	11.2	0.7	386	4.1
B	25 Aug 11	18.6	0.7	9.4	0.5	239	3.3
C	25 Aug 11	15.1	0.8	12.1	0.7	369	3.9

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 (2007)	17.0	2.4	18.6	4.4	397	71.3
12 (2008)	18.0	4.7	16.5	1.7	382	20.6
13 (2009)	19.1	2.2	17.3	3.4	313	115
14 (2010)	14.3	2.2	12.5	0.3	301	71.5
15 (2011)	16.9	1.8	10.9	1.4	331	80

2.11 No exceedance of Investigation Level is observed.

Grass

2.12 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	25 Aug 11	0.011#	0.004	0.143	0.004
B	25 Aug 11	0.009#	0.004	0.127	0.004
C	25 Aug 11	0.042	0.004	0.188	0.005

* $Bq\ g^{-1}$ refers to dry mass of grass
\# Below minimum detectable activity of 0.013 $Bq\ g^{-1}$

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 (2007)	0.030	0.022	0.27	0.06
12 (2008)	0.012	0.020	0.17	0.04
13 (2009)	0.014	0.016	0.10	0.03
14 (2010)	0.038	0.027	0.21	0.04
15 (2011)	0.021	0.019	0.15	0.03

2.13 No exceedance of Investigation Level is observed.

Sea Water

2.14 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)**.

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

2.16 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	25 Aug 11	1	0.00#	0.00	3.10	0.33
		3.5	0.00#	0.00	2.28	0.33
B	25 Aug 11	1	0.48#	0.39	3.90	0.29
		6.5	0.00#	0.00	3.40	0.34
C	25 Aug 11	1	0.00#	0.00	4.42	0.35
		7.5	0.44#	0.40	3.68	0.33
D	25 Aug 11	1	0.18#	0.18	2.24	0.33
		5	0.00#	0.00	0.00#	0.00

Below minimum detectable activity of 1.5 Bq L^{-1} for α and 1.0 Bq L^{-1} for β.

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 (2007)	0.00	0.00	2.35	0.21
12 (2008)	0.00	0.00	4.08	0.42
13 (2009)	0.32	0.29	5.44	1.27
14 (2010)	0.00	0.00	4.80	0.41
15 (2011)	0.14	0.21	2.88	1.39

Marine Organisms

2.17 Fishes were caught along the jetty and sea snails were collected randomly along the shores.

2.18 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	25 Aug 11	0.003#	0.001	0.04	0.001

* $Bq\ g^{-1}$ refers to wet mass of fish flesh.
# Below minimum detectable α activity of 0.008 $Bq\ g^{-1}$.

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 (2007)	0.0003	0.001	0.055	0.012
12 (2008)	0.0000	0.000	0.067	0.003
13 (2009)	0.0075	0.002	0.079	0.000
14 (2010)	0.0030	0.003	0.111	0.023
15 (2011)	0.0032	0.001	0.040	0.001

2.19 No exceedance of 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	25 Aug 11	0.002#	0.001	0.048	0.001

* $Bq\ g^{-1}$ refers to wet mass of sea snail flesh.
# Below minimum detectable α activity of 0.008 $Bq\ g^{-1}$

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 (2007)	0.000	0.001	0.043	0.002
12 (2008)	0.000	0.000	0.024	0.002
13 (2009)	0.003	0.003	0.035	0.004
14 (2010)	0.005	0.000	0.034	0.002
15 (2011)	0.002	0.001	0.048	0.001

2.20 No exceedance in Investigation Level is observed.

Airborne Particulates

2.21 No airborne particulate sample was measured because the cloth on the samplers was either severely torn or was missing.

2.22 The reason for this accident was not known.

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 A slight exceedance in gamma dose-rate is observed in Location H & J. The exceedances were very small and no action is required. The overall mean gamma dose-rate remains steady over the years.

3.3 No other exceedance is 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 7.0 x 10^8 Bq/month, which is below the A/L Levels.

4.6 It was reported last year that some jumbo filter papers might have been accidentally contaminated due to mis-handling. After improvement in the handling procedures, there is no more recorded abnormal activities this year.

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 (3/10th 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 ($\mu Sv\ h^{-1}$)	A	0.23	3 × 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 ^{228}Th ^{40}K	32.0 38.1 894	3 × SU of baseline samples
	Other γ emitters		Occurrence in any quantities
Grass (Bq g^{-1})	Gross α Gross β	0.22 0.43	3 × SU of baseline samples
	γ emitters not found in baseline		Occurrence in any quantities
Sea water (Bq L^{-1})	Gross α Gross β	1.52 9.3	3 × SU of baseline samples
	γ emitters not found in baseline		Occurrence in any quantities
Fish (Bq g^{-1})	Gross α Gross β	0.021 0.076	3 × SU of baseline samples
Sea snails (Bq g^{-1})	Gross α Gross β	0.048 0.076	3 × SU of baseline samples
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.