Collecting and Analysing Samples from Bulk Materials in Accordance with the Nuclear Industry Code of Practice:

Improvements and Impracticalities

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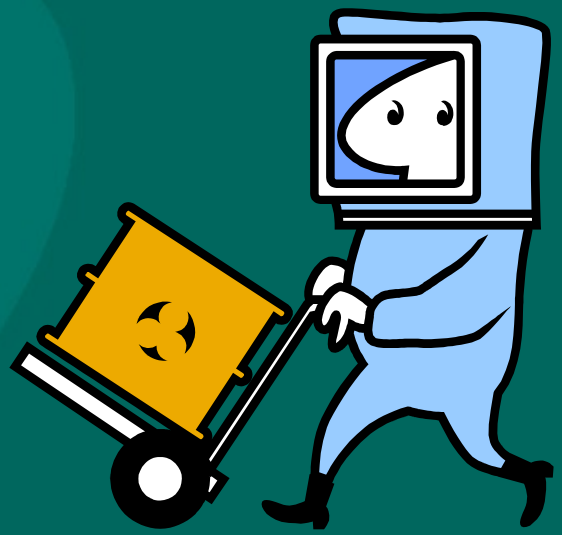
What we do

Collect and analyse samples to determine how to dispose of bulk materials arising from various projects across AWE



Why we do it

The correct sentencing of bulk wastes relies on the accuracy of the sampling and analysis that precedes it.

Total Error = Sampling Error + Analytical Error

Overview of Sampling Procedures

Collecting Samples

- We commonly collect samples of:
  - Soil
  - Tarmac
  - Concrete
  - Plaster
  - Brick and
  - Sand

- Soil and sand samples are collected from the top 5cm using a trowel.
- All other samples are collected by drilling into the top 2mm of the material and creating a dust.

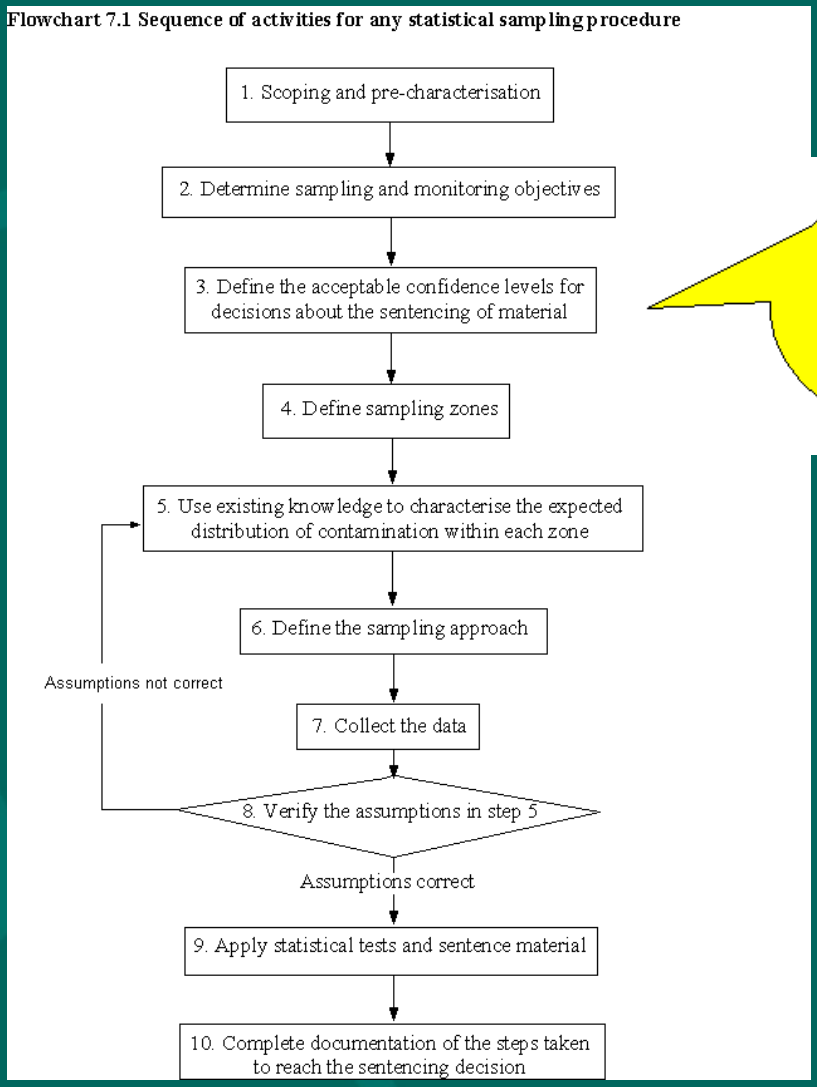
Classification of Tasks: Class 4 Tasks

- All jobs are grouped into one of four classes.
- Class 4 tasks are jobs with a low potential for contamination (based on history) and expected arrisings of less than 40m^3.
- These tasks are sampled judgementally.
- This is justified in chapter 6.2 of the Code of Practice, where is states:

"If provenance alone is enough to provide strong justification that an item or material has not been activated or contaminated, measurements are only taken for reassurance. It is not necessary in this case to follow statistical guidance, although professional judgement is required to decide the extent of and locations where measurements should be made."

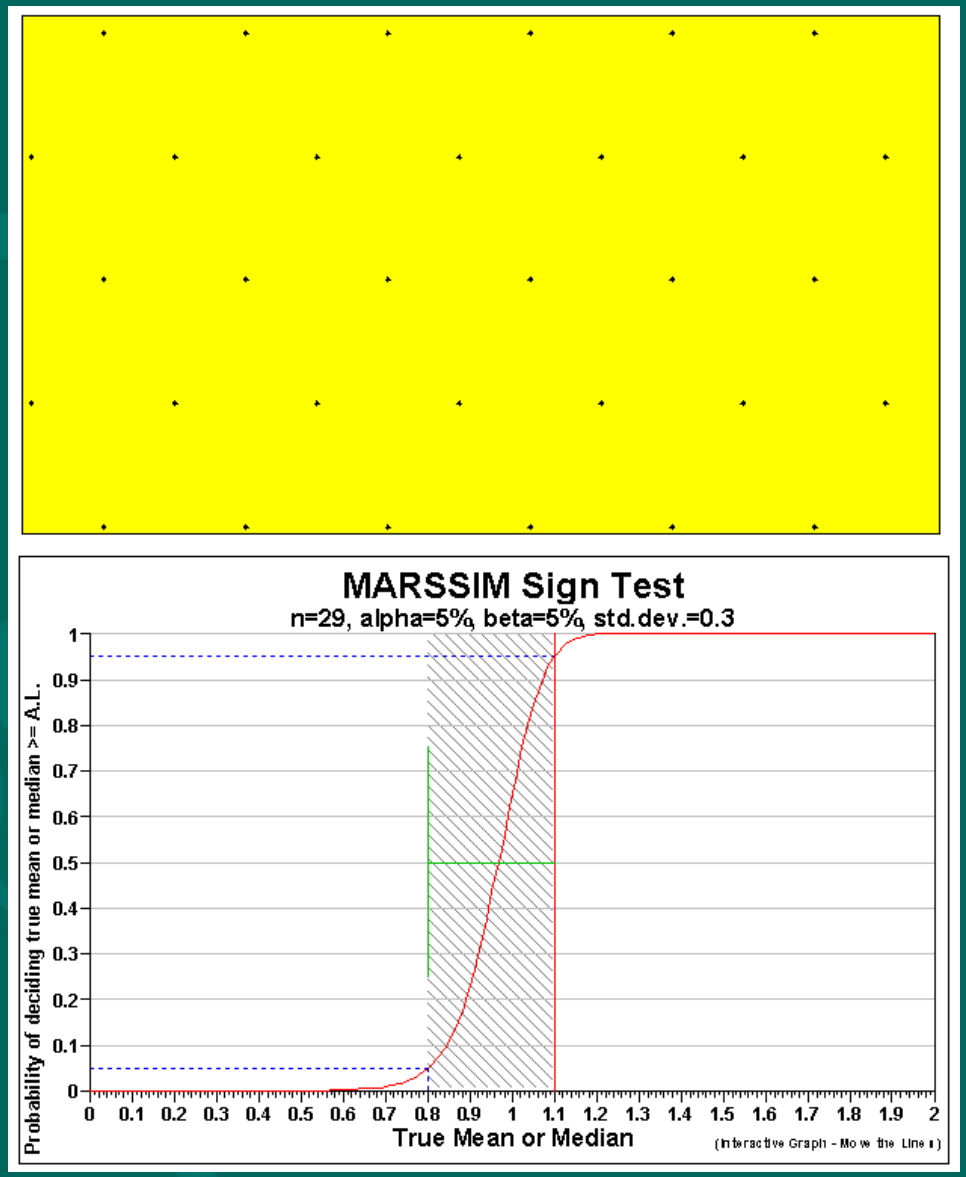
Class 1 – 3 Tasks

- Class 1 – 3 jobs are higher risk tasks, as there is either a greater chance of contamination, or a larger amount of waste.
- These tasks follow the 7-step DQO (Data Quality Objectives) process, and sampling is dictated by VSP (Visual Sampling Plan) software.



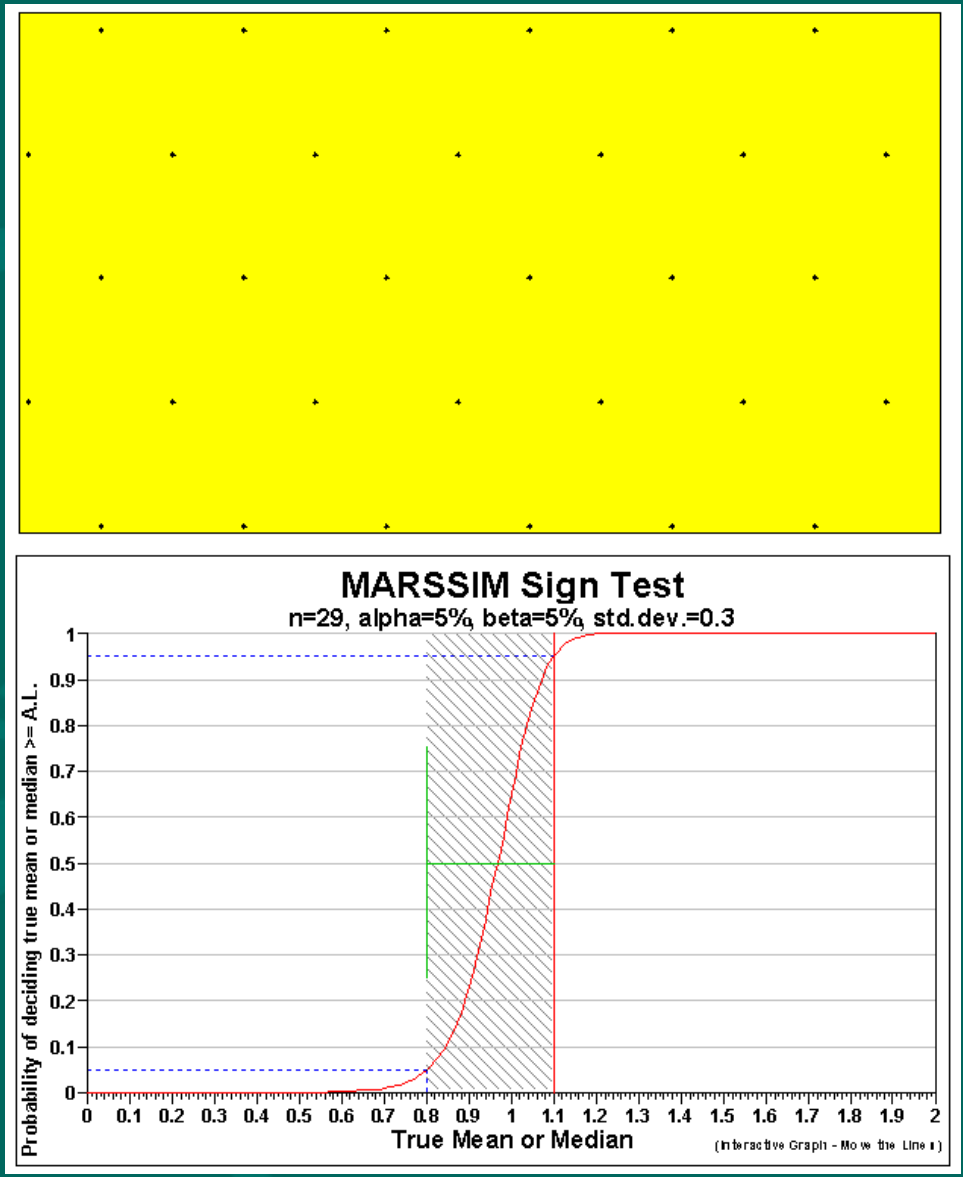
VSP Software

- Takes the parameters that were decided during the DQO process and uses them alongside suitable statistics to produce a sampling plan.
- The alpha level of 5% is the risk of concluding that the site is clean when in fact it's dirty.
- The beta level is the risk of concluding that the site is dirty when in fact it's clean.



VSP Software (2)

- Marssim is a non-parametric statistical test (does not assume normal distribution)
- Ensures enough samples are taken to accurately sentence the waste.
- Can also be used within buildings.



Advantages

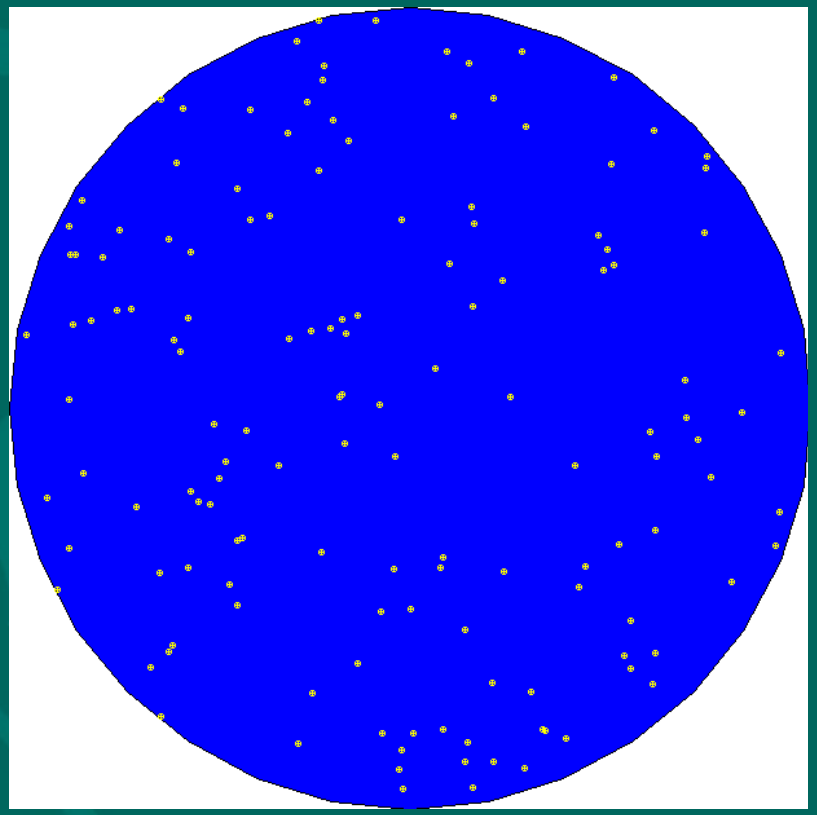
- The judgemental sampling of the class 4 jobs ensures that we get a 'worst case scenario' result.
- Using the DQO process on the class 1 – 3 jobs we can consider a wide range of contaminants and be 95% confident that we have correctly sentenced the waste, and if necessary, we can defend all of the decisions we've made.
- Chapter 7.2 of the Code of Practice states:

> - *Generation of a sampling plan that will provide demonstrable compliance with the regulatory requirements for clearance of materials; and*
> - *Ensuring that the sampling and assessment process is robust and defensible*

Disadvantages: Example 1

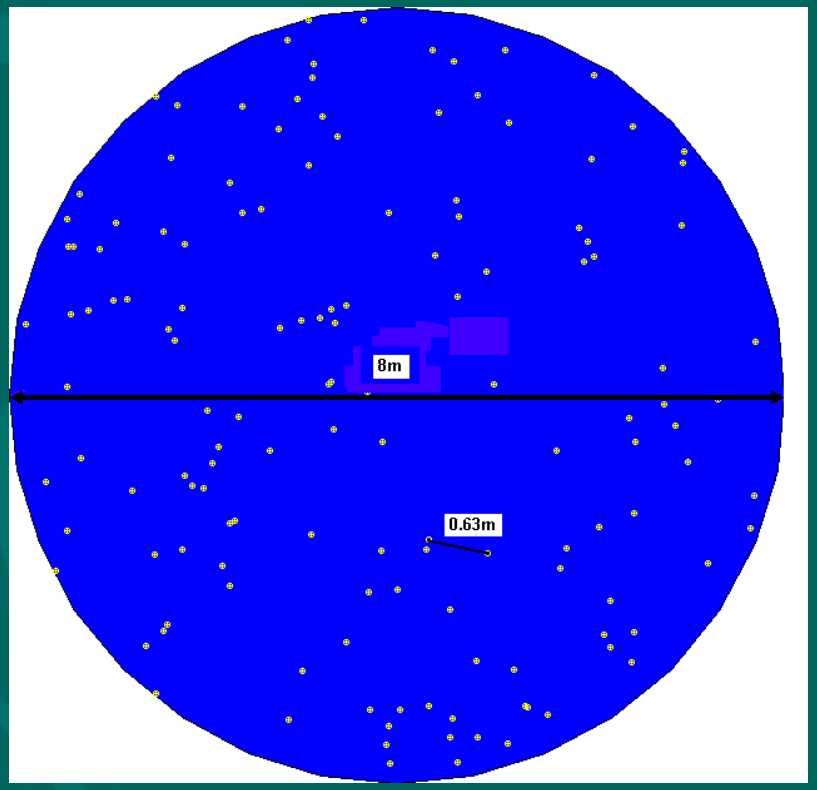
The scenario

- A building at AWE
- History shows potential for significant contamination
- The building gets classed as a class 1 project
- The alpha and beta levels are set at 1%
- 140 samples are required



Disadvantages: Example 1

- The building is one circular room with a diameter of 8m
- The average distance between samples is 0.63m
- There is only likely to be 5m^3 of waste produced
- By collecting 140 samples 0.5% of the waste has already been removed



Disadvantages: Example 2

- Historically all samples were collected from the surface of a material. This practice has continued.
- Often means buildings are sentenced as hazardous waste, when the average concentration of a contaminant could have been lowered if we had drilled deeper than 2mm.
- Other departments at AWE are looking into the feasibility of sandblasting walls and scabbling floors to remove surface contamination. These are expensive techniques.
- The Code of practice suggests:

> *"Acceptable dilution may occur as a result of the nature of the material (for example, where brickwork is contaminated only close to the surface on one side but segregation or separation is not practicable)."*

- What is the definition of 'Practicable'

Overview of Analytical Procedure

- Sites containing mixed wastes are frequently found at AWE
- All contaminants are considered in the DQO Process
- We collect and analyse samples for the following determinants:

  - Gross Activity
  - Tritium
  - Chemicals
  - Explosives

RA Analysis

- Waste sentencing originally focused on radioactive analysis, so the procedures are well defined
  - The area is scanned using an XRM-610 monitor
  - 10 minute gamma screen
  - Tritium if required
  - Gross alpha / beta analysis

- If the results of the gross analysis are greater than 0.4 Bq/g above background (SoLA exemption order limit) then they're subject to further analysis
  - High Alpha activity = further analysis by alpha spectrometry
  - High Beta activity = further analysis by gamma spectrometry

Chemical Analysis

- Until recently chemical sampling on all classifications of project was judgemental.
- Now it is integrated into the DQO procedure, and considered on all classification 4 projects.
- A generic chemical suite, suitable for most of the grounds and buildings at AWE, has been introduced for cases when there is uncertainty about the history.
- As a result a large amount of material is now being sentenced as Hazardous Waste.

Advantages of Analytical Procedure

- Radioactive, chemical and explosive contamination are all considered together. Therefore analyses can be performed simultaneously, cutting down on processing time.
- Use techniques that are extremely accurate, often an order of magnitude more accurate than is required to make the sentencing decision.
- Alpha Spectrometry can be used to assess whether the uranium present within a sample is natural, enriched or depleted. This is essential when deciding on a waste route.

Disadvantages of Analytical Procedures

- Time taken to complete analysis is still 6 weeks.
- Tritium screening technique is very crude.
- Difficult to analyse materials such as lino.
- Gamma Spectrometry uses assumptions to calculate Plutonium and Uranium activity.
- High alpha results don't necessarily mean high levels of Uranium or Plutonium, we assume that if these radio-nuclides aren't present then the remaining activity is natural.

Field Techniques

- Portable XRF
- Portable PID
- Chemical test kits
  - Sulphates, Nitrates, Chloride, ammonia, COD – spill kit.
  - PCB's, PAH's, BETEX – smear tests.
- Aim to take more field samples, and fewer lab samples, to build up a better picture of the areas of contamination at less cost, and without sacrificing confidence.

Background levels

- Investigation instigated after release of Code of Practice, felt it was necessary to update the data we were using to decide which samples required further analysis.

Threshold limit (Bq/g) = Background Activity (Bq/g) + 0.4 Bq/g

- Threshold limits for Alpha, Beta and Total Activity.

Alpha Activity above Threshold = Further Analysis by Alpha Spectrometry

Beta or Total Activity above Threshold = Further Analysis by Gamma Spectrometry

Background Levels (2)

- Initial Background levels were based on 80 samples collected in 1995.
- The mean of the data was used.
- For some matrices there were only 2 samples collected.

Figure 1. Average Background Activity for Specified Sample Matrix [7]

Matrix	**Background Alpha Activity (Bq/g)**	Threshold Limit Alpha Activity (Bq/g)	**Background Beta Activity (Bq/g)**	Threshold Limit Beta Activity (Bq/g)	Threshold Limit Total Activity (Bq/g)
Soil (Burghfield)	**0.7**	1.1	**0.7**	1.1	1.8
Soil (Aldermaston)	**0.7**	1.1	**0.7**	1.1	1.8
Tarmac / Bitumen	**0.4**	0.8	**0.2**	0.6	1.0
Concrete	**0.3**	0.7	**0.3**	0.7	1.0
Brick	**1.3**	1.7	**1.4**	1.8	3.1
Plaster	**0.1**	0.5	**0.2**	0.6	0.7
Sand	**1.6**	2.0	**1.0**	1.4	3.0

Background Levels (3)

- New background levels were based on over 3000 pieces of data.
- Results from samples containing unnatural activity were removed.
- Over 1900 results were used to assess the average activity in Aldermaston soil samples.
- Data is skewed
- Log normal distribution

Figure 6. The Distribution of Alpha Activity in Aldermaston Soil

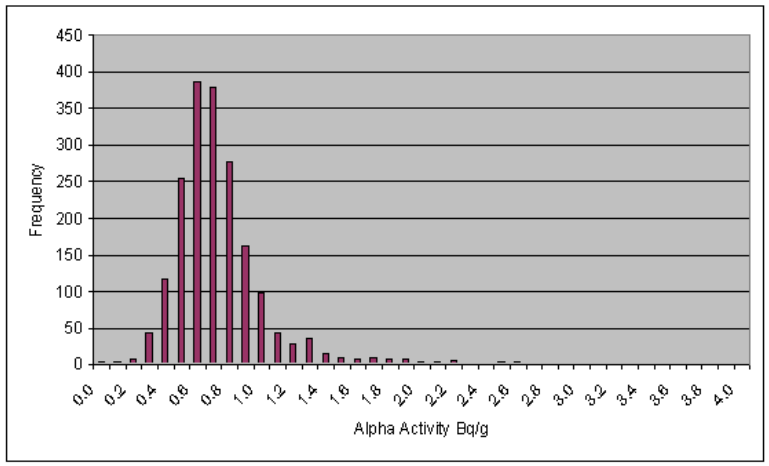
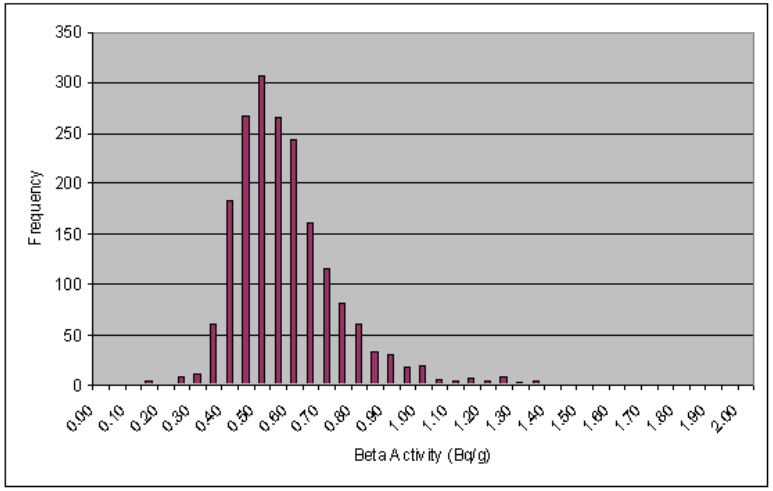
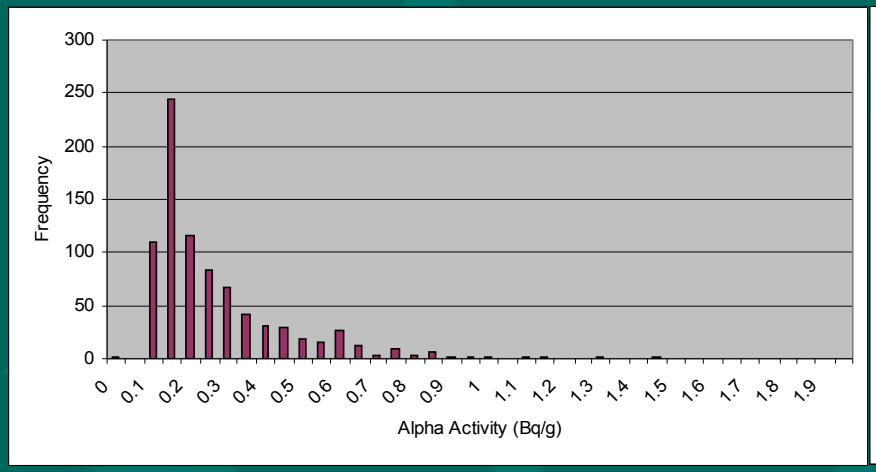


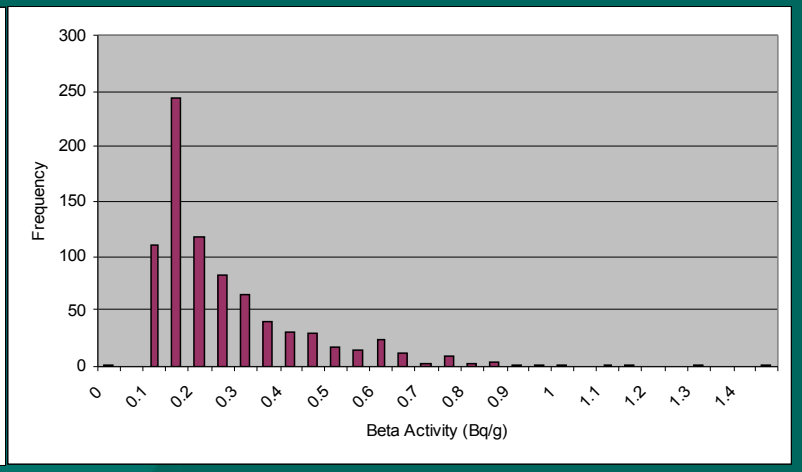
Figure 7. The distribution of Beta Activity in Aldermaston Soil Samples



Background Levels (4)

Concrete Samples – 814 data points



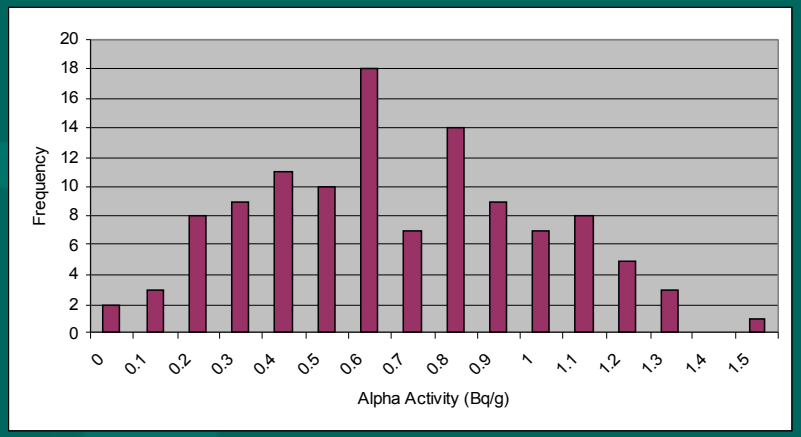


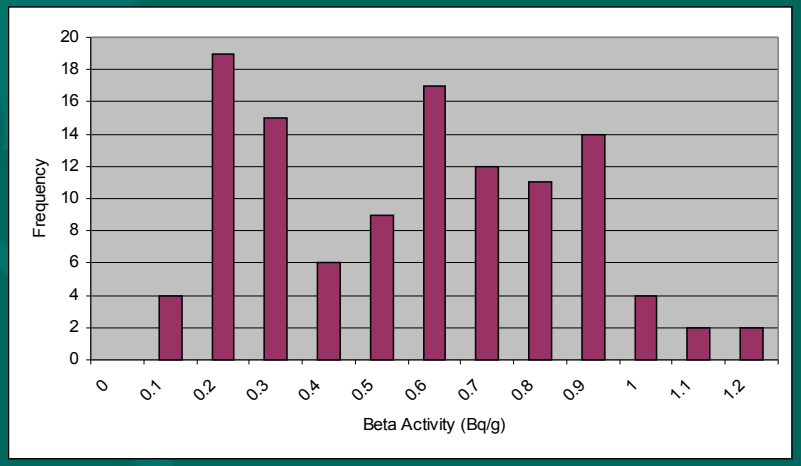
	Alpha Activity (Bq/g)	Beta Activity (Bq/g)
Mean	**0.25**	**0.28**
Median	**0.18**	**0.21**

- Mean and median vary significantly

Background Levels (5)

- 114 Brick Samples
- Data is bi-modal.
- Mean of 0.71 Bq/g Alpha activity, and 0.61 Bq/g Beta activity.
- Medians of 0.68 Bq/g and 0.64 Bq/g for Alpha and Beta activity respectively.
- Majority of data comes from 4 buildings.
- Could be an explanation for the bi-modal data.
- Averages are significantly different to those previously used (1.3 and 1.4 Bq/g).





Background Levels Conclusions

- The old Threshold Levels were not suitable
- It would be more appropriate to use the median rather than the mean, as the majority of data is log-normally distributed and this is the more conservative of the two estimates.
- The following values were accepted as the new Threshold Levels

Matrix	Background Alpha Activity (Bq/g)	Threshold Limit Alpha Activity (Bq/g)	Background Beta Activity (Bq/g)	Threshold Limit Beta Activity (Bq/g)	Threshold Limit Total Activity (Bq/g)
Soil	0.7	1.1	0.6	1.0	1.7
Tarmac / Bitumen	0.4	0.8	0.4	0.8	1.2
Concrete	0.2	0.6	0.2	0.6	0.8
Brick	0.7	1.1	0.6	1.0	1.7
Plaster	0.1	0.5	0.2	0.6	0.7
Sand	1.6	2.0	1.0	1.4	3.0

- The data should be re-assessed annually, to add to the data sets and to lessen the affects of bi-modal populations.

Impracticalities and Improvements

Impracticalities

- Is 140 samples for 5m3 of waste too much?
  - Is it possible to have too many samples?
  - As the person collecting and analysing those samples, I would argue – YES!
- Is it reasonable to sentence an entire building based on results from samples taken in the top 2mm of a wall or floor?
  - Should we be taking core samples?
  - Should we be sandblasting and scabbling as a matter of course?
  - Is it ‘practicable’ to spend the money on these techniques?

Improvements

- We have a sampling and assessment process that is robust and defensible.
- We have been encouraged to look for alternative analytical techniques, to improve confidence in our measurements.
- We have a better understanding of the levels of natural activity that exist in our environment.
- We also have the assurance that we're all doing the same thing, and all facing similar problems.

Thank You