



RWE NUKEM

Dalgety Bay

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ABSTRACT

RWE NUKEM Limited undertook a radiological surface survey of 1.1 hectares of the foreshore area at Dalgety Bay, Fife between 2nd and 4th March 2006. The survey resulted in identification, excavation and removal of 37 radioactive artefacts from the foreshore with an estimated activity of 2.2MBq. The weight of waste removed amounted to approximately 1227g.

The survey results provide comprehensive information about the distribution of radioactive particles across the foreshore and in the exposed cliff face believed to be the contamination source. However, these results relate to a particular instance in time and do not provide any information on the rates of release and transport of particles. It is recommended that a further survey is undertaken at regular intervals to acquire comparative data which will provide such information.

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Cliff face survey results.

Photographic log of contaminated items removed.

1 INTRODUCTION

RWE NUKEM Limited was contracted by the Scottish Environment Protection Agency (SEPA) to undertake a radiological survey followed by radioactive hotspot removal on the foreshore area at Dalgety Bay, Fife, Scotland. The work took place between the 2nd and 4th of March 2006. The primary aim of the work was to gain further information on the distribution and radioactivity content of radioactive particles in the area.

1.1 History

The radioactive contamination existing at Dalgety Bay is believed to be related to the Donibristle naval airbase which closed in 1959. It is believed that waste was incinerated and the resultant ash and clinker was buried in an area of ground that, as a result of erosion, is now exposed and adjacent to the foreshore. Some of the incinerated material contained items which had been painted with luminous paint containing radium-226, a naturally occurring radioactive material. The result of this is that the exposed waste material erodes, clinker-like material contaminated with radium is released and becomes distributed along the shoreline. Survey work has been routinely undertaken by other organisations since the discovery of radioactive artefacts in 1991 and recovered particles have been removed from the site and placed in temporary storage prior to disposal to licensed facilities.

2 SCOPE OF WORK

The investigation comprised a surface radiation survey within the survey area used during previous investigations (Figure 2.1) to identify and record the location of radioactive particles, followed by retrieval of identified particles for assay and subsequent disposal. Information obtained on the distribution and radioactivity content of particles would enable a better understanding of the radiological situation at Dalgety Bay.

Each item excavated was photographed and the following information recorded:

- Location (national grid reference to 8 figures)
- Depth at which detected
- Mass
- Dimensions
- Brief description
- Count-rate/activity concentration
- Unique identification number

The waste was transferred to a temporary storage location prior to disposal by a specialist contractor under authorisation by SEPA.



Figure 2.1 Survey grid of previous investigations. After BES/SEPA, 2005.

3 EQUIPMENT USED

The monitoring equipment used for the surface radiation survey was the RWE NUKEM Limited Groundhog detection system comprising a 76mm sodium iodide scintillation detector connected to a logger/ratemeter and a global positioning system (GPS) capable of sub-metre accuracy. The probe was used for the detection of gamma emitting radionuclides.

3.1 Instrument response

The response of the instrument to radium contamination was calculated using MCNP software which is a general-purpose Monte Carlo N-Particle code that can be used for neutron, photon, electron, or coupled neutron/photon/electron transport.

Assuming a background level of 150 counts per second (cps) and a threshold for positive identification of an artefact of 75 cps above background level, computer modelling has been used to calculate minimum quantities of radium-226 detectable by the detector deployed 0.2m above the ground surface for a range of source depths. These are shown in Table 3.1 below:

Depth of source (cm)	Minimum Detectable Activity kBq Ra-226
Surface	20 kBq
10	70 kBq
20	170 kBq

Table 3.1 Groundhog detector response

3.2 Other instruments used during the investigation

Additional equipment was used during the excavation and monitoring of radioactive items and this included:

Mini Instruments 44B probe and Mini 900 ratemeter

This probe (44B) has a small beryllium end window (32mm diameter) and the side of the probe is shielded with lead which makes the instrument highly suited for pinpointing gamma emitting radioactive sources during excavation work.

NE Technology PDR1

The dose rate meter used was a NE Technology portable gamma dose rate meter PDR 1. This instrument was used to measure dose rate from the recovered artefacts.

4 METHODOLOGY

The Groundhog detection system is operated by traversing the survey area at a velocity of 1 ms⁻¹ on lines spaced 1 m apart, resulting in a survey resolution of one reading per square metre. On site, the data is uploaded into a computer and is displayed (radiation levels expressed as counts per second) in a Geographical Information System (GIS) as a graduated colour plot.

When recovering identified artefacts, areas with elevated count rate (e.g. hotspots) were located using a colour plot of the radiation survey results, a hand held GPS and the Groundhog detector. On locating the area of interest, the surface was surveyed with the Groundhog detector and the 44B probe and excavation was undertaken with a spade and/or a trowel. The artefact was then subject to measurement and monitoring (see Section 2).

The field data were subsequently differentially corrected to enhance positional accuracy and interpolated contour plots of radiation levels produced.

5 SURFACE RADIATION SURVEY

The initial aim of the investigation was to survey only the area subjected to previous investigation work by Babcock Engineering Services. This area amounted to approximately 5000 m². Additional areas to the north, east and south of the previously investigated area were also surveyed, which covered areas of 1200 m², 2800 m² and 2000 m² respectively. The full survey area is shown in Figure 5.1.



Figure 5.1 Extent of survey coverage at Dalgety Bay.
Note, total area approximately 1.1 hectares.

5.1 Identification of hotspots

The colour radiation plot of the survey undertaken is shown below in Figure 5.2.

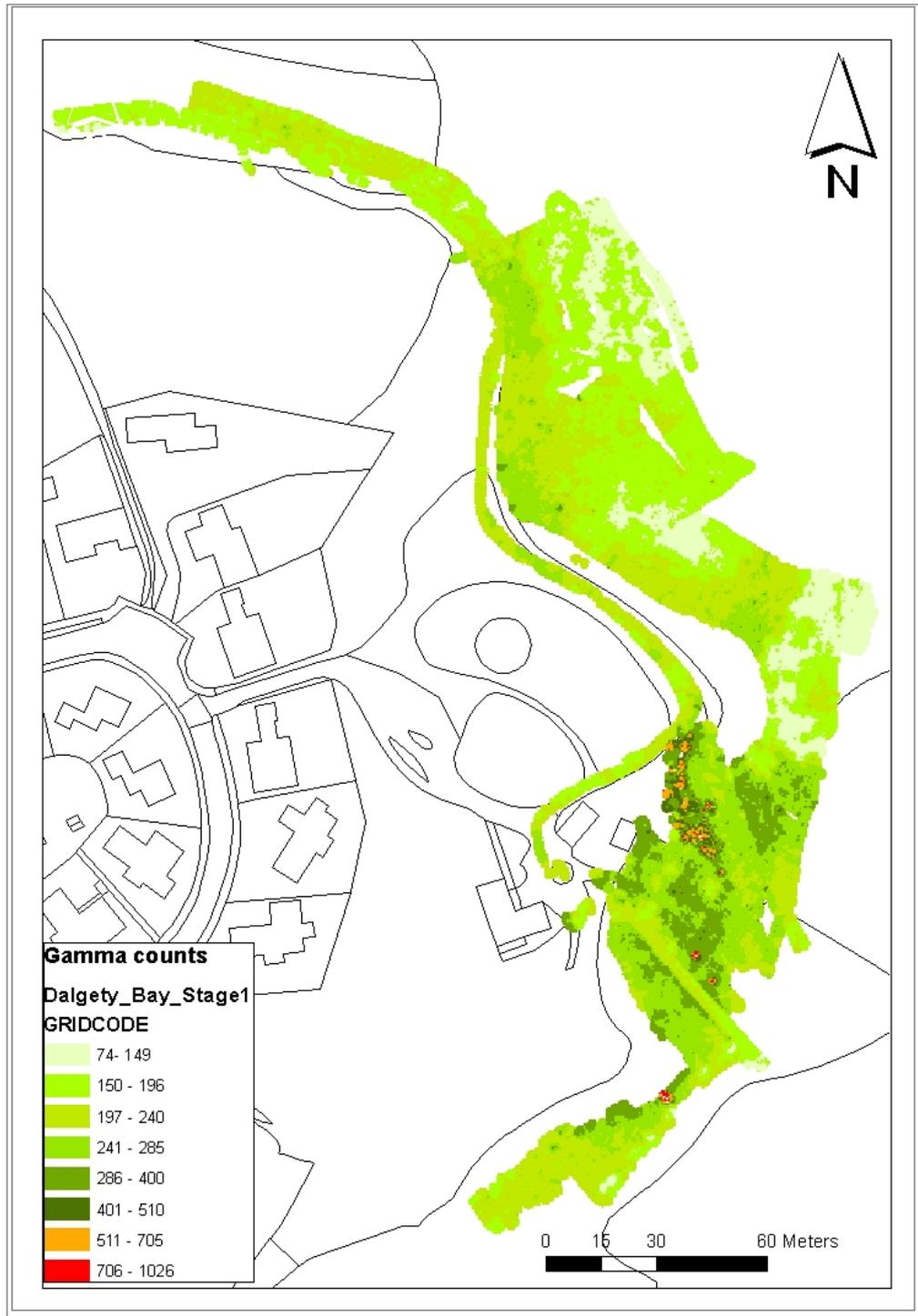


Figure 5.2 Groundhog survey plot of Dalgety Bay foreshore.

Identification of hotspots was undertaken by use of the colour coded plot showing radiation levels in cps. In order to assist in the decision making process the software used to plot the data (ArcView) produces classification statistics of the plotted data, (Table 5.1).

Count (number of readings)	47124
Min (cps)	74
Max (cps)	1242
Mean (cps)	217
Standard deviation	68

Table 5.1 Classification statistics of the count rate data at Dalgety Bay.

Areas which exceeded background (the mean count rate) by the largest amount were investigated first as the highest priority targets. For example areas in which count rates exceeded 510cps (as shown on Figure 5.2).

5.2 Main hotspot clusters

Four main hotspot clusters were identified during the survey (Figure 5.3) and these areas are described below.

5.2.1 Hotspot Cluster area 1

This area is approximately 600m² and contained 14 hotspot localities in a relatively confined area immediately west of the northern-most slipway. The upper reaches of the area did not appear to be submerged during high tides as small boats were tied up at the location. Excavations in the area indicated a higher proportion of dark ash type residue and clinker.

5.2.2 Hotspot Cluster area 2

This area is approximately 300m² and contained 5 hotspot localities. The area of interest is immediately west of the northern-most slipway and appeared to be affected by wave action/erosion. Large quantities of imported rock had been placed at the top of the foreshore for reinforcement.

5.2.3 Hotspot Cluster area 3

This area is approximately 350m² and contained 6 hotspot localities and is situated around the mid and southern slipways.

5.2.4 Hotspot Cluster area 4

This area is approximately 470m² and contained 4 hotspot localities, two of which were located on the foreshore and two within the cliff section. The foreshore was much rockier than other parts of the survey area and numerous fragments of metallic items were identified during the survey.

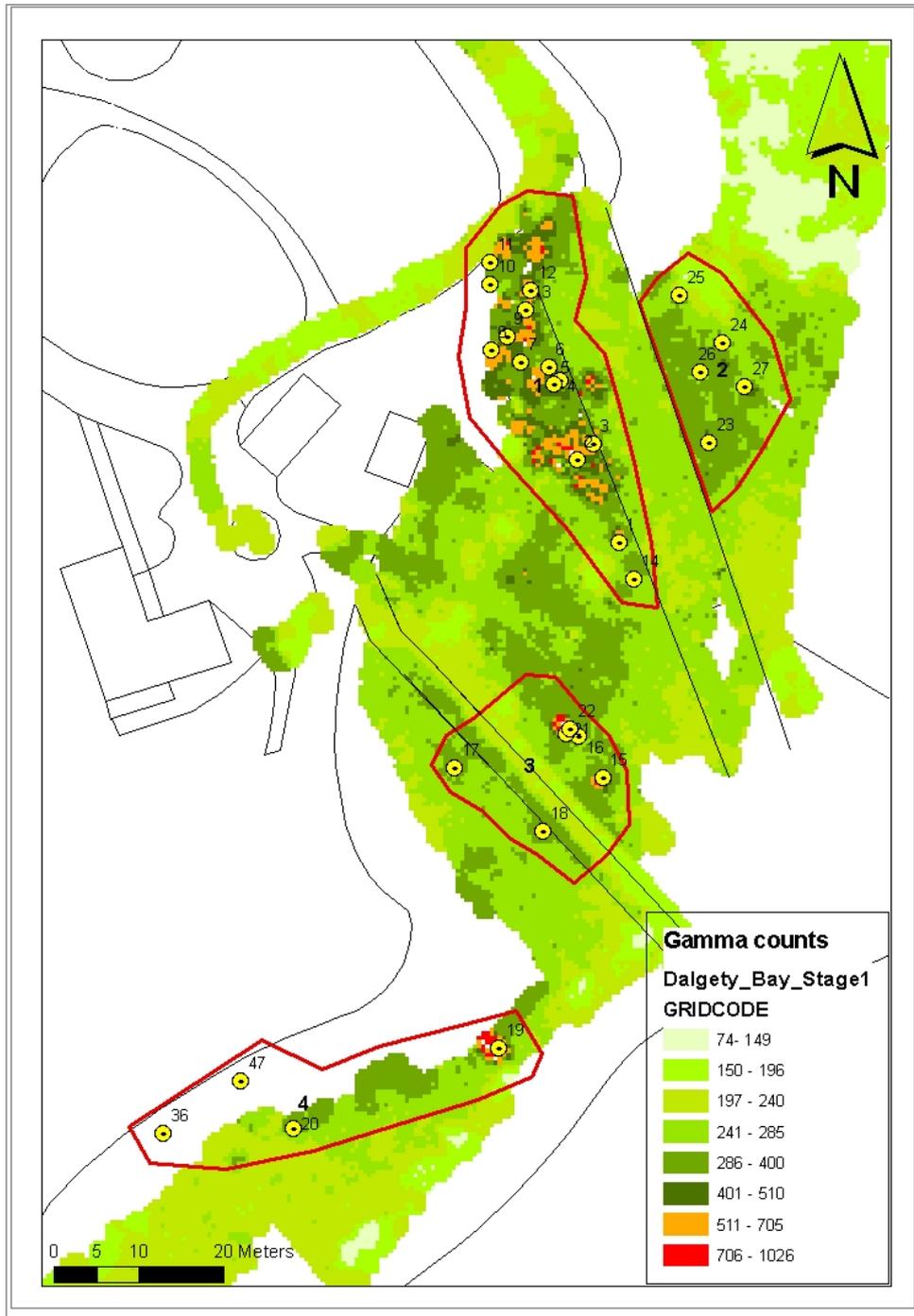


Figure 5.3 Hotspot clusters and locations at Dalgety Bay.

6 ARTEFACTS RETRIEVED

A total of 37 artefacts were retrieved from 29 locations during the three day investigation (Figure 5.3). The depth at which these items were retrieved ranged from surface (0mm) to 270mm below ground level. The size of the recovered items varied from 1mm to 120mm whilst the weight range was <1g to approximately 380g. Information on each hotspot is given in Table 6.1, and each location/artefact is described below and

photographs of the items are contained in the appendix. Note that particle size described is in accordance with BS5930, (BSI,1999). On completion of excavation work, areas were resurveyed to ensure that all radioactive items had been removed.

No.	Date	Location	ID No	Easting	Northing	Weight (g)	Length (mm)	Width (mm)	Depth (mm)
1	02/03/06	HS_1	1_0.1m	316502.04	683110.47	0.5	8	4	2
2	02/03/06	HS_2	2_0.05m	316496.80	683120.25	4	18	15	8
3	02/03/06	HS_3	3_surface	316498.78	683122.35	<1	4	3	2
4	02/03/06	HS_3	3_0.15m	316498.78	683122.35	<1	7	6	4
5	02/03/06	HS_4	4_0.03m	316495.17	683129.68	<1	3	3	2
6	02/03/06	HS_5	5_0m	316494.24	683129.45	<1	3	3	2
7	02/03/06	HS_6	6_0.05m	316493.66	683131.54	<1	2	2	1
8	02/03/06	HS_6	6_0.1m	316493.66	683131.54	5	25	20	10
9	02/03/06	HS_7	7_0.15m	316490.40	683132.01	2	10	8	8
10	02/03/06	HS_8	8_0.15m	316486.67	683133.52	30	50	40	25
11	02/03/06	HS_9	9_0.05m	316488.77	683135.27	7	20	15	15
12	02/03/06	HS_10	10_0m	316486.79	683141.21	5	15	10	10
13	02/03/06	HS_11	11_0.05m	316486.67	683143.88	17	25	20	15
14	02/03/06	HS_12	12_0.03m	316491.56	683140.74	5	10	5	4
15	02/03/06	HS_13	13_0.075m	316490.75	683138.30	10	30	15	10
16	03/03/06	HS_14	14_0.12m	316503.79	683106.14	<1	2	2	1
17	03/03/06	HS_15	15_0.27m	316500.18	683082.50	167	85	70	50
18	03/03/06	HS_16	16_0.1m_A	316497.15	683087.28	<1	8	4	1
19	03/03/06	HS_16	16_0.1m_B	316497.15	683087.28	<1	4	4	3
20	03/03/06	HS_17	17_0.05m	316482.48	683083.55	<1	4	3	2
21	03/03/06	HS_18	18_0.15m	316492.96	683075.98	<1	1	1	1
22	04/03/06	HS_19	19_0m	316487.72	683592.68	86	85	50	25
23	04/03/06	HS_20	20_0.05m	316463.29	683040.45	10	20	15	15
24	04/03/06	HS_21	21_0.1m	316495.39	683087.90	10	25	20	10
25	04/03/06	HS_22	22_0.15m	316496.51	683089.02	<1	5	5	4
26	04/03/06	HS_23	23_0.15m	316513.04	683122.82	1	8	6	5
27	04/03/06	HS_24	24_0.2m	316514.54	683135.21	382	115	75	55
28	04/03/06	HS_25	25_0.1m	316510.03	683140.10	<1	9	6	1
29	04/03/06	HS_26	26_0.15m_A	316511.91	683130.71	32	55	30	20
30	04/03/06	HS_26	26_0.15m_B	316511.91	683130.71	36	45	35	25
31	04/03/06	HS_27	27_0.2m_A	316511.91	683130.71	319	120	90	50
32	04/03/06	HS_27	27_0.2m_B	316511.91	683130.71	1	9	7	5
33	04/03/06	HS_27	27_0.2m_C	316511.91	683130.71	<1	7	5	5
34	04/03/06	HS_27	27_0.2m_D	316511.91	683130.71	<1	7	5	7
35	04/03/06	HS_27	27_0.2m_E	316511.91	683130.71	<1	10	7	1
36	04/03/06	CF_36	0.075m	316448.45	683040.21	61	60	40	30
37	04/03/06	CF_47	0.1m	316456.71	683046.21	21	fine material	fine material	fine material

Table 6.1 Position and description of hotspots removed from Dalgety Bay.

6.1 Items retrieved on the 2nd March 2006.

HS_1

HS_1 was a medium gravel sized piece of clinker found at a depth of 0.1m. The maximum dose rates at contact and at 10cm were 125 and 5 μ Sv/h respectively. Direct 44B probe readings were at full scale deflection (>5000cps).

HS_2

HS_2 was a fragment of dark clinker material of coarse gravel size. Direct 44B probe readings of 700cps were recorded and maximum dose rates at contact and 10cm were 1.5 and 0.15 μ Sv/h respectively. Note that the dose rate measured at 10cm was effectively at background level.

HS_3

The first item at this location was isolated at the surface and comprised a fine gravel sized fragment of dark clinker. Maximum dose rates at contact and 10cm were 0.4 and 0.15 μ Sv/h respectively. Maximum 44B probe readings were 500cps.

The second item located comprised a medium gravel sized clinker fragment and was found at a depth of 0.15m. Direct 44B probe readings were up to 1000cps and maximum dose rates at contact and 10cm were 2 and 0.5 μ Sv/h respectively.

HS_4

HS_4 was a fine gravel sized piece of clinker located at 0.03m. Maximum dose rates at contact and 10cm were 16 and 0.6 μ Sv/h respectively and direct 44B readings exceeded 5000cps.

HS_5

HS_5 was a fine gravel sized piece of clinker located on the surface of the shoreline. Maximum dose rates at contact and 10cm were 10 and 1 μ Sv/h respectively and direct 44B readings exceeded 5000cps.

HS_6

The first item found at the location was fine gravel sized and located at a depth of 0.05m. Direct 44B probe readings of 300 cps were recorded. Maximum dose rates at contact and 10cm were 0.3 and 0.15 μ Sv/h respectively.

The second item was located at a depth of 0.1m and comprised a coarse gravel sized fragment of clinker. Maximum dose rates at contact and 10cm were 0.4 and 0.15 μ Sv/h respectively and direct 44B probe readings were 300cps.

HS_7

HS_7 was found at a depth of 0.15m and comprised a medium gravel sized fragment of clinker. 44B probe readings were 1500cps and maximum dose rates at contact and 10cm were 2 and 0.15 μ Sv/h respectively.

HS_8

HS_8 was located at 0.15m and comprised a coarse gravel sized fragment of clinker. Maximum dose rates at contact and 10cm were 10 and 1.5 μ Sv/h respectively whilst direct 44B readings of 2000cps were recorded.

HS_9

HS_9 was a coarse gravel sized fragment of clinker found at 0.05m. Direct 44B probe readings were 500cps and maximum dose rates at contact and 10cm were 1.5 and 0.6 μ Sv/h respectively.

HS_10

Located at the surface, HS_10 comprised a medium gravel sized clinker fragment. Maximum dose rates at contact and at 10cm were 0.5 and 0.15 μ Sv/h respectively. 44B probe readings of up to 500cps were recorded.

HS_11

A medium gravel sized fragment of clinker was excavated at a depth of 0.05m. Direct 44B probe readings were 1500cps and maximum dose rates at contact and at 10cm were 5 and 0.7 μ Sv/h respectively.

HS_12

HS_12 was a medium gravel sized fragment of clinker found at 0.03m. Direct 44B probe readings were 1500cps and maximum dose rates at contact and at 10cm were 10 and 0.2 μ Sv/h respectively.

HS_13

HS_13 was located at 0.075m and comprised a coarse gravel sized fragment of clinker. Maximum dose rates at contact and at 10cm were 0.5 and 0.15 μ Sv/h respectively whilst direct 44B readings of 300cps were recorded.

6.2 Items recovered on the 3rd March 2006**HS_14**

HS_14 was a coarse sand sized fragment located at 0.12m. Direct 44B probe readings exceeded 5000cps and maximum dose rates at contact and at 10cm were 125 and 5 μ Sv/h respectively.

HS_15

HS_15 comprised a cobble sized piece of clinker found at 0.27m. Direct 44B probe readings exceeded 5000cps and maximum dose rates at contact and at 10cm were 250 and 10 μ Sv/h respectively.

HS_16

The first item was found at 0.1m and comprised a fine gravel sized fragment of clinker. Maximum dose rates at contact and at 10cm were 40 and 3 μ Sv/h respectively and direct 44B probe readings exceeded 5000cps.

The second artefact was also located at 0.1m and was also fine gravel sized. Direct 44B probe measurements were 2000cps and maximum dose rates at contact and at 10cm were 2 and 0.5 μ Sv/h respectively.

HS_17

HS_17 comprised a fine gravel sized fragment of clinker which was found at a depth of 0.05m. Maximum dose rates at contact and at 10cm were 3 and 0.4 μ Sv/h respectively. Direct 44B probe readings were measured at 2000cps.

HS_18

HS_18 was a coarse sand sized fragment located at a depth of 0.15m. Maximum dose rates at contact and at 10cm were 10 and 0.3 μ Sv/h respectively. Direct probe measurements of 5000cps were recorded.

6.3 Items recovered on the 4th March 2006.

HS_19

A cobble sized piece of clinker was located at the surface of the foreshore with a maximum 44B probe reading of >5000cps. Maximum dose rates at contact and at 10cm were 200 and 8 μ Sv/h respectively.

HS_20

A coarse gravel fragment of clinker was found at a depth of 0.05m. Maximum dose rates at contact and 7.5cm were 0.5 and 0.6 μ Sv/h respectively. Direct 44B probe measurements were 3500cps.

HS_21

HS_21 comprised a coarse gravel sized piece of clinker located at a depth of 0.1m. Direct probe readings exceeded 5000cps. Maximum dose rates at contact and at 10cm were 150 and 6 μ Sv/h respectively.

HS_22

HS_22 was located at a depth of 0.15m and comprised fine gravel sized clinker. Maximum dose rates at contact and at 10cm were 30 and 1.5 μ Sv/h respectively. Direct probe readings of >5000cps were recorded.

HS_23

A clinker fragment of medium gravel size was found at 0.15m. Direct 44B probe measurements exceeded 5000cps. Maximum dose rates at contact and at 10cm were 125 and 5 μ Sv/h respectively.

HS_24

HS_24 was one of the largest pieces of contaminated material encountered at the site (cobble size) and was found at a depth of 0.2m. Maximum dose rates at contact and at 10cm were 7 and 1.5 μ Sv/h respectively. Direct probe readings of 2000cps were recorded.

HS_25

HS_25 (coarse sand) was located at a depth of 0.1m. Maximum dose rates at contact and at 10cm were 10 and 1 μ Sv/h respectively. Direct probe readings were greater than 5000cps.

HS_26

Two items were located at 0.15m and were coarse gravel sized clinker. Maximum dose rates at contact and at 10cm were 10 and 1.5 μ Sv/h for item "A" and 25 and 3 μ Sv/h for item "B" respectively. Direct 44B probe readings were 4000cps and >5000cps for "A" and "B".

HS_27

Five separate items were collected at this location of a similar size (medium gravel) and all at a depth of 0.2m. Direct 44B probe readings for items A, B, C, D and E were >5000, 300, 1500, 3000 and 700cps respectively. Dose rate measurements are listed below:

Item	Dose (contact) μ Sv/h	Dose (10cm) μ Sv/h
A	25	2.5
B	0.6	0.15
C	2	0.3
D	3	0.6
E	1.5	0.4

7 CLIFF FACE SURVEY

The cliff face describes an area of land south of the main survey area which is believed to comprise made ground arising from Donibristle air base (Figure 7.1).

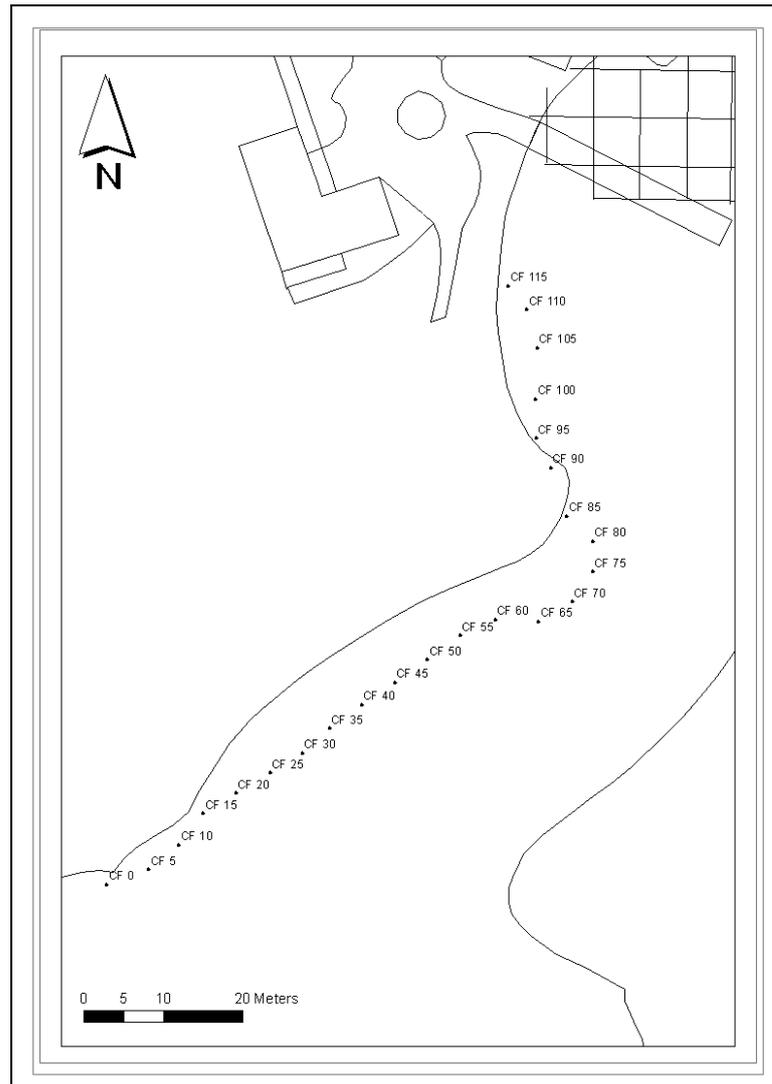


Figure 7.1 Extent of the cliff survey.
Note labelling denotes (CF), Cliff face 5 metre intervals along cliff edge.

Much of the section was obscured by imported stone that had been recently delivered for use as rock armour (Figure 7.2). Therefore, a full survey of the cliff was not possible.



Figure 7.2 Rock armour obscuring a large proportion of the cliff section.
Photograph taken looking north east along edge of cliff section.

The survey was undertaken on accessible exposures of made ground/fill material along the section. A tape measure was used to mark points at 5m intervals along the section and these positions were logged with a hand-held GPS unit capable of sub-metre accuracy.

Readings were collected on the exposed cliff face between the cliff-top and the base of the made- ground section at 0.25m intervals of height, at 1m intervals along the section. The instrument used was a 76mm sodium iodide scintillation detector (a Groundhog probe) with associated ratemeter. A table of data is found in the Appendix.

7.1 Summary of findings

The count rate of fill material monitored was between 130 and 540 cps, and the average reading was 238 cps (comparable to earlier Groundhog survey results from the beach survey). Two areas at CF36 (0.5m to 0.75m) and CF47 (0.5m) exceeded background conditions and required further investigation. A small amount of excavation into the cliff face was required in both cases; 75mm and 100mm for CF 36 and CF47 respectively and radium contaminated items were removed from both locations and the positions logged with a hand-held GPS. Data on the items can be found below.

Cliff face items retrieved on the 4th March 2006

CF_36

This item was removed from the cliff face section and comprised a coarse gravel sized clinker fragment. It was located at a depth of 0.075m into the cliff face. Direct probe readings of 3000cps were recorded on the item. Maximum dose rates at contact and at 10cm were 15 and 2 μ Sv/h respectively.

CF_47

Material removed from this section of the cliff face was fine material including some green coloured (paint?) flakes which could not be segregated further. Maximum dose rates at contact and at 10cm were 3 and 0.7 μ Sv/h respectively. Maximum probe readings taken on the bagged material were 1500cps.

8 ACTIVITY ASSESSMENT

The contaminated items discovered during the investigation are listed in Table 7.1.

Activity assessment was initially undertaken using a relationship between measured dose rate and radioactivity content determined by a Microshield computer model. The model calculated a relationship of 0.0005573 μ Sv per Bq Ra-226.

In some cases where the dose rate exceeded the range on the dose rate meter (100 μ Sv/h) the inverse square law was used to calculate dose rate in close proximity to the particles:

$$D_1 r_1^2 = D_2 r_2^2$$

Where D1 is the dose rate at distance r1 from the source and D2 is the dose rate at distance r2 from the source.

Location	Easting	Northing	ID No	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	44B cps	Max Dose Rate (μSvh^{-1})	Distance (cm)	Max Dose Rate (μSvh^{-1})	Distance (cm)	Inventory (kBq)
HS_1	316502.04	683110.47	1_0.1m	0.5	8	4	2	>5000	125	2	5	10	224
HS_2	316496.80	683120.25	2_0.05m	4	18	15	8	700	1.5	2	0.15	10	3
HS_3	316498.78	683122.35	3_surface	1	4	3	2	500	0.4	2	0.15	10	1
HS_3	316498.78	683122.35	3_0.15	1	7	6	4	1000	2	2	0.5	10	4
HS_4	316495.17	683129.68	4_0.03	1	3	3	2	>5000	16	2	0.6	10	29
HS_5	316494.24	683129.45	5_0m	1	3	3	2	>5000	10	2	1	10	18
HS_6	316493.66	683131.54	6_0.05m	1	2	2	1	300	0.3	2	0.15	10	1
HS_6	316493.66	683131.54	6_0.1m	5	25	20	10	300	0.4	2	0.15	10	1
HS_7	316490.40	683132.01	7_0.15m	2	10	8	8	1500	2	2	0.15	10	4
HS_8	316486.67	683133.52	8_0.15m	30	50	40	25	2000	10	2	1.5	10	18
HS_9	316488.77	683135.27	9_0.05m	7	20	15	15	500	1.5	2	0.6	10	3
HS_10	316486.79	683141.21	10_0m	5	15	10	10	500	0.5	2	0.15	10	1
HS_11	316486.67	683143.88	11_0.05m	17	25	20	15	1500	5	2	0.7	10	9
HS_12	316491.56	683140.74	12_0.03m	5	10	5	4	1500	10	2	0.2	10	18
HS_13	316490.75	683138.30	13_0.075m	10	30	15	10	300	0.5	2	0.15	10	1
HS_14	316503.79	683106.14	14_0.12m	1	2	2	1	>5000	125	2	5	10	224
HS_15	316500.18	683082.50	15_0.27m	167	85	70	50	>5000	250	2	10	10	449
HS_16	316497.15	683087.28	16_0.1m_A	1	8	4	1	>5000	40	2	3	10	72
HS_16	316497.15	683087.28	16_0.1m_B	1	4	4	3	2000	2	2	0.5	10	4
HS_17	316482.48	683083.55	17_0.05m	1	4	3	2	2000	3	2	0.4	10	5
HS_18	316492.96	683075.98	18_0.15m	1	1	1	1	5000	10	2	0.3	10	18
HS_19	316487.72	683592.68	19_0m	86	85	50	25	>5000	200	2	8	10	359
HS_20	316463.29	683040.45	20_0.05m	10	20	15	15	3500	7.5	2	0.6	10	13
HS_21	316495.39	683087.90	21_0.1m	10	25	20	10	>5000	150	2	6	10	269
HS_22	316496.51	683089.02	22_0.15m	1	5	5	4	>5000	30	2	1.5	10	54
HS_23	316513.04	683122.82	23_0.15m	1	8	6	5	>5000	125	2	5	10	224
HS_24	316514.54	683135.21	24_0.2m	382	115	75	55	2000	7	2	1.5	10	13

Location	Easting	Northing	ID No	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	44B cps	Max Dose Rate (μSvh^{-1})	Distance (cm)	Max Dose Rate (μSvh^{-1})	Distance (cm)	Inventory (kBq)
HS_25	316510.03	683140.10	25_0.1m	<1	9	6	1	>5000	10	2	1	10	18
HS_26	316511.91	683130.71	26_0.15m_A	32	55	30	20	4000	10	2	1.5	10	18
HS_26	316511.91	683130.71	26_0.15m_B	36	45	35	25	>5000	25	2	3	10	45
HS_27	316511.91	683130.71	27_0.2m_A	319	120	90	50	>5000	25	2	2.5	10	45
HS_27	316511.91	683130.71	27_0.2m_B	1	9	7	5	300	0.6	2	0.15	10	1
HS_27	316511.91	683130.71	27_0.2m_C	1	7	5	5	1500	2	2	0.3	10	4
HS_27	316511.91	683130.71	27_0.2m_D	1	7	4	1	3000	3	2	0.6	10	5
HS_27	316511.91	683130.71	27_0.2m_E	1	3	2	1	700	1.5	2	0.4	10	3
CF_36	316448.45	683040.21	0.075m	61	60	40	30	3000	15	2	2	10	27
CF_47	316456.71	683046.21	0.1m	21	fine material	fine material	fine material	1500	3	2	0.7	10	5
				WEIGHT (g)	1226.5						TOTAL INVENTORY		2210 kBq
											2.21 MBq		

Table 8.1

Radioactive inventory of items found at Dalgety Bay March, 2006.

Note: the figure of 2cm is used for contact dose rate measurements for calculation purposes.

The number refers to the distance between the outer casing of the instrument and the centre of the GM tube.

9 DISCUSSION

Sources of radioactive contamination

The survey has indicated that there may be two source areas of contamination at Dalgety Bay: the cliff face section south of the main survey area and the area adjacent to the north slipway. The former area yielded two contaminated items during the survey whilst the latter area contained a greater number of items than any other area. Additionally, the soils present at the northern end of the area contained more ashy clinker material than areas subject to tidal/wave action.

Transport of radioactive particles

Radioactive particles will almost certainly be transported by tidal/wave action from source areas, which would explain the distribution of some of the smaller hotspots that were located remote from the contamination source. Heavier items found at depth are likely to have been buried by sand and sediment disturbed by wave action and eddies created by water flow around rocks.

10 RECOMMENDATIONS

The survey results provide comprehensive information on the distribution of radioactive particles across the foreshore and in the exposed cliff face believed to be the contamination source. However, these results relate to a particular instance in time and do not provide any information on the rates of release and transport of particles. It is recommended that a further survey is undertaken at regular intervals to acquire comparative data which will provide such information.

11 CONCLUSION

A three day investigation of the Dalgety Bay site was undertaken between the 2nd and 4th of March 2006 comprising surface radiation surveys and removal of identified hotspots. In total, 37 radioactive items were identified and removed during the investigation. The general form of the material was clinker with the exception of small loose flakes of paint found in the cliff face. The total weight of waste materials was approximately 1227 g which is scheduled to be transported to a licensed waste facility.

12 REFERENCES

BES/SEPA, 2005. Dalgety Bay Monitoring Project, March 2005.

BRITISH STANDARDS INSTITUTE, BSI, 1999. Code of practice for site investigations British Standard 5930.



RWE NUKEM

Appendix

TR/89191/01
Issue A

Depth (m)	CF48	CF49	CF50	CF51	CF52	CF53	CF54	CF55	CF56	CF57	CF58	CF59	CF60	CF61	CF62	CF63
0	N/A	N/A	N/A	N/A	160	190	N/A									
0.25	-	-	-	-	220	260	-	-	-	-	-	-	-	-	-	-
0.5	-	-	-	-	220	360	-	-	-	-	-	-	-	-	-	-
0.75	-	-	-	-	-	300	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	320	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Depth (m)	CF64	CF65	CF66	CF67	CF68	CF69
0	N/A	N/A	260	230	260	230
0.25	-	-	280	300	290	280
0.5	-	-	350	300	340	350
0.75	-	-	400	310	380	320

Notes

CF24 and CF25 waste appears to be domestic rather than industrial: plastic can holder, sock, brick, glass

CF36 Elevated activity detected at ~0.75m (cps, 44B probe 25) contaminated items removed (see artefact log)

CF47 Elevated activity detected at ~0.5m (cps, 44B probe 100) contaminated items removed (see artefact log)

CF70 to CF115 inaccessible due to imported stone

Dalgety Bay photographic log of artefacts removed during site work



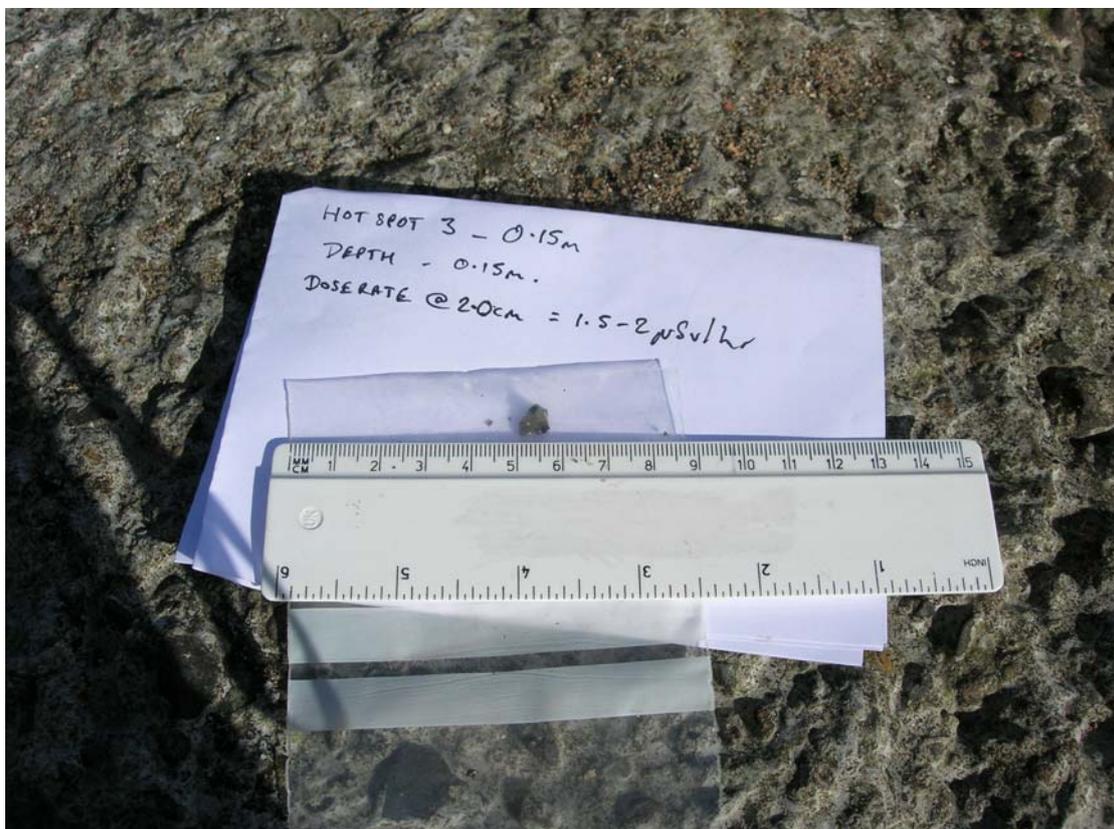
Hotspot 1 (by tip of trowel)



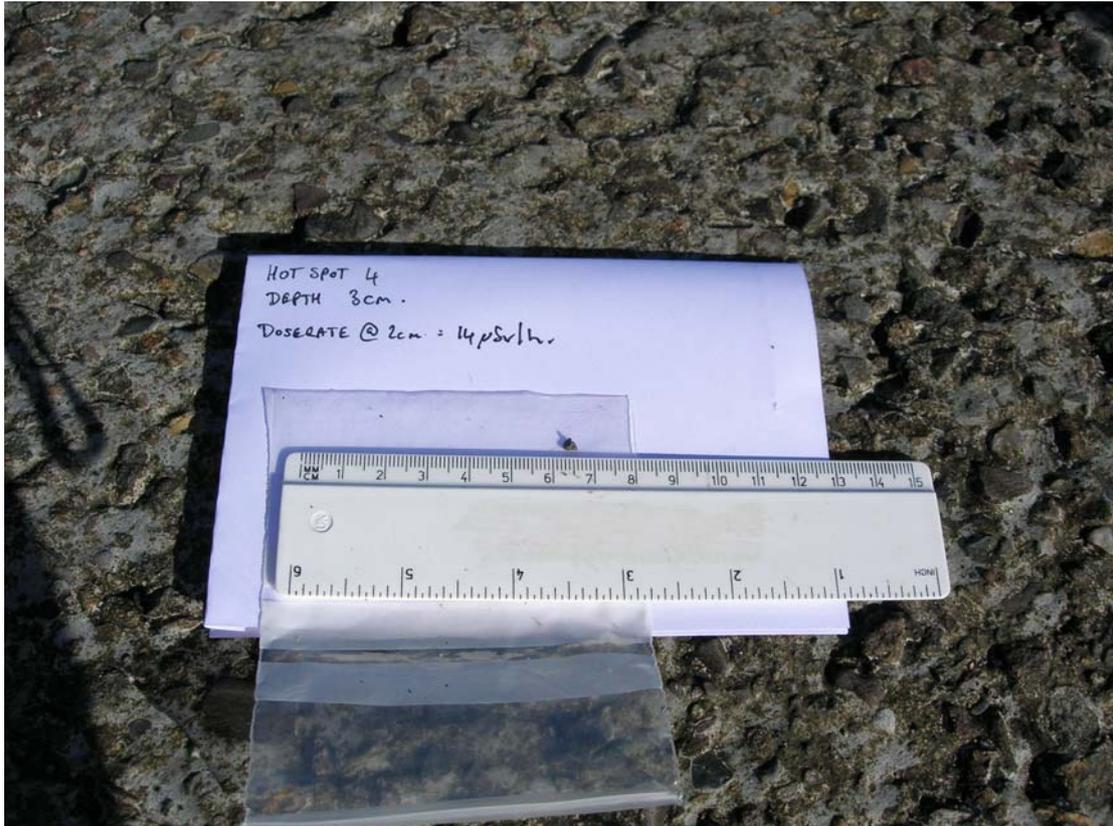
Hotspot 2



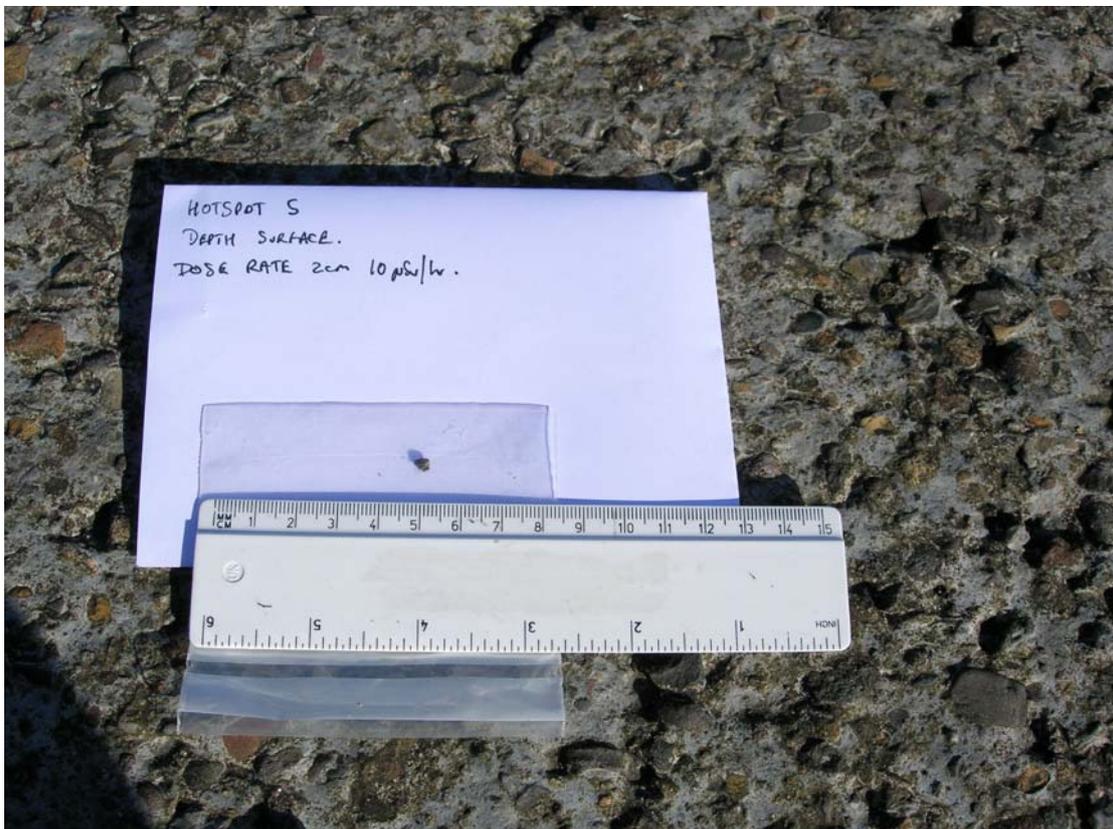
Hotspot 3 at surface



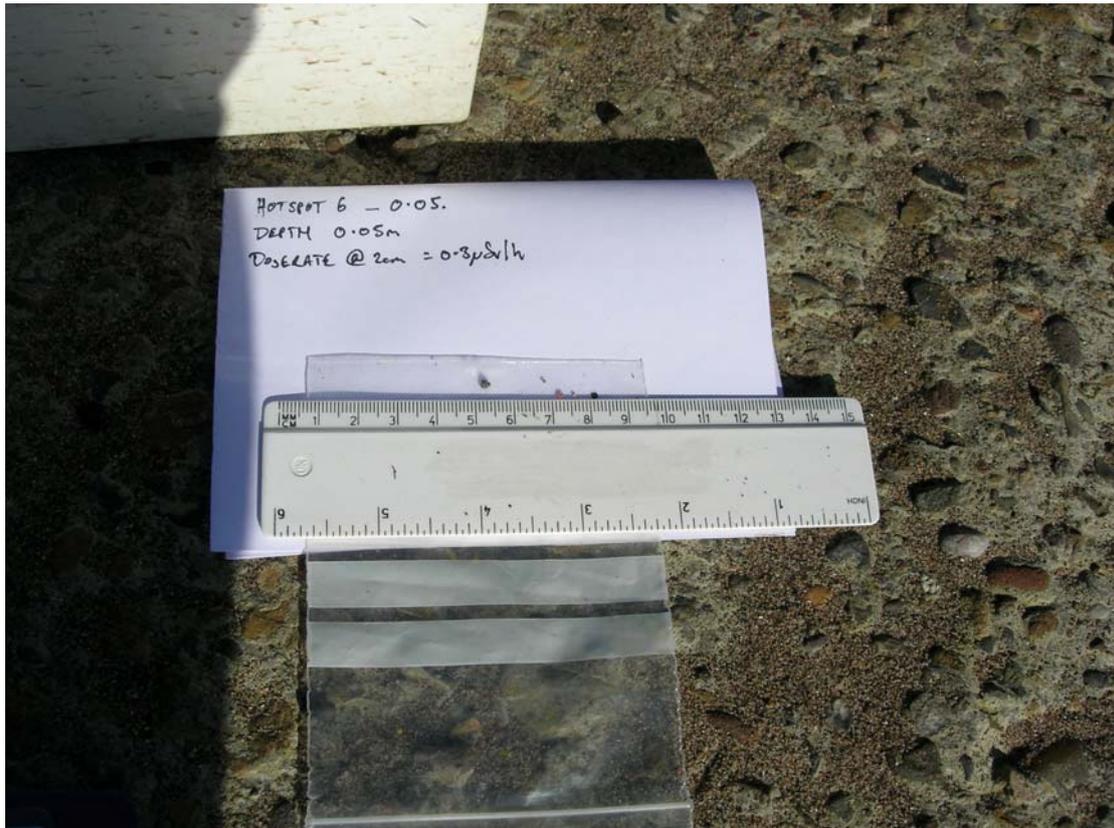
Hotspot 3 at 0.15m



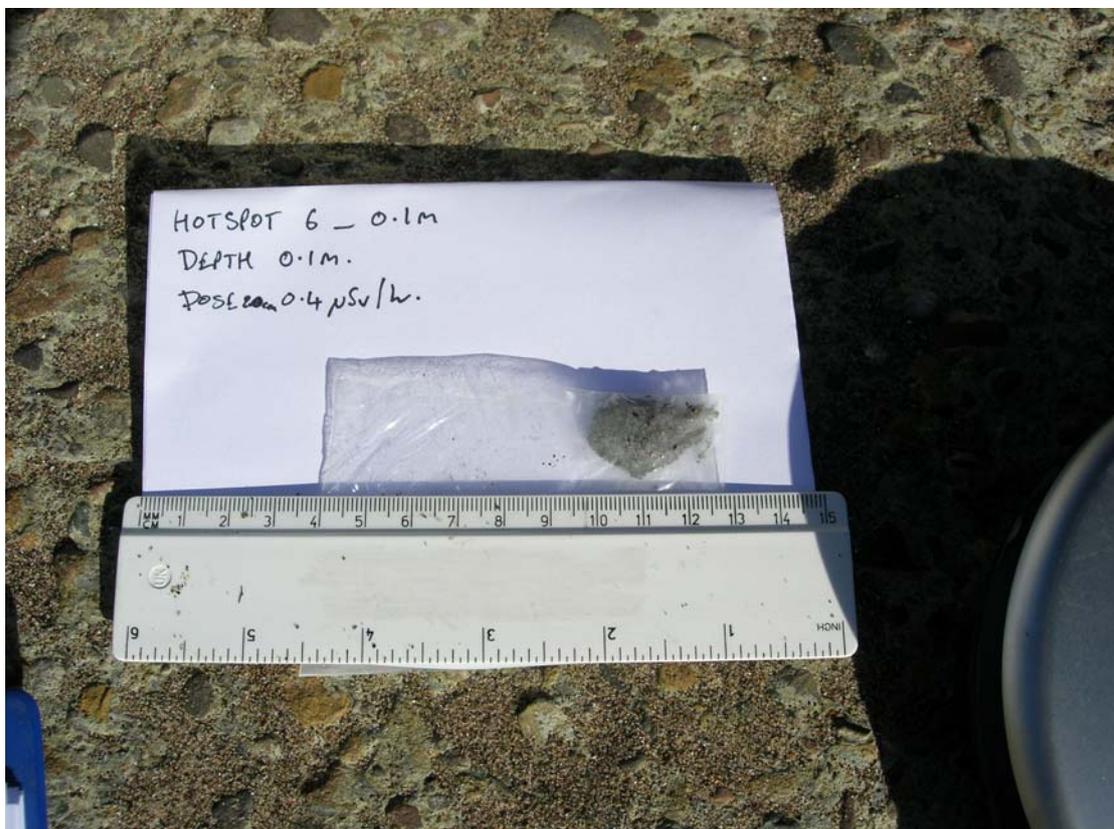
Hotspot 4



Hotspot 5



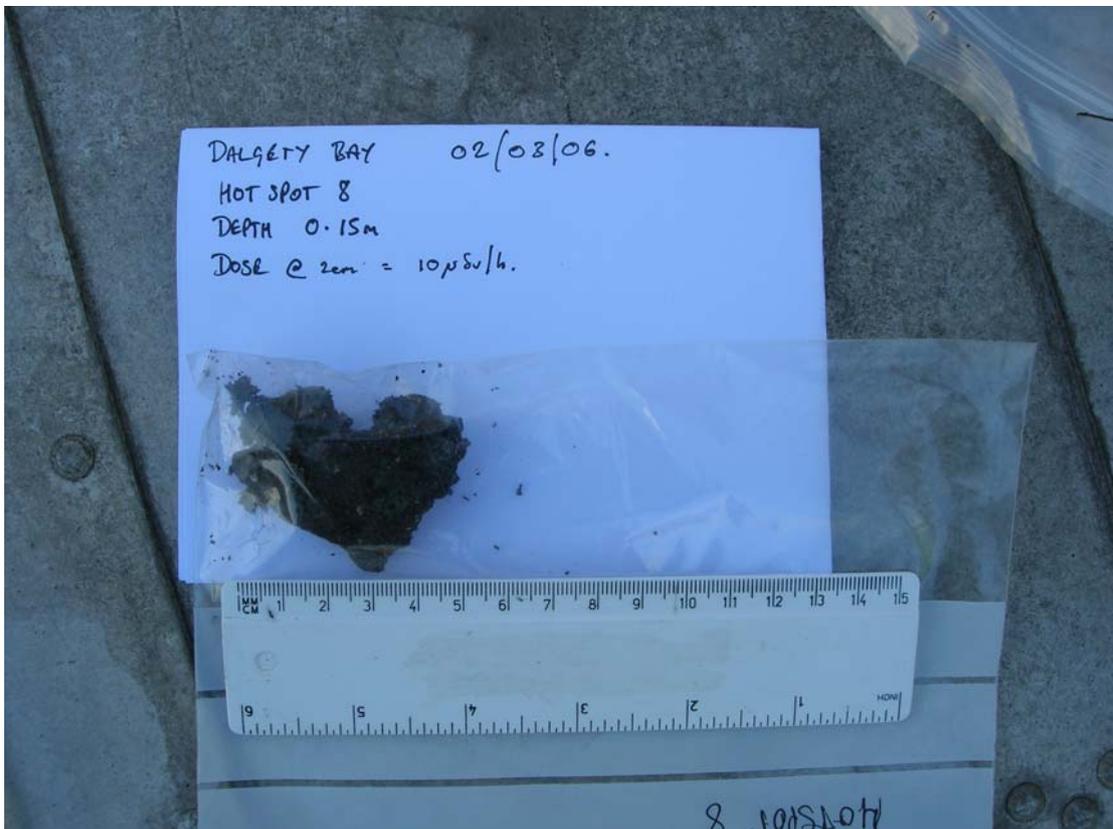
Hotspot 6 at 0.05m



Hotspot 6 at 0.1m



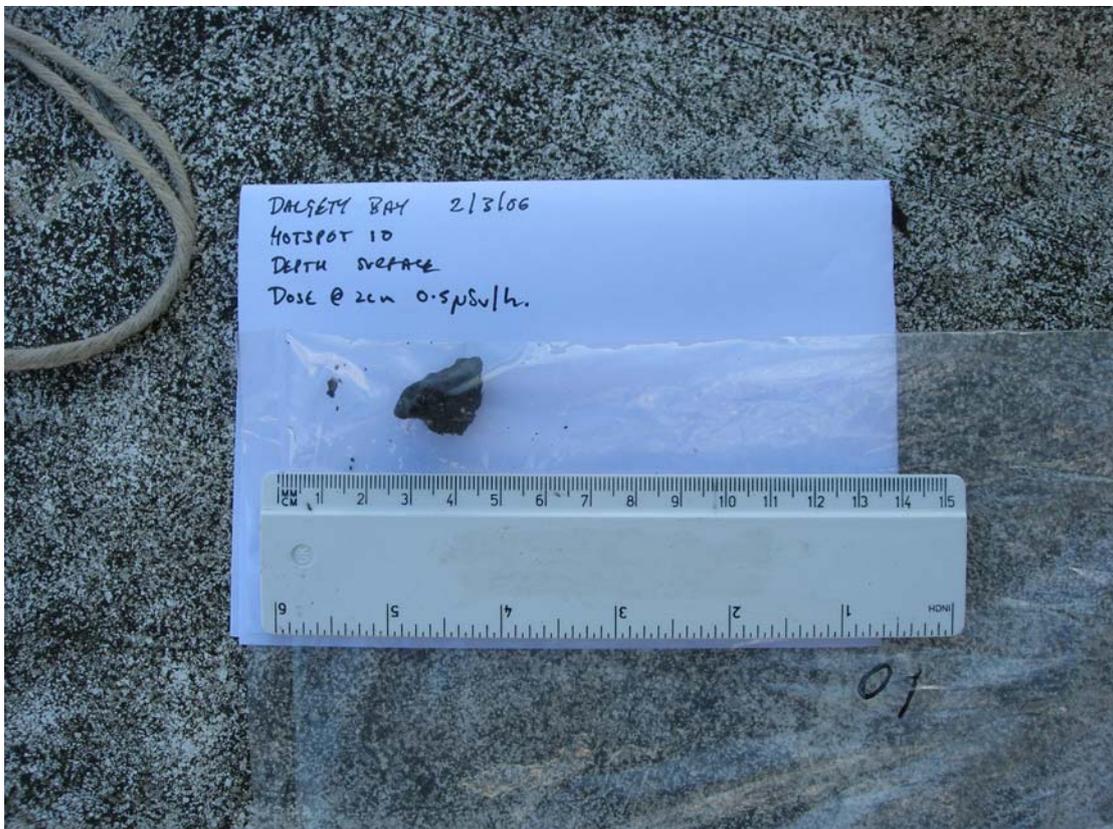
Hotspot 7



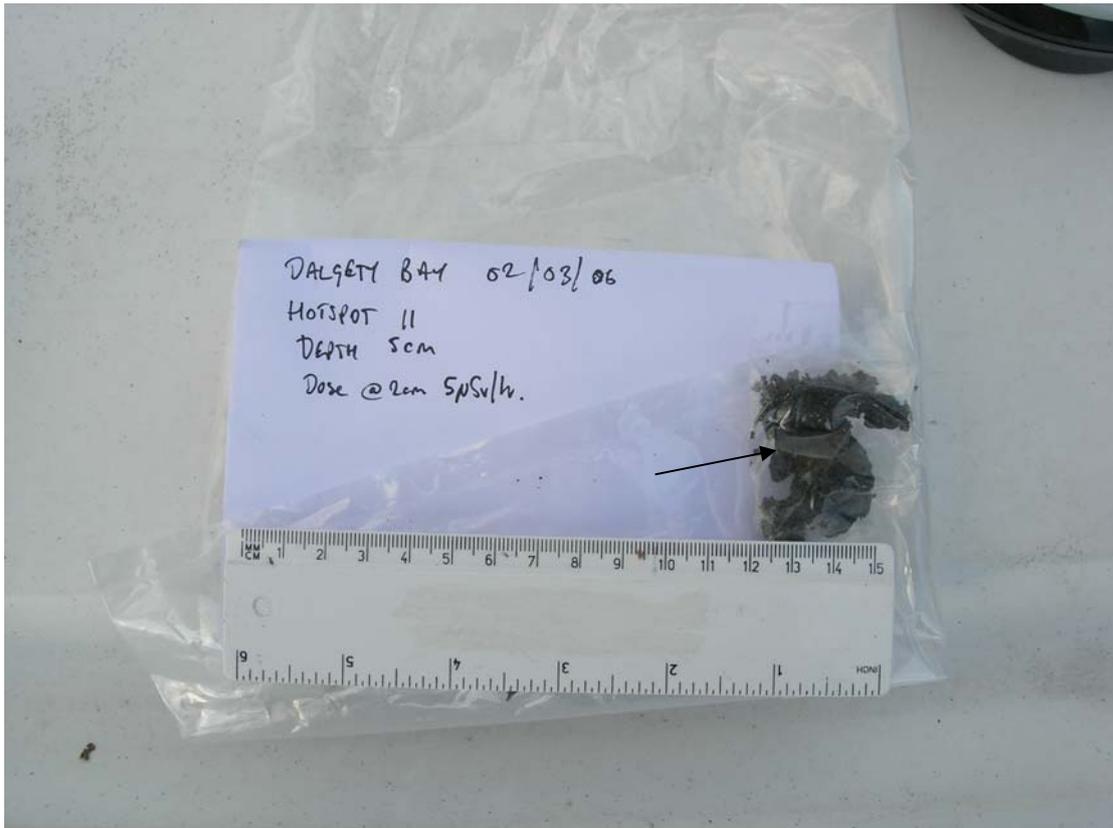
Hotspot 8



Hotspot 9



Hotspot 10



Hotspot 11



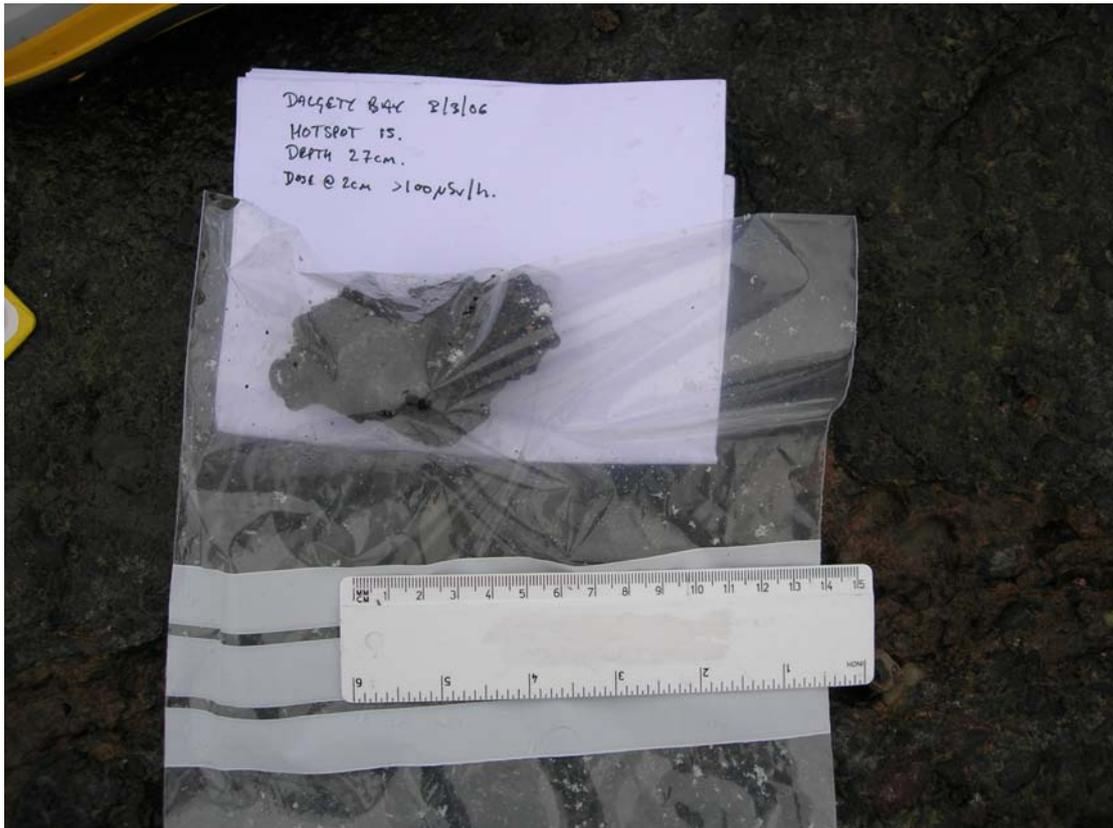
Hotspot 12



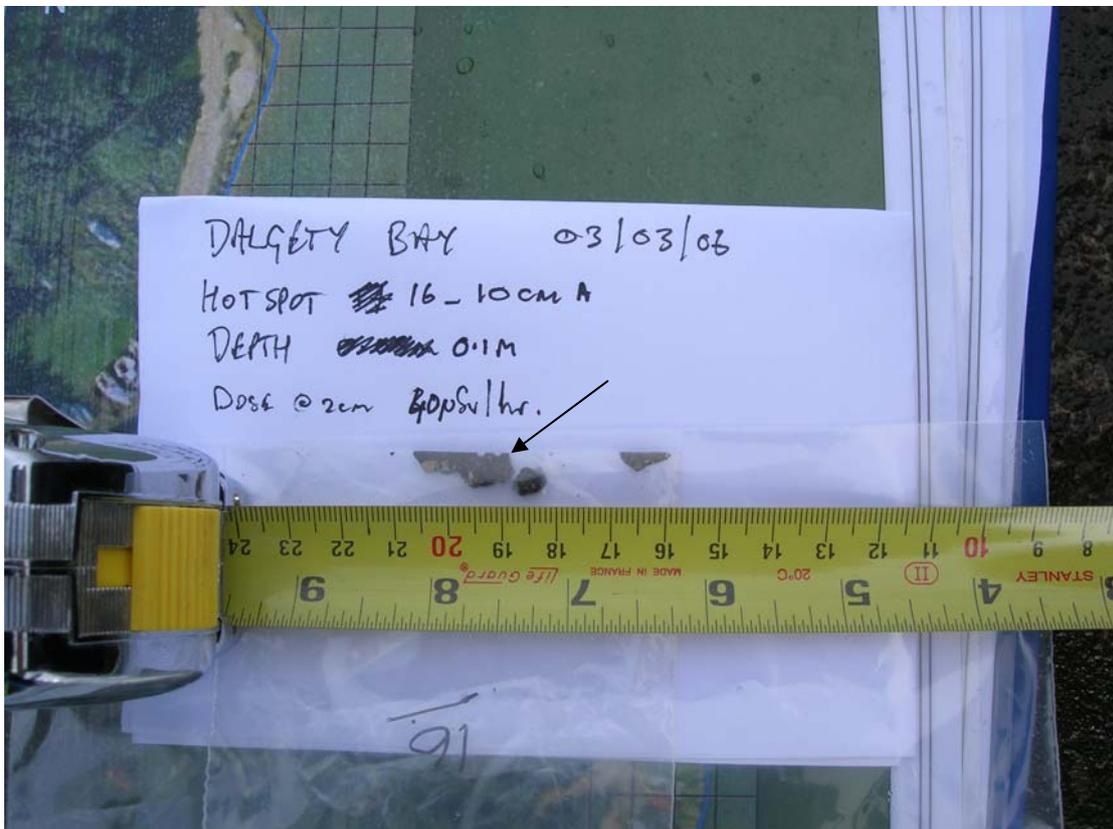
Hotspot 13



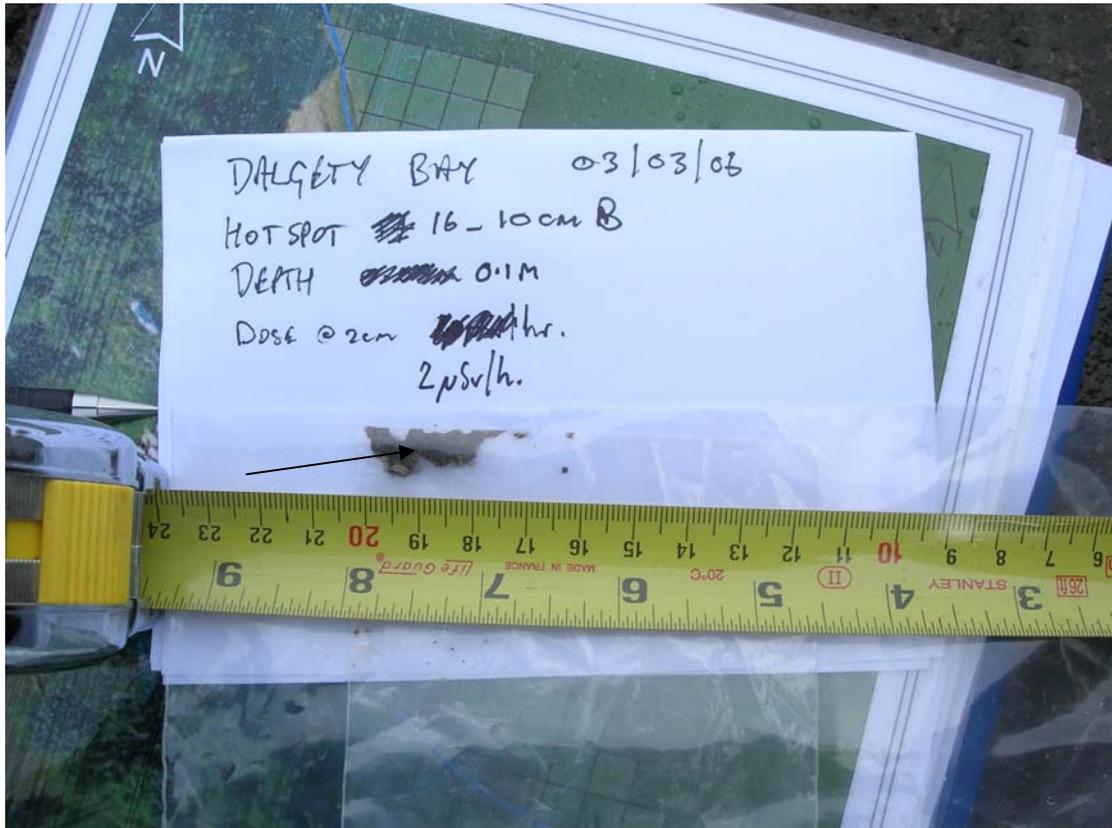
Hotspot 14



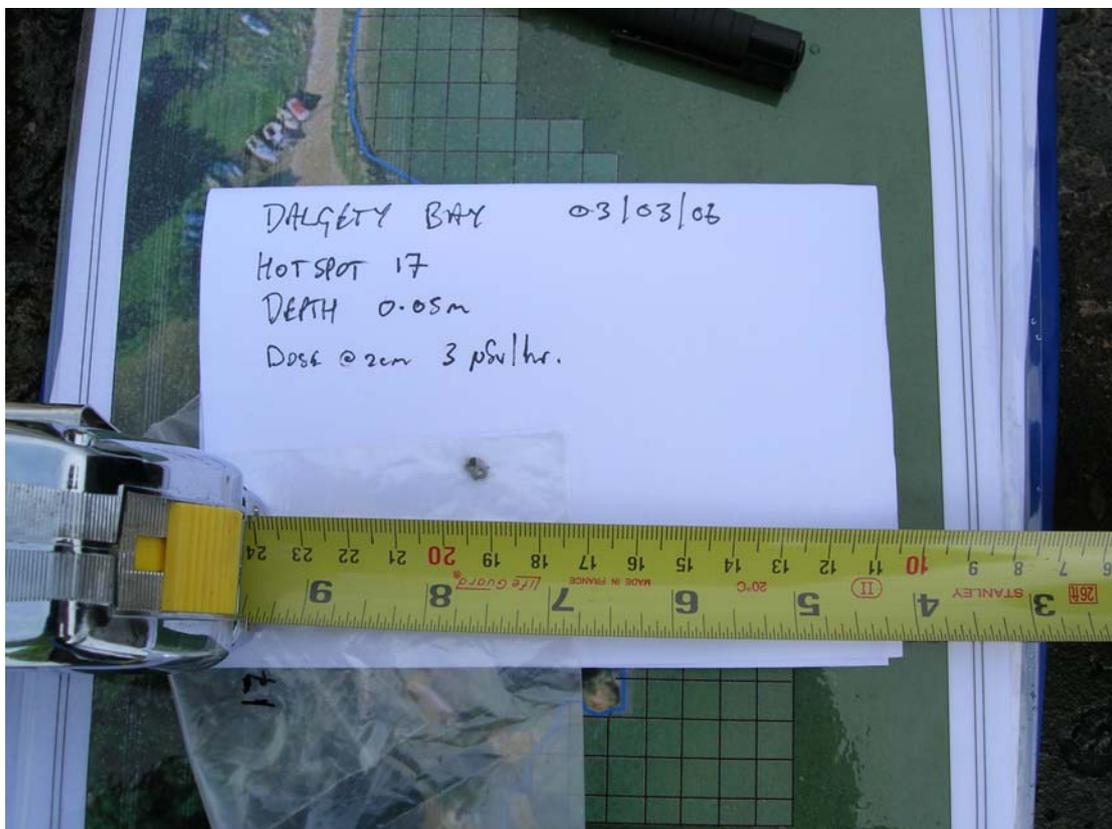
Hotspot 15



Hotspot 16 0.1m_A



Hotspot 16 0.1m_B



Hotspot 17

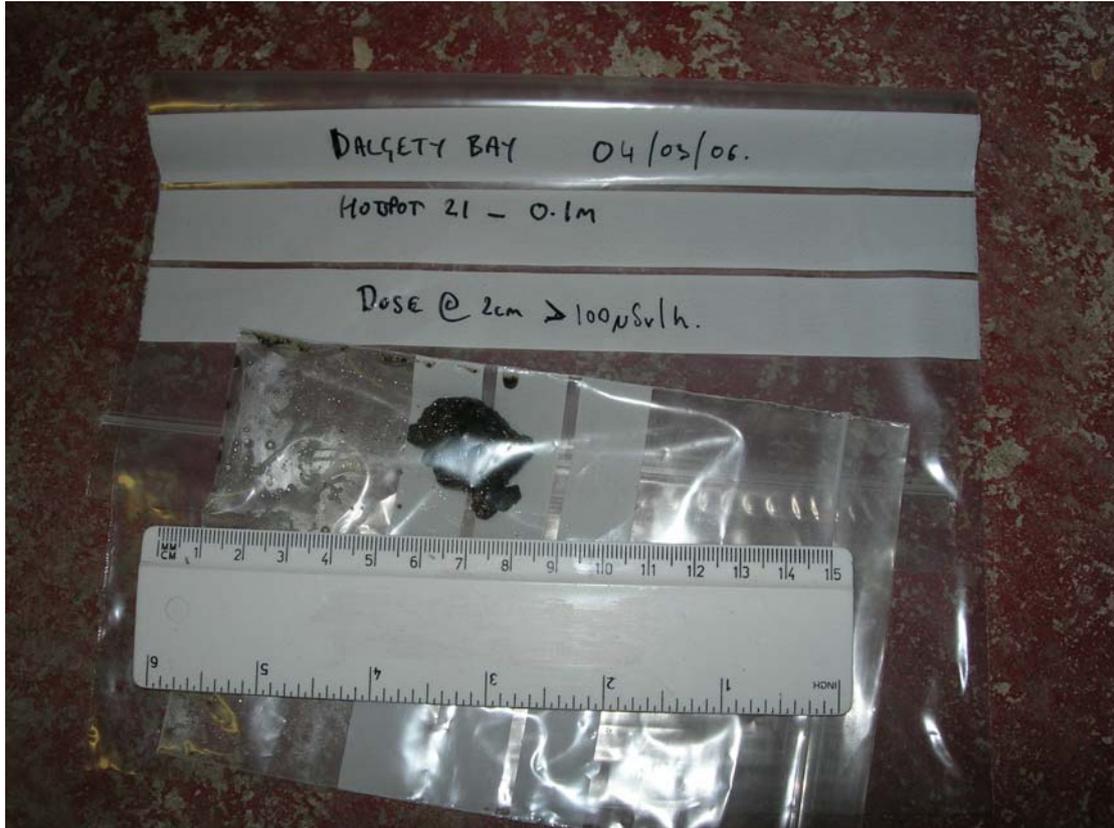
Please note that no photograph is available for Hotspot 18



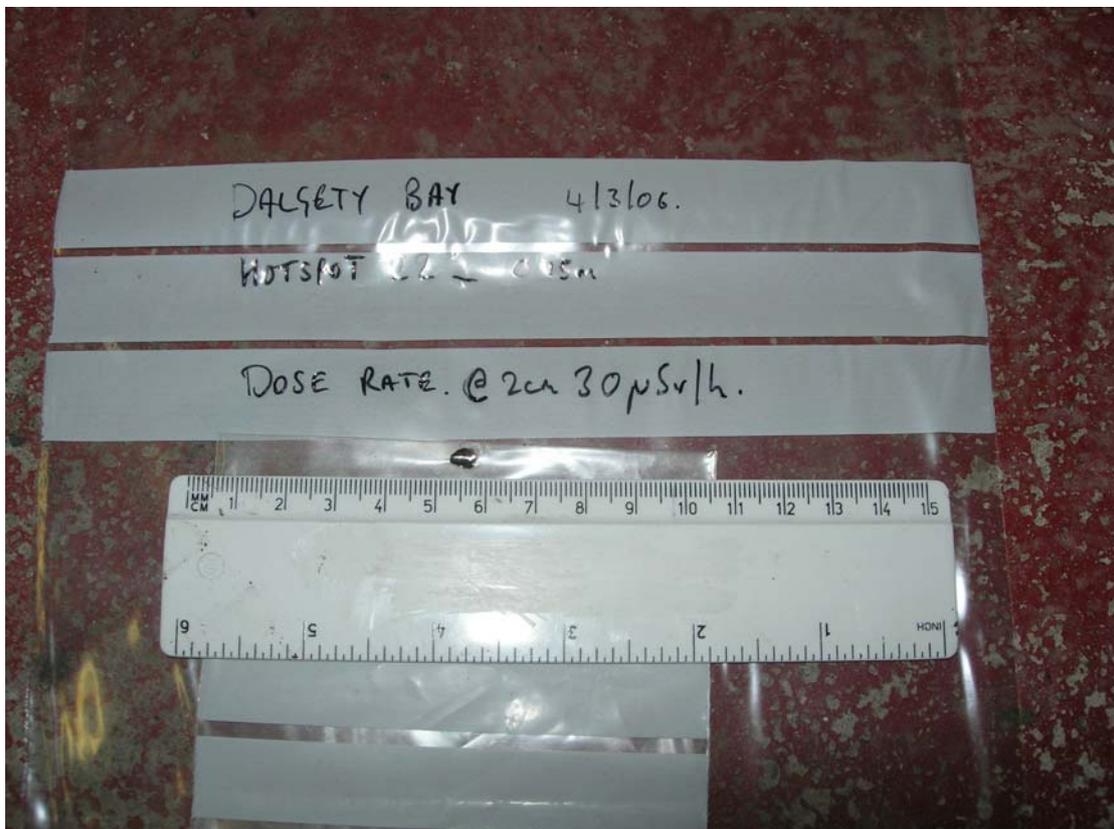
Hotspot 19



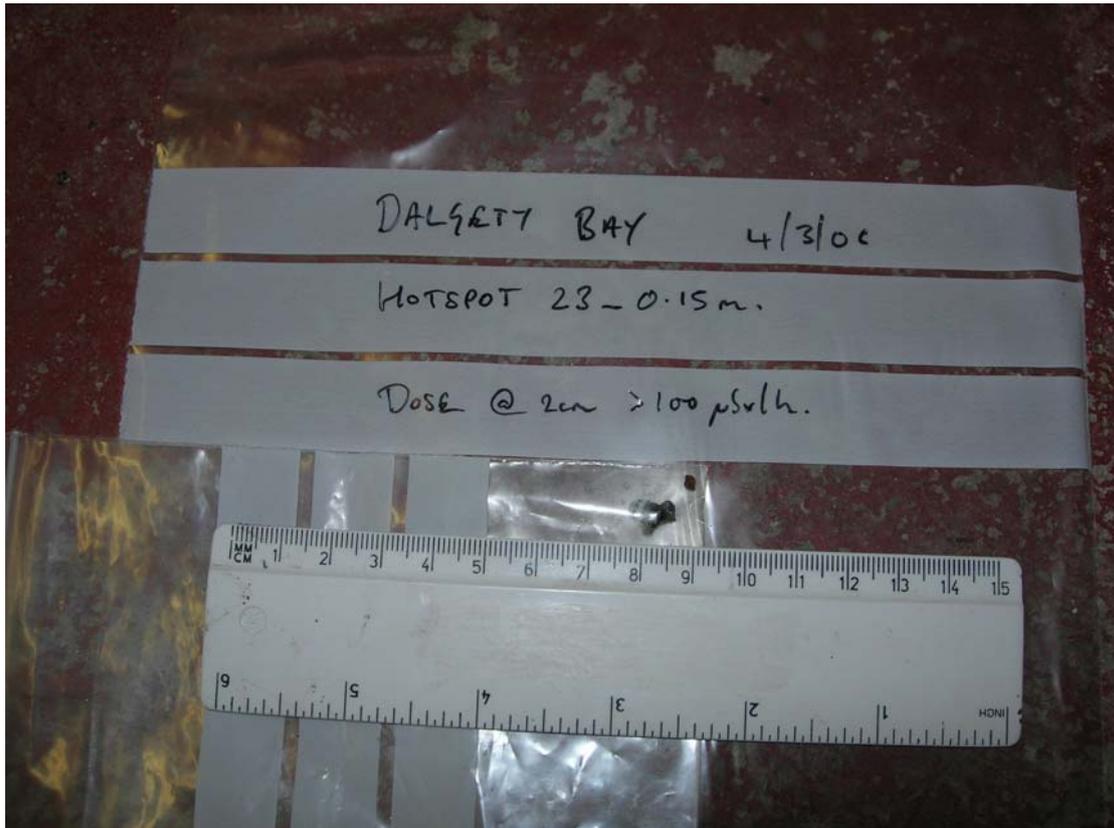
Hotspot 20



Hotspot 21



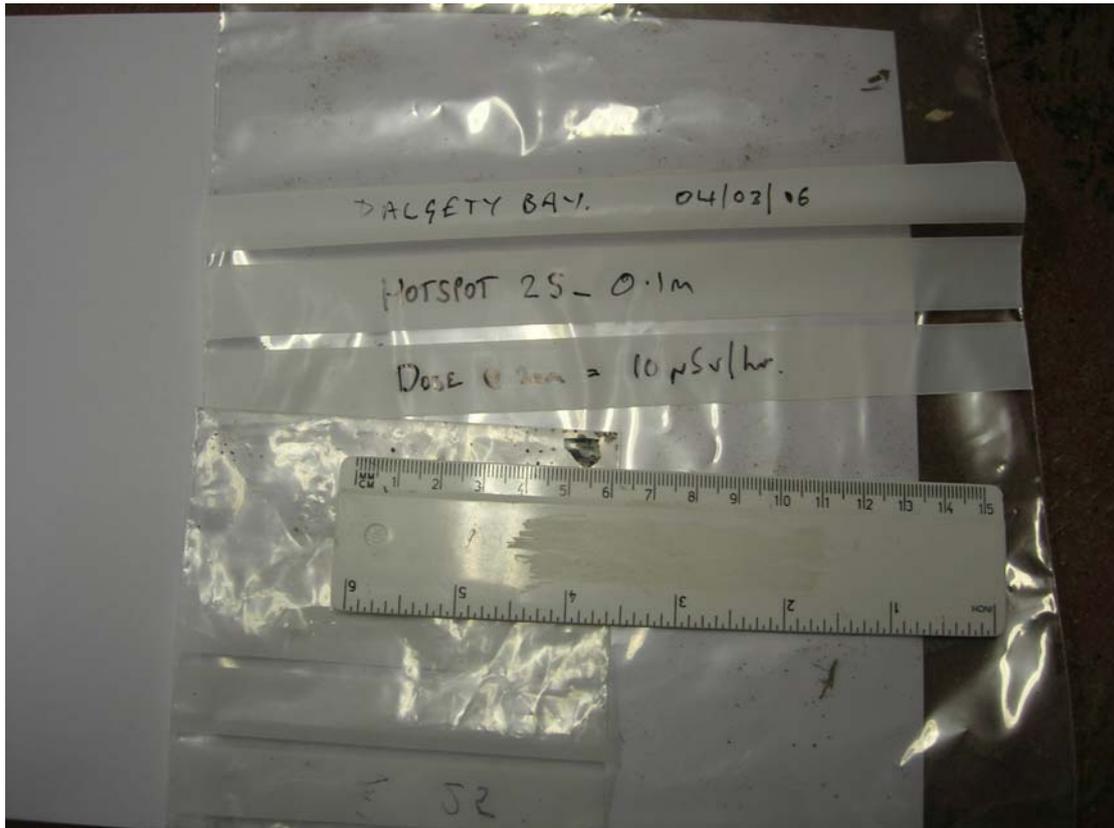
Hotspot 22



Hotspot 23



Hotspot 24



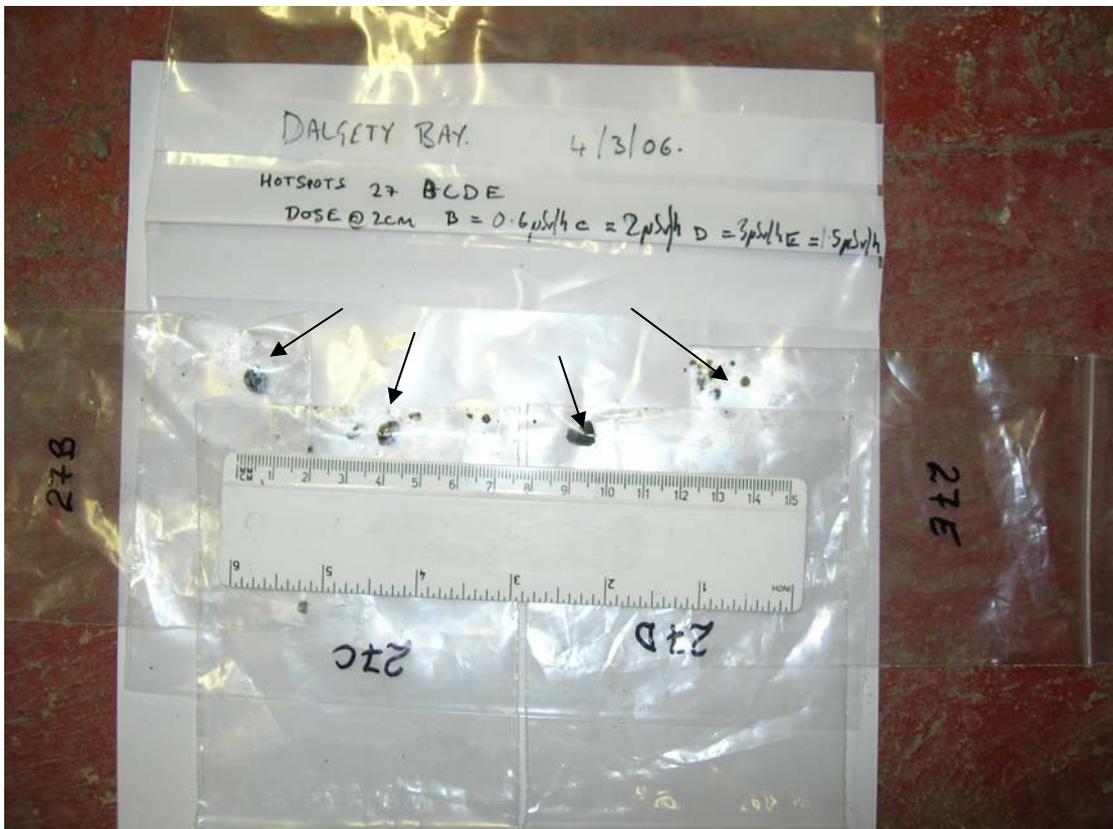
Hotspot 25



Hotspots 26A and 26B



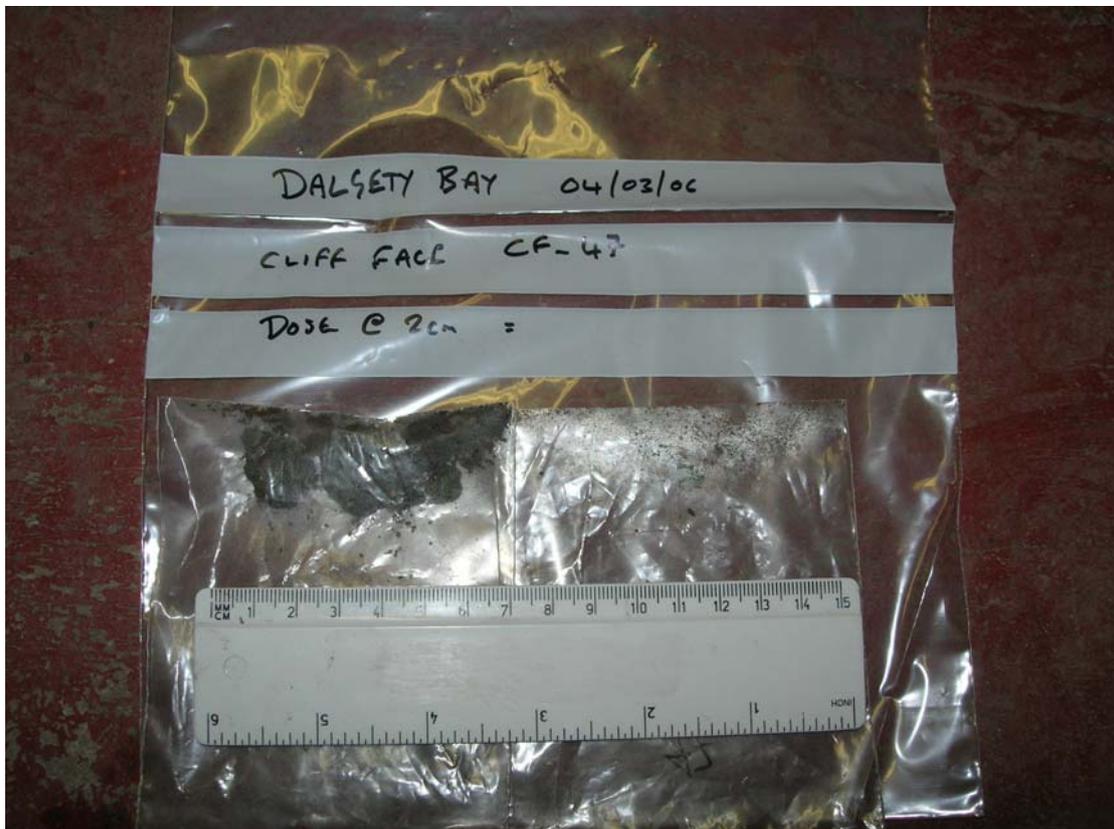
Hotspot 27A



Hotspots 27B to 27E



Hotspot (Cliff face) CF_36



Hotspot (Cliff face) CF_47