



Appendix 5

OST Baseline Radiation Survey

Retention Lease Proposal

On

Mineral Claim 4280

for a

Uranium In-situ Recovery Field Trial

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Report Number 10070
Your Order letter dated 21st May 2010

**Report Title Baseline Radiation Survey
Mullaquana Project**

Report by John Waters

Authorized

A handwritten signature in blue ink, appearing to read "John Waters", written over a light blue grid background.

DipAppSc(Chem), CChem, MRACI, MARPS

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1 Introduction

Uranium SA Ltd is currently developing a uranium prospect referred to as the “Mullaquana Project” approximately 25km south west of Whyalla in South Australia.

This report details the results of a baseline radiological investigation undertaken between September and December 2010.

The mineralization is located in an aquifer at a depth between 40 and 70m.

The proposed mining process is In Situ Recovery.

The purpose of this baseline investigation is to provide a set of data against which potential future radiological impacts can be measured.

Note that the investigation of the current radiological status of the marine environment is beyond the scope of the current investigation.

2 Environmental Context

The project is located on pastoral land primarily used for sheep grazing. The two properties involved are the Nonowie and Mullaquana stations.

The exploration area is located in a coastal plain with the sparsely inhabited coast of Spencer Gulf to the east and low hills (running in a north south direction) to the west.

There are a number of seasonal drainage creeks that run from the west to the east across the exploration area but, other than stock watering dams there are no permanent surface water features.

Three aquifers have been identified at the site, these have been designated as:

- B Quaternary Aquifer
- A Miocene Aquifer
- C Eocene Aquifer

The quaternary upper aquifer “B” is isolated. It has been assumed that the “A” and “C” aquifers are confined but interconnected. A detailed hydrological investigation of the area is being undertaken by another organisation and is the subject of a separate report. This report deals with the radionuclide content of groundwater samples collected by URS Australia Ltd in May 2010.

3 Radiological Context

The In Situ Recovery process being considered for development of the project is, compared to other mining techniques, a relatively low impact process. Because the uranium is mined in solution and the solution is returned to the mineralized zone after extraction there is little surface impact with respect to tailings and waste disposal.

The primary potential mechanisms for environmental contamination with radionuclides are:

- 1) Release of radon (and consequently radon daughters) into the atmosphere when the leachate is brought to the surface
- 2) Increased surface deposition or plant uptake of Pb^{210} (and Po^{210} by ingrowth) due to elevated radon and radon daughter levels in the local environment
- 3) Contamination of surface soil with spilt leach liquor
- 4) Contamination of surface water (dams or seasonal drainage channels) with redistributed contaminated surface soil
- 5) Increased dust levels due to site preparation or operational activities (for example earthworks, vehicular traffic etc)
- 6) Contamination of groundwater with radionuclides released by either a change in water chemistry or the fugitive release of leachate solution

The issue of occupational exposure to ionizing radiation is beyond the scope of this investigation and will be monitored and controlled by the project occupational health and safety procedures.

The establishment of typical baseline levels of radionuclides in the environment is an important part of the ongoing assessment of the projects environmental impact. Baseline radiological conditions must be established because the presence of low levels of radionuclides in the environment is ubiquitous. Exposure to background radiation is unavoidable irrespective of the development or avoidance of uranium prospects.

For the purposes of measuring possible future radiological impacts this investigation has identified a number of sensitive receptors and reference sites.

4 Sensitive Receptors

Sensitive receptors are chosen on the basis of members of the public (i.e. not workers involved in the project) that are the most likely to be exposed to elevated radiological impacts from the proposed development. The identification of a sensitive receptor does not imply or suggest that an impact will occur, it only identifies the person or persons that would be most impacted if any impact occurred.

In the context of the Mullaquana project three sensitive receptors have been identified, these are:

- 1) Occupants of the Mullaquana Homestead approximately 4km to the SW of the development area. At present there are two permanent residents at this location, however, this may increase on a seasonal basis to provide a workforce for various activities undertaken on the property.
- 2) Occupants of the Nonowie Homestead approximately 8km NNW of the development area. At present there are between 7 and 10 occupants of the site, the majority of these are employees of Uranium SA Ltd.
- 3) Cowleds Landing, on the coast approximately 6km to the NE of the development area. This site consists of a number of approximately a dozen shacks. There appears to be no permanent residents and the shacks appear to be used as holiday accommodation.

5 Reference Sites

Three reference sites have been identified for baseline and ongoing monitoring. These were selected, as far as practical, to represent a similar geological, meteorological and land use setting as the proposed development site.

The selected reference sites are located between the coast and the low hills on the same sheep grazing properties as the proposed development. They have similar drainage patterns to the proposed development site and also have a stock watering dam.

In addition to the reference sites three dams were included for monitoring. The monitoring sites include:

- 1) The Northern Reference Site approximately 12km north of the development area.
- 2) The Central Reference Site approximately 6km north of the development area. The dam at this site has been damaged and does not hold any water.
- 3) The Southern Reference Site approximately 4km south of the development area
- 4) The “Road Dam” approximately 4km north west of the development area
- 5) The dams at the Mullaquana and Nonowie homesteads
- 6) The “Operational Dam” located in the development area

It is proposed that any future measured elevation of environmental radionuclides in the development area would be compared with levels at the reference sites to confirm if the measured impact is local (due to operational activity) or regional (due to natural variation).

The location of the proposed development and details of sensitive receptor and reference sites are provided in Appendix 1.

6 Water Analysis

Detailed results of the water analysis is provided in Appendix 2.

6.1 Ground Water

Th²³⁰, Pb²¹⁰, Po²¹⁰ and Th²³² in groundwater samples are low and results do not provide sufficient numerical data to undertake a statistical analysis. Sample “MHR 1C” does have detectable levels of Th²³⁰, Pb²¹⁰ and Po²¹⁰, however in the context of the Ra²²⁶ result these are not radiologically significant.

The U²³⁸ and Ra²²⁶ results are highly variable both within and between aquifers. A summary of the results for each aquifer is provided in Table 1.

Aquifer	U ²³⁸ Bq/l		Ra ²²⁶ Bq/l	
	Average	Std Dev	Average	Std Dev
A	1.17	1.02	5.2	8.8
B	0.05	0.03	2.2	2.0
C	0.66	0.81	304	404

Table 1 Summary Ground Water Results

The spread of results is such that it may be difficult (on the available data) to identify future changes due to mining activities. It is recommended that an investigation be undertaken to identify the temporal and special variability of dissolved uranium and Ra²²⁶ in the three aquifers. The regular analysis of other radionuclides is not warranted at this time, however, periodic check should be undertaken once pilot trials commence.

6.2 Surface Water

Other than the stock watering dams there are no permanent surface water features (creeks, rivers or dams) in the investigation area. Opportunistic sampling of creeks and pools during rain events was not considered necessary because the dams provide a valid surface water sample and represent water collected from a wide area around the dam.

The dam water results collected to date (and presented in Appendix 2) provide a sufficient baseline against which to assess future operational impacts. Low levels of Ra²²⁶ and Pb²¹⁰ were detected in the samples.

It is suggested that periodic sampling be undertaken with analysis for U²³⁸, Ra²²⁶ and Pb²¹⁰ being conducted to further define the special and temporal variation in these samples. Ongoing analysis is suggested because of the significant water level changes in the dams as they periodically dry out and are refilled by rain events.

7 Soil Analysis

Detailed results of soil analysis are provided in Appendix 3.

A summary of the results is provided in Table 2.

A number of general comments can be made concerning the soils results:

- 1) There is no statistically significant difference between sample location or sample type except that Pb²¹⁰ is elevated in the surface and sediment samples compared to the 5-15cm soil samples. This is not unexpected because the natural elevation of Pb²¹⁰ in undisturbed surface soil and sediments due to atmospheric Pb²¹⁰ deposition is well documented.
- 2) Except as noted above the samples are in approximate secular equilibrium with respect to the uranium and thorium decay chains.

It is considered that the soil data collected to date is sufficient to provide the baseline radiological data required for this investigation.

Possible future operational impacts can be assessed by use of the current data and the re-sampling of the reference and operational sites during and after the proposed pilot plant.

Parameter	Th ²³²	Ra ²²⁸	Th ²²⁸	U ²³⁸	Ra ²²⁶	Pb ²¹⁰
	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g
Soil						
Average	0.046	0.067	0.064	0.023	0.023	0.039
Std Dev	0.012	0.015	0.018	0.006	0.013	0.023
Surface Soil						
Average	0.050	0.068	0.053	0.021	0.030	0.077
Std Dev	0.010	0.013	0.015	0.006	0.008	0.059
Dam Sediment						
Average	0.047	0.044	0.052	0.025	0.025	0.071
Std Dev	0.014	0.015	0.018	0.008	0.013	0.034
All Sample						
Average	0.047	0.059	0.056	0.023	0.026	0.062
Std Dev	0.011	0.018	0.016	0.006	0.011	0.042

Table 2 Summary of Soils Results

8 Dust

Detailed results of dust analysis are provided in Appendix 4.

In summary the Total Suspended Particulate (TSP) monitoring undertaken at Mullaquana Homestead confirm that ambient dust levels are low (average 0.016 mg/m³, standard deviation 0.007 mg/m³) and that the long lived alpha activity is consistent similarly low (average 0.029 mBq/m³, standard deviation 0.013 mBq/m³).

The natural radioactivity in the local dust contributes between 5% and 50% of the long lived alpha activity with the remainder coming from atmospheric Po²¹⁰ derived from natural atmospheric radon daughter product.

PM₁₀ particulate matter is similarly low (at both the Nonowie and Mullaquana homesteads) with typical levels between 0 and 0.004 mg/m³.

Peaks of up to 0.2 mg/m³ associated with local vehicular traffic have been identified. These peaks are characterized by their short duration, generally one to five minutes. These peaks are of such a short duration that they have no real impact on average 24 hour PM₁₀ levels which range from 0.001 to 0.003 mg/m³.

It is recommended that high volume (TSP) sampling be continued at Mullaquana Homestead and that a monitor be deployed at the proposed development site as soon as 240 volt power is available.

Continued monitoring of PM₁₀ is recommended using a single instrument that can be deployed at rotating locations around the investigation area. The continued use of two monitors is not considered necessary.

9 Radon and Radon Daughters

Complete results for radon and radon daughter monitoring are provided in Appendix 5.

Radon levels at the Nonowie homestead vary from 10 to 30 Bq/m³ with occasional elevated levels up to 45 Bq/m³. Variation in the radon concentration at Nonowie shows a diurnal variation that is typical of ambient atmospheric radon.

Grab samples taken at other locations are consistent with those measured at Nonowie showing little statistically significant variation (average 16 Bq/m³, standard deviation 4 Bq/m³) except that the Cowleds Landing (average 8 Bq/m³, standard deviation 4 Bq/m³) results are statistically lower than the other sites. This is consistent with the coastal location of Cowleds Landing.

Radon daughter levels show a similar trend in that the Cowleds Landing values (average 10 nJ/m³, standard deviation 3 nJ/m³) are statistically lower than the other sites (average 17 nJ/m³, standard deviation 6 nJ/m³).

As shown in Table 3 radon daughter levels are similar to those reported for other South Australian arid inland locations.

Location	Radon Daughters nJ/m ³ PAEC			
	Minimum	Maximum	Average	Std Dev
Cowled Landing	6	14	10	3
Mullaquana Area	8	27	17	6
Olympic Dam	10	40		
Honeymoon	17	22	19	2
Woomera	37	60	50	8
Edinburgh	1	8	4	2

Table 3 Radon Daughters at Other Locations

At this stage there has not been sufficient data collected to quantify seasonal variations in radon or radon daughter concentrations, however, ongoing monitoring will provide this data as the project progresses.

Continued monitoring for radon and radon daughters is recommended to collect additional special and temporal data.

10 Plant Analysis

Complete results for the analysis of plant samples are provided in Appendix 6.

Blue Bush, tentatively identified as *Maireana Sedifolia*, was sampled from the three reference sites and the proposed development area in September 2010. Fleshy recent growth and woody old growth sub samples were analysed for radionuclides.

Th²³² and Pb²¹⁰ were consistently detected above the analytical detection limit. Other nuclides were generally at or below the detection limit.

The woody sample from the proposed development area (operations area) had a significantly elevated Th²³² content. It is of note that the soil Th²³² at the operational site is elevated (average 0.056 Bq/g, standard deviation 0.007 Bq/g) compared to the other sites (average 0.045 Bq/g, standard deviation 0.011 Bq/g). However, this is not sufficient to account for the 6 fold difference in the plant samples (woody plant from the operational area 0.06 Bq/g ash, all other plant samples average 0.011 Bq/g ash, standard deviation 0.002 Bq/g ash)

The operational site will be re-sampled to establish if the September sample is an anomaly or there is a real elevation of Th²³² in the area.

11 Regulatory Context of Baseline Results

In South Australia, the regulation of radioactivity is implemented through the Radiation “Protection and Control Act (1982)” and the associated regulations Radiation Protection and Control (Ionising Radiation) Regulations (2000”).

The South Australian regulations are primarily aimed at occupational exposure and specify an exemption level in terms of activity (35kBq/kg) for the sum of individual isotopes and a mass concentration (0.02% uranium and 0.05% thorium) for minerals and ores.

In the exploration phase the regulations are most likely applicable to mineral samples and recovered core. However, none of the environmental samples collected during the baseline study exceed the regulatory exemption limit.

There is little applicability of the regulations to environmental assessment which is usually done on a case by case basis taking into account the typical environmental values (baseline values) for the area. The intended use of the data provided in this report is to establish those baseline values for the Mullaquana area.

Nationally, the radiological protection framework is described in the “National Directory for Radiation Protection” published by ARPANSA. This document provides exemption levels for individual isotopes. For samples with radionuclide concentrations below these exemption levels it is considered that:

- a) the health risks associated with the source, practice, or type of person using a source are sufficiently low as to be of no regulatory concern; and
- b) radiation protection, including the cost of regulatory control, has been optimised.

As with the South Australian regulations, the National Directory is not aimed at providing a level of environmental protection, it is targeted at protection of humans from the effects of exposure to ionising radiation, particularly occupational exposure.

The exemption limits for radionuclides of relevance to Mullaquana project are provided in Table 4. These exemption levels are lower than the corresponding South Australian level, however, it is still true that none of the samples collected in this study are above the exemption level.

Isotope	National Directory Exemption Level (Bq/g)
U ²³⁸	10
Th ²³²	1
Th ²³⁰	1
Ra ²²⁶	10
Ra ²²⁸	10
Pb ²¹⁰	10
Po ²¹⁰	10

Table 4 National Directory Exemption Levels

Assessment for the environmental impact of radionuclides at background levels is typically done on a case by case basis using typical regional, national or local background levels. As discussed elsewhere in this report the radionuclide levels found in samples collected from the study area are considered typical for the environmental setting.

With respect to radon and radon daughters in air the values reported in this study are considered lower than average values reported for inland Australia and average world levels. This is considered to be due to the coastal setting of the area. To put the reported radon levels in context, the intervention limit¹⁾ for Radon in dwelling is 200Bq/m³, an order of magnitude higher than the ambient levels found in this study.

The criteria generally applied to water samples is the Australian drinking water guidelines²⁾ however, in the case of groundwater, these must be interpreted in the context of the suitability of the water for beneficial use. In the case of groundwater at the Mullaquana site, the water is generally not suitable for beneficial use because of the salinity. In this case, the radionuclide content (and any impact from uranium mining) must be assessed in the context of natural regional and temporal variation. The drinking water guideline limits are provided in Table 5.

Radionuclide	Guideline Limit (Bq/l)
Uranium	0.02 mg/l (0.24 Bq/l U ²³⁸)
Gross Alpha Activity	0.5
Gross Beta Activity	0.5
Ra ²²⁶ , Ra ²²⁸	0.5

Table 5 Drinking Water Guidelines

All of the surface water samples comply with the drinking water guidelines. The majority of the groundwater samples do not comply with the drinking water guidelines, generally with respect to uranium and Ra²²⁶.

1) National standard for limiting occupational exposure to ionizing radiation
Appendix C
[NOHSC:1013(1995)]

2) AUSTRALIAN DRINKING WATER GUIDELINES 6
2004
Endorsed by NHMRC 10 – 11 April 2003

12 Discussion

The data provided in this report provides sufficient detail to establish a radiological baseline against which to measure potential future impacts of the Mullaquana uranium project.

Sensitive receptors have been identified and monitored and data has been collected from three reference sites.

The requirement for ongoing or confirmatory monitoring has been identified in the following areas:

- 1) On going Total Suspended Particulate Monitoring (TSP) using a high volume sampler should continue at Mullaquana homestead as this is the closest sensitive receptor to the proposed development area.
- 2) Establishment of a TSP monitoring site within the proposed development area once 240 volt power is available.
- 3) Continued PM₁₀ monitoring using a single unit to be rotated through the various monitoring locations.
- 4) Continued continuous radon monitoring. The radon monitor will be moved to the Mullaquana homestead in January 2011.
- 5) Continued grab samples for radon and radon daughters at all monitoring locations. Continuous track etch monitors for radon will be deployed to provide average levels of radon over quarterly intervals.
- 6) Re-sampling of plant material at the proposed development site to confirm the elevated Th²³² in the September sample.
- 7) Establishment of a regular groundwater U²³⁸ and Ra²²⁶ monitoring program to further define the temporal and spatial variation of these parameters.
- 8) Continued monitoring of dam water samples for U²³⁸, Ra²²⁶ and Pb²¹⁰.



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Appendix 1

Sample Locations

The context of the investigation area is provided in Figures 1 and 2

Groundwater sample locations are shown in Figure 3.

Details for the Mullaquana and Nonowie homesteads are provided in Figures 4 and 5.



Figure 1 Investigation Area Location



Figure 2 Investigation Area

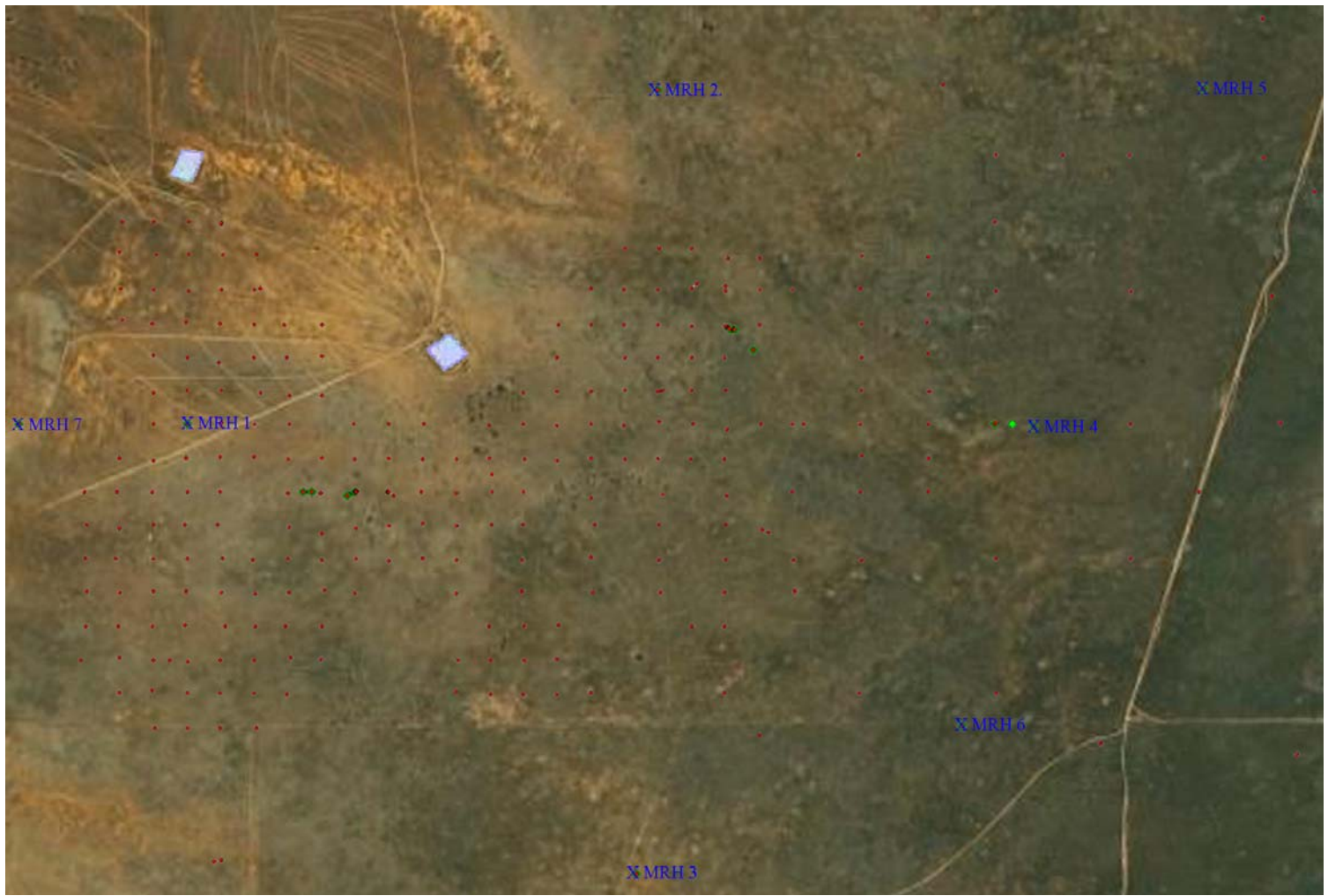


Figure 3 Ground Water Sample Locations



Figure 4 Mullaquana Homestead

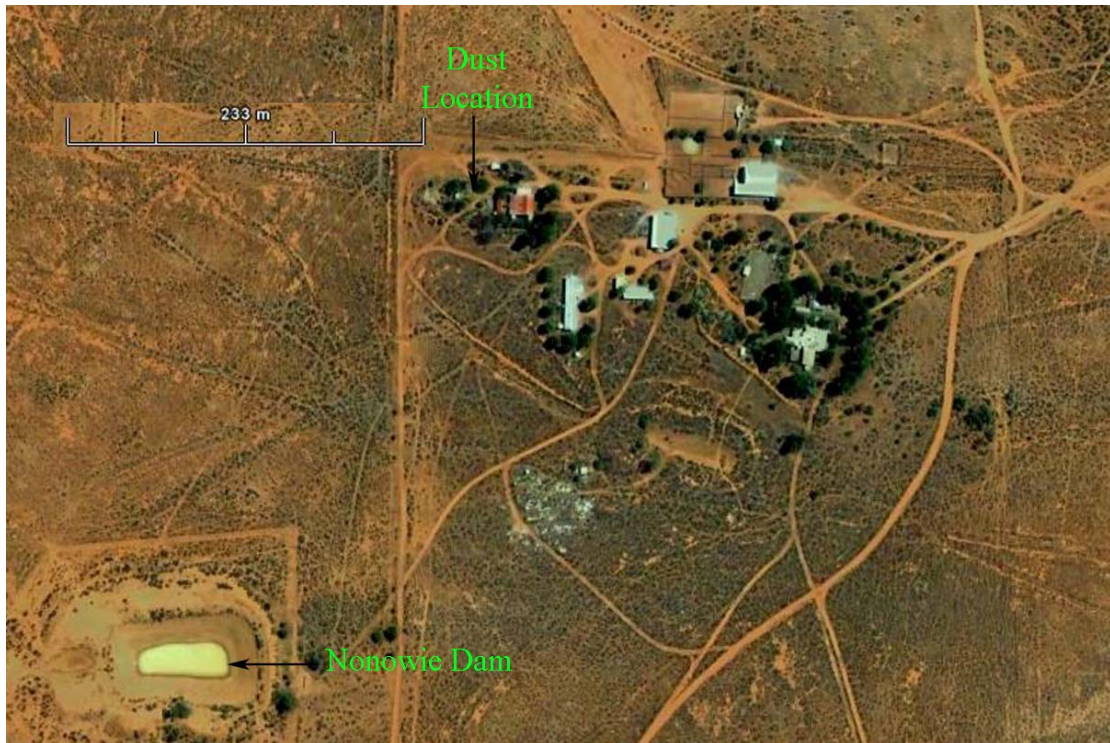


Figure 5 Nonowie Homestead



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Appendix 2

Water Analysis

Groundwater Samples

Sixteen groundwater samples were received for URS Australia Pty Ltd. The sample details are provided in Table 1.

URS Project	Sample ID	Sample Date
42637428	MRH 1A	24/5/2010
42637428	MRH 2A	23/5/2010
42637428	MRH 3A	21/5/2010
42637428	MRH 4A	22/5/2010
42637428	MRH 5A	23/5/2010
42637428	MRH 6A	22/5/2010
42637428	MRH 7A	24/5/2010
42637428	MRH 3B	21/5/2010
42637428	MRH 4B	22/5/2010
42637428	MRH 5B	23/5/2010
42637428	MRH 6B	21/5/2010
42637428	MRH 1C	24/5/2010
42637428	MRH 4C	22/5/2010
42637428	Tap Water	24/5/2010
42637428	QC-1	23/5/2010
42637428	QC-2	23/5/2010

Table 1 Ground Water Sample Information

Detailed sample locations are provided in Appendix 1

Samples were received as collected without filtration or preservation by On Site Technology Pty Ltd on 26th May 2010. Samples were filtered through 0.45 µm membrane filters and acidified to pH less than 2 with nitric acid within 24 hours of receipt. The sample containers were leached for 24 hours at room temperature with AR grade concentrated hydrochloric acid. The containers were agitated to ensure all of the internal surface came into regular contact with the acid. The container leachate was added to the filtered sample. When analysis was undertaken an adjustment in the sample volume was made to account for the increase in volume due to the container leachate addition.

Sample aliquots were submitted to Amdel Ltd for the determination of uranium and thorium by inductively coupled plasma mass spectrometry. These results were compared to those determined by ALS Environmental Pty Ltd on separate samples filtered and preserved in the field by URS Australia Ltd. This comparison provides confidence that the laboratory filtering and container leaching procedure adequately recovers dissolved metals. Comparative results are provided in Table 2 and Figure 1.

Sample	ALS	Amdel
Filtered and Preserved	in field	in lab
	µg/l	µg/l
MRH 1A	229	225
MRH 1C	84.2	100
MRH 2A	37.7	36
MRH 3A	59.3	60
MRH 3B	5.2	6.5
MRH 4A	54.2	55
MRH 4B	2.1	2.1
MRH 4C	6.6	7.0
MRH 5A	24	25.5
MRH 5B	1.8	2.0
MRH 6A	55.4	60
MRH 6B	4.3	4.5
MRH 7A	174	205

Table 2 “In Field” vs “In Lab” Preservation

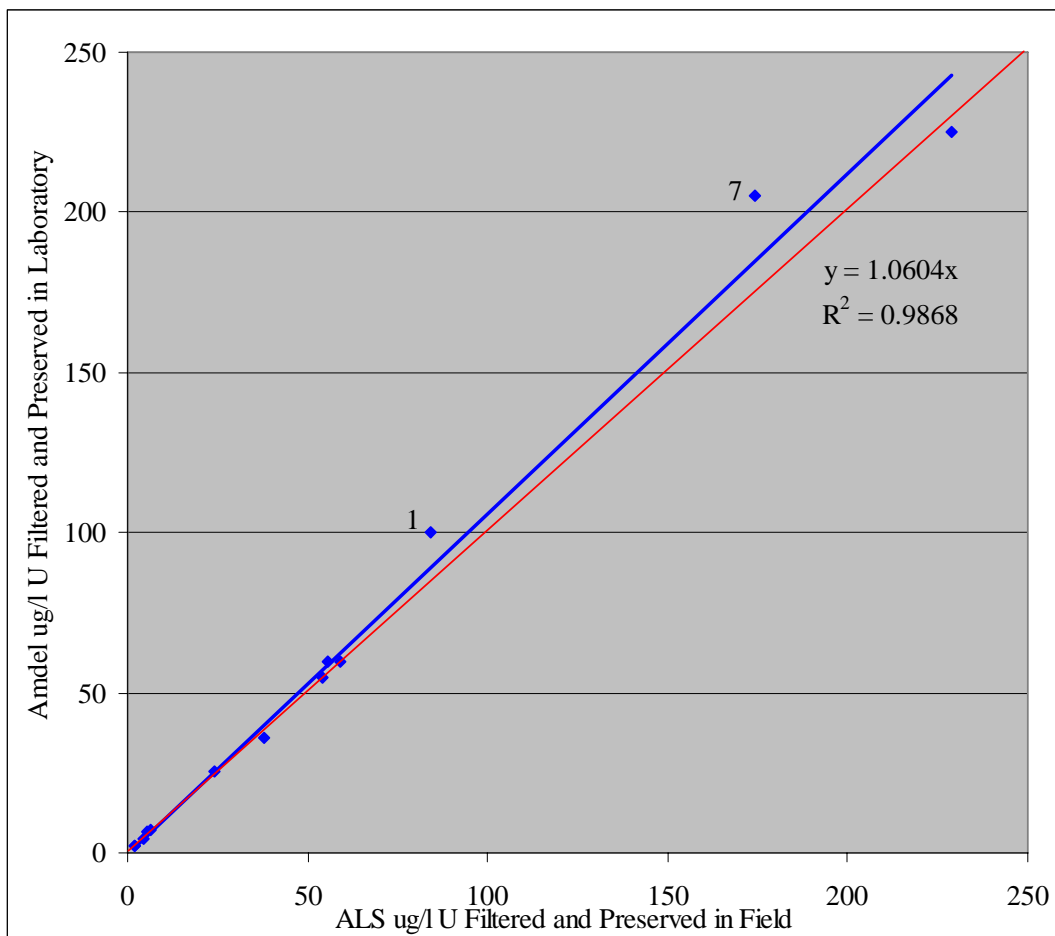


Figure 1 “In Lab” vs “In Field” Preservation

Surface Water Samples

Surface water samples were collected from numerous dams by On Site Technology Pty Ltd on 2nd September and 12th November 2010. Details are provided in Table 3.

Unfiltered samples were acidified to 1M hydrochloric acid and heated to 90°C to facilitate digestion of nuclides absorbed onto colloidal material. The samples were then filtered prior to analysis. When analysis was undertaken an adjustment in the sample volume was made to account for the increase in volume due to acid addition.

Sample aliquots were submitted to Amdel Ltd for the determination of uranium and thorium by inductively coupled plasma mass spectrometry

Radiochemical Analysis

Radionuclide determination was undertaken by On Site Technology Pty Ltd using the following procedures:

Pb^{210} , Bi^{210} and Po^{210} were extracted into 1% Diethyl ammonium diethyldithiocarbamate in chloroform from a sample aliquot acidified with hydrochloric acid. Po^{210} was autodeposited onto silver and determined by alpha spectrometry using Po^{208} as an internal standard. Po^{210} results have been corrected to sampling time for ingrowth from Pb^{210} where appropriate. Pb^{210} was determined by gross beta counting after precipitation of lead and bismuth as the chromate.

Ra^{226} was determined by gross alpha counting of a sulphate precipitate obtained from the aqueous phase of the lead, bismuth polonium extraction. Radium was initially co-precipitated with lead followed by clean up with EDTA and final co-precipitation with barium carrier. Counting was undertaken after ingrowth of radon and radon daughters.

Th^{230} was determined by alpha spectrometry after extraction with Thenoyltrifluoroacetone in Xylene. Th^{228} derived from a certified U^{232} solution was used as an internal standard.

U^{238} and Th^{232} values were calculated from the ICP-MS uranium and thorium results.

Quality control was maintained by the analysis of a sample digest of certified reference material NBL-6A supplied by the US Department of Energy New Brunswick Laboratory. Traceability is provided through this certified reference material.

Results for radiochemical analysis are provided in Table 3 (Ground Water) and Table 4 (Surface Water).

Sample	U ²³⁸	Th ²³⁰	Ra ²²⁶	Pb ²¹⁰	Po ²¹⁰	Th ²³²
	Bq/l	Bq/l	Bq/l	Bq/l	Bq/l	Bq/l
MRH 1A	2.77	<0.03	5.60	0.06	<0.03	0.002
MRH 2A	0.44	<0.03	24.8	0.37	<0.03	0.001
MRH 3A	0.74	<0.03	0.76	0.07	<0.03	0.001
MRH 4A	0.68	<0.03	1.01	0.04	<0.03	<0.001
MRH 5A	0.31	0.03	1.27	0.11	<0.03	<0.001
MRH 6A	0.74	<0.03	1.09	<0.05	<0.03	<0.001
MRH 7A	2.53	<0.03	1.58	<0.05	<0.03	<0.001
MRH 3B	0.080	<0.03	4.93	<0.05	<0.03	<0.001
MRH 4B	0.026	<0.03	1.55	0.06	<0.03	<0.001
MRH 5B	0.025	<0.03	0.22	<0.05	<0.03	<0.001
MRH 6B	0.055	<0.03	2.10	<0.05	<0.03	<0.001
MRH 1C	1.23	0.10	590	7.65	1.0	0.001
MRH 4C	0.086	<0.03	18.1	0.32	<0.03	<0.001
MRH 4C Duplicate	0.086	<0.03	19.4	0.18	<0.03	<0.001
QC1	0.34	<0.03	1.25	0.10	<0.03	<0.001
QC2	0.33	<0.03	1.16	0.06	<0.03	<0.001
Tap Water	0.02	<0.03	0.03	<0.05	<0.03	<0.001
Detection Limit	0.001	0.03	0.01	0.05	0.03	0.05

Table 3 Radionuclide Analysis of Ground Water

Sample	Date	U ²³⁸	Th ²³⁰	Ra ²²⁶	Pb ²¹⁰	Po ²¹⁰	Th ²³²
		Bq/l	Bq/l	Bq/l	Bq/l	Bq/l	Bq/l
Mullaquana Dam	12/11/10	<0.0001	<0.03	0.07	0.03	<0.03	<0.0001
Nonowie Dam	12/11/10	<0.0001	<0.03	0.05	0.04	<0.03	<0.0001
North Dam	2/09/10	<0.0001	<0.03	0.17	0.09	<0.03	<0.0001
North Dam	12/11/10	<0.0001	<0.03	0.04	0.04	<0.03	<0.0001
Operations Dam	2/09/10	<0.0001	<0.03	0.04	0.04	<0.03	<0.0001
Operations Dam	12/11/10	<0.0001	<0.03	0.02	0.06	<0.03	<0.0001
South Dam	2/09/10	<0.0001	0.03	0.15	0.06	0.03	<0.0001
Road Dam	12/11/10	<0.0001	<0.03	0.08	0.03	<0.03	<0.0001
Blank		<0.0001	<0.03	0.03	<0.05	<0.03	<0.0001
Detection Limit		0.0001	0.03	0.01	0.05	0.03	0.0001

Table 4 Radionuclide Analysis of Surface Water



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Appendix 3

Soil Analysis

Samples

Samples were collected from four locations by On Site Technology Pty Ltd on 2nd September 2010. At each location a surface sample (0-2cm) a sub surface sample (5-15cm) and a dried dam sediment sample was collected. Plant matter was excluded from the surface soil samples.

Sample locations were selected to provide reference sites that are unlikely to be impacted by operational activities (North, Central and South Dams) and the operational area (operations dam).

Sample details are provided in Table 1 and typical surface and dam sediment sample locations are shown in Figures 1 and 2.

Sample ID	Location	E	N	Description	Note	Th	U
		53H	53H			mg/kg	mg/kg
10019-001	South Dam	723264	6320767	Soil	5-15cm	8.0	1.2
10019-002	South Dam	723264	6320767	Surface	0-1cm	9.9	1.4
10019-003	South Dam	723264	6320767	Dam Sediment	0-1cm	7.3	1.2
10019-007	Operation	723534	6324743	Soil	5-15cm	14	2.0
10019-008	Operation	723534	6324743	Surface	0-1cm	15	2.3
10019-009	Operation	723534	6324743	Dam Sediment	0-1cm	12	1.9
10019-004	Central Dam	723349	6330407	Soil	5-15cm	9.5	2.3
10019-005	Central Dam	723349	6330407	Surface	0-1cm	10	1.6
10019-006	Central Dam	723349	6330407	Dam Sediment	0-1cm	11	2.1
10019-010	North Dam	726066	6335896	Soil	5-15cm	13	1.9
10019-011	North Dam	726066	6335896	Surface	0-1cm	13	1.4
10019-012	North Dam	726066	6335896	Dam Sediment	0-1cm	16	2.8

Table 1 Sample Information, Thorium and Uranium Results



Figure 1 Typical Surface Soil



Figure 2 Typical Dam Sediment

Analysis

Samples were submitted to Genalysis Laboratory Services Pty Ltd for drying, pulverizing and determination of uranium and thorium by inductively coupled plasma mass spectrometry (ICP-MS) following total digestion of the sample.

Prepared samples were returned to On Site Technology Pty Ltd for determination of Th^{228} , Ra^{226} , Ra^{228} and Pb^{210} by gamma spectrometry.

Calibration and traceability was provided by the analysis of the following certified reference materials:

U^{238} and Th^{232} were calculated from the ICP-MS uranium and thorium results.

Results are provided in Table 2.

Sample ID	Th^{232}	Ra^{228}	Th^{228}	U^{238}	Ra^{226}	Pb^{210}
	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g
10019-001	0.033	0.045	0.040	0.015	0.008	0.044
10019-002	0.041	0.061	0.054	0.017	0.024	0.005
10019-003	0.030	0.022	0.026	0.015	0.009	0.025
10019-007	0.056	0.072	0.082	0.024	0.024	0.068
10019-008	0.062	0.086	0.067	0.029	0.028	0.117
10019-009	0.049	0.052	0.055	0.024	0.028	0.065
10019-004	0.039	0.068	0.062	0.029	0.022	0.017
10019-005	0.043	0.069	0.033	0.020	0.041	0.133
10019-006	0.044	0.046	0.067	0.025	0.022	0.097
10019-010	0.054	0.081	0.072	0.024	0.039	0.025
10019-011	0.055	0.056	0.057	0.017	0.026	0.052
10019-012	0.064	0.055	0.060	0.034	0.039	0.098

Table 2 Radionuclide Results for Soil Samples



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Appendix 4

Dust

Samples

Dust sampling locations have been established at two of the identified sensitive receptors, these being;

Nonowie Homestead

TSI Dustrack II recording PM₁₀ at one minute intervals

Mullaquana Homestead

TSI Dustrack II recording PM₁₀ at one minute intervals

High Volume air sampler collecting Total Suspended Particulate (TSP) over 1 to 2 week intervals

Data was collected at Nonowie between 11/11/10 and 26/11/10. Data was not collected between 26/11/10 and 23/12/10 because the power to the equipment was switched off at 12:48 on 26/11/10.

Data has been collected at Mullaquana between 12/11/10 and 23/12/10 except for the period 7/12/10 to 13/12/10 which was impacted by a prolonged power failure.

High volume samples were analysed for gross alpha activity, gross beta activity and sample weight by On Site Technology Pty Ltd. Samples have been retained for future analysis if required.

Results

Table 1 provides results for high volume filter analysis including alpha activity expressed as mBq/m³ and Bq/g of collected dust.

Filter Number	Sample Start		Sample Stop		Dust mg/m ³	Alpha mBq/m ³	Beta mBq/m ³	Alpha Bq/g
	Date	Time	Date	Time				
37 ¹⁾	12/11/10	10:30	23/11/10	11:00	0.015	0.016	0.229	1.03
37 ²⁾						0.015	0.221	0.97
37 ³⁾						0.013	0.135	0.86
39	25/11/10	11:26	02/12/10	15:03	0.012	0.027	0.150	2.25
41	02/12/10	15:10	07/12/10	18:00	0.012	0.027	0.153	2.13
43	13/12/10	10:44	23/12/10	12:07	0.024	0.048	0.392	2.00
	Soil							0.47
	95% CI							0.03
	Average				0.016	0.029	0.231	1.85
	Std Dev				0.007	0.013	0.113	0.56

Table 1 High Volume Sample Results

Note that for filter number 37 three counts were undertaken to provide an estimate of error in alpha concentration determination. Counts 1 and 2 were undertaken 15 days after sampling and are effectively duplicate counts, count 3 was undertaken 42 days after sampling.

The results for filter 37 demonstrate that:

- 1) The determination of alpha activity is reproducible and independent of counting delay.
- 2) The determination of beta activity is dependent on count delay. The reason for this is discussed below.

Gross alpha activity in the high volume samples is derived from two sources.

- 1) Natural activity originating from the uranium and thorium decay chains in the local soil making up the dust.
- 2) Naturally elevated atmospheric Po^{210} originating from the decay of Rn^{222} in the atmosphere. It is of note that alpha emitting decay products from atmospheric Rn^{220} and Rn^{219} are not determined because the sample are counted 5 days or more after sampling. This delay allows for the complete decay of Rn^{220} and Rn^{219} daughter products.

The gross alpha activity (in Bq/g) reported in Table 1 is elevated compared to the typical soil activity for the area (derived from data in Appendix 3) and indicates that the contribution from atmospheric Po^{210} is between 55% and 80% of the measured activity.

This calculation provides an estimate for atmospheric Po^{210} in the range 0.01 to 0.04 mBq/m^3 which is somewhat lower than the world average of 0.05 mBq/m^3 used in the Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. Annex B Exposure from Natural Radiation Sources (UNSCEAR).

The gross beta activity in the high volume samples is derived from four sources:

- 1) Natural activity originating from the uranium and thorium decay chains in the local soil making up the dust.
- 2) Naturally elevated atmospheric Pb^{210} originating from the decay of Rn^{222} in the atmosphere. It is of note that beta emitting decay products from atmospheric Rn^{220} and Rn^{219} are not determined because the sample are counted 5 days or more after sampling. This delay allows for the complete decay of Rn^{220} and Rn^{219} daughter products.
- 3) Naturally occurring K^{40} in the soil making up the dust

- 4) Naturally occurring cosmogenic beta emitters present in the atmosphere. These are predominantly long lived Be^{10} and short lived (14 to 90 day half life) Be^7 , P^{32} , P^{35} and S^{35} .

UNSCEAR reports typical average atmospheric concentration of Pb^{210} of 0.5 mBq/m^3 and cosmogenic nuclide activity of 0.73 mBq/m^3 (dropping to approximately 0.2 to 0.4 mBq/m^3 by natural decay for the counting times used in Table 1). The decay of the short lived cosmogenic nuclides is evident when comparing count 3 to counts 1 and 2 for filter 37.

Approximately 10% of the beta activity on the filters can be accounted for by uranium thorium and potassium in the local soil.

At this time it is difficult to assess the natural range of atmospheric Pb^{210} for this site from gross beta counting however it can be confidently concluded that the Pb^{210} level is significantly lower than the UNSCEAR reported world average of 0.5 mBq/m^3 . More detailed analysis of the filters will provide a more precise estimate of local atmospheric Pb^{210} concentration.

Considering the TSP results for the sampling period (four filters) the average dust loading of 0.016 mg/m^3 (standard deviation 0.007 mg/m^3) is typical of arid rural environments and will provide a suitable baseline against which to measure operational dust impacts.

Figures 1 and 3 provide data for the Dustrak II PM_{10} results at Mullaquana homestead. The one minute measurements of PM_{10} are plotted against the time of day for the sampling period. When interpreting individual PM_{10} results it is important to consider the measurement error of 0.002 mg/m^3 .

Similar plots for the Nonowie Homestead data are provided in Figures 4 and 5. Figure 6 provides the daily range of dust levels (blue) compared to the daily rainfall (crimson) for the Nonowie Homestead site.

Figure 1 provides data for the first monitoring site at Mullaquana Homestead. The equipment was moved to the second site on 25/11/10 because of noise complaints from the landholder. The main differences between the two sites is that location 1 was away from significant dust generating traffic and sheep movements. Location 2 is adjacent to a vehicular track and in an area frequented by sheep.

The single high result depicted in Figure 1 is the result of vehicular dust produced during equipment maintenance.

The Nonowie homestead site is behind the buildings used by Uranium SA as office and accommodation. This site is subject to dust generated by vehicular and road maintenance traffic on the surrounding unsealed roads and tracks.

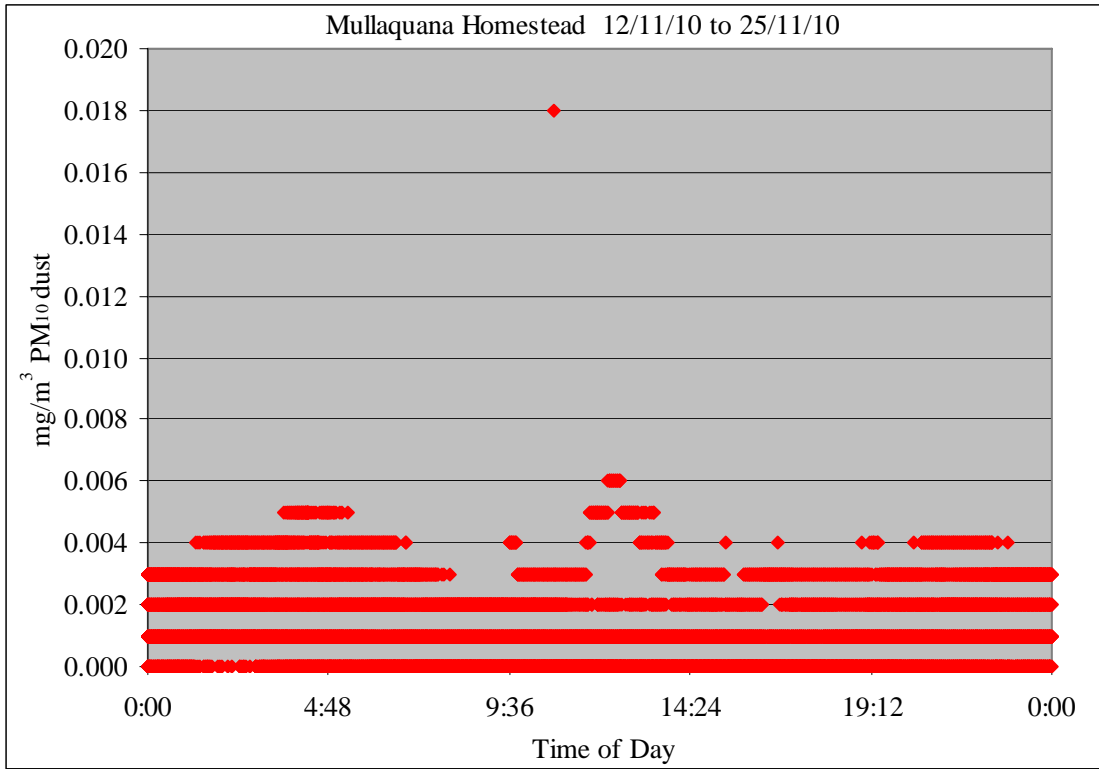


Figure 1

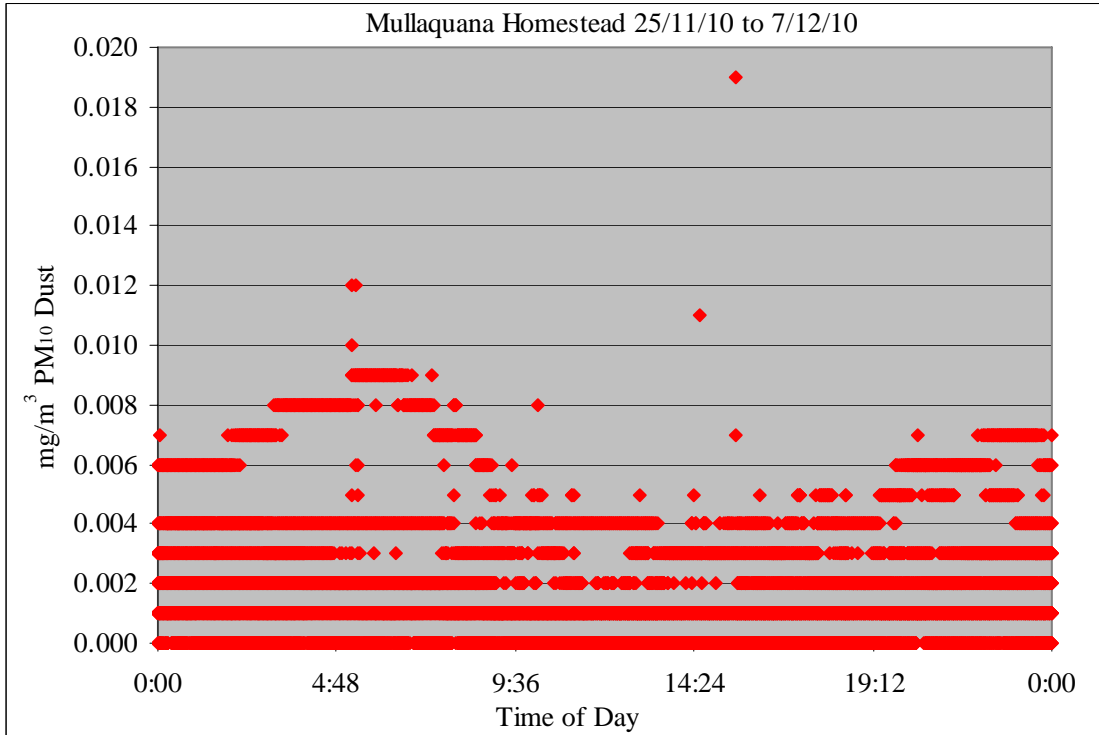


Figure 2

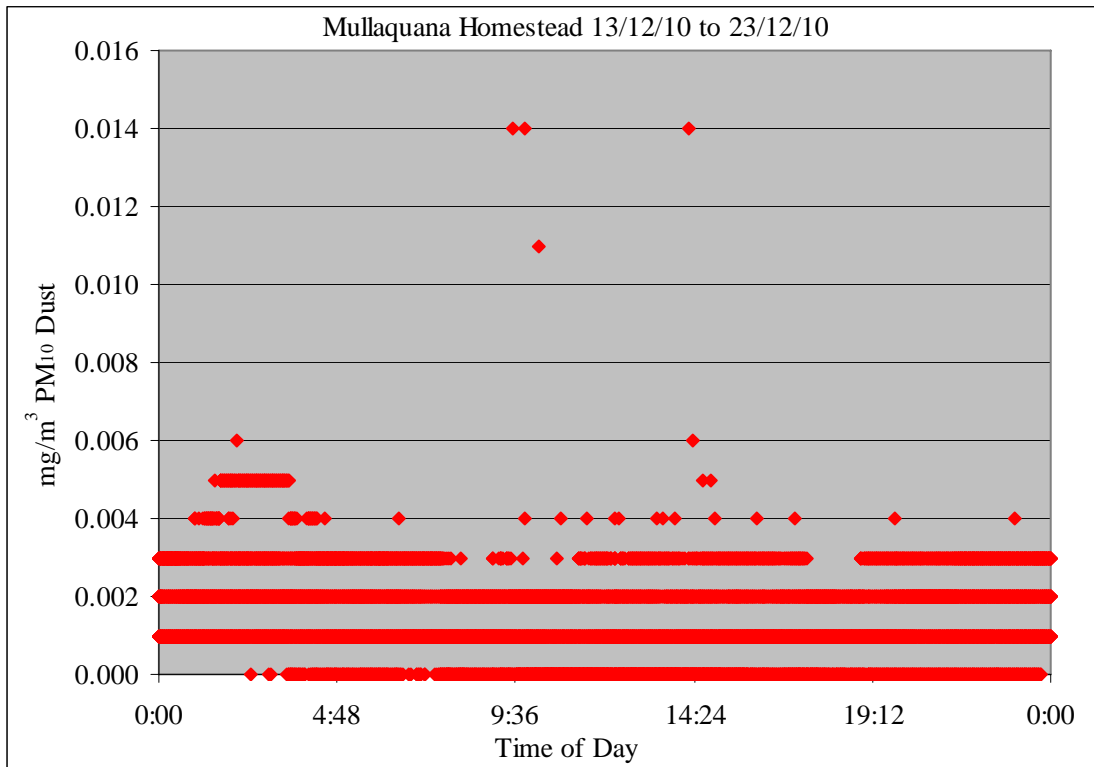


Figure 3

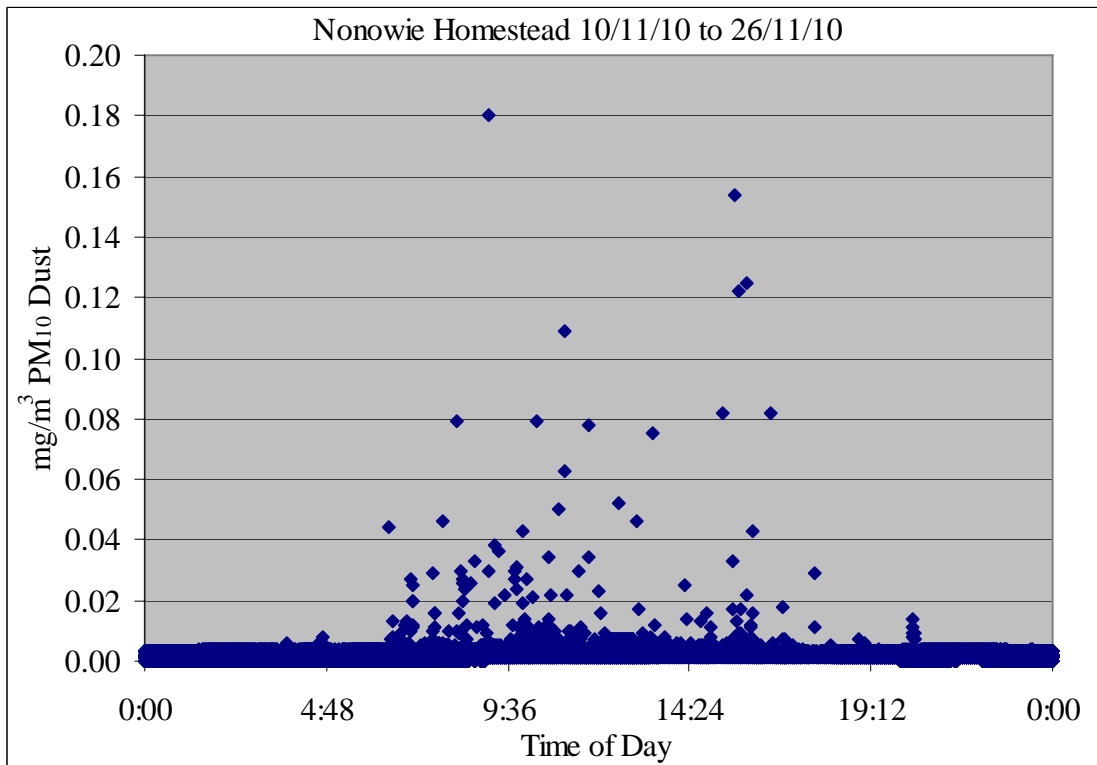


Figure 4

Discussion

PM10 dust levels at both monitoring sites appear to be characterized by three components shown in Figure 7 as;

- A. Low level ambient dust on the range 0 to 0.004 mg/m³, these levels represent the lower limit range of the measurement method.
- B. Elevated dust levels over extended period (hours to days) in the range 0.003 to 0.010 mg/m³ and are most probably dominated by local meteorological conditions (surface soil moisture and wind turbulence and speed).
- C. Significantly elevated short duration (generally over one to several minutes) dust levels. These are most probably related to vehicle activity (and possibly sheep movements) near the monitoring sites. This conclusion is supported by;
 - 1) The occurrence of these spikes in predominantly daylight (working) hours, i.e. 6am to 8pm
 - 2) The higher incidence of these spikes at Nonowie where vehicular traffic is more frequent
 - 3) The increased frequency at the Mullaquana site when the monitoring location was moved

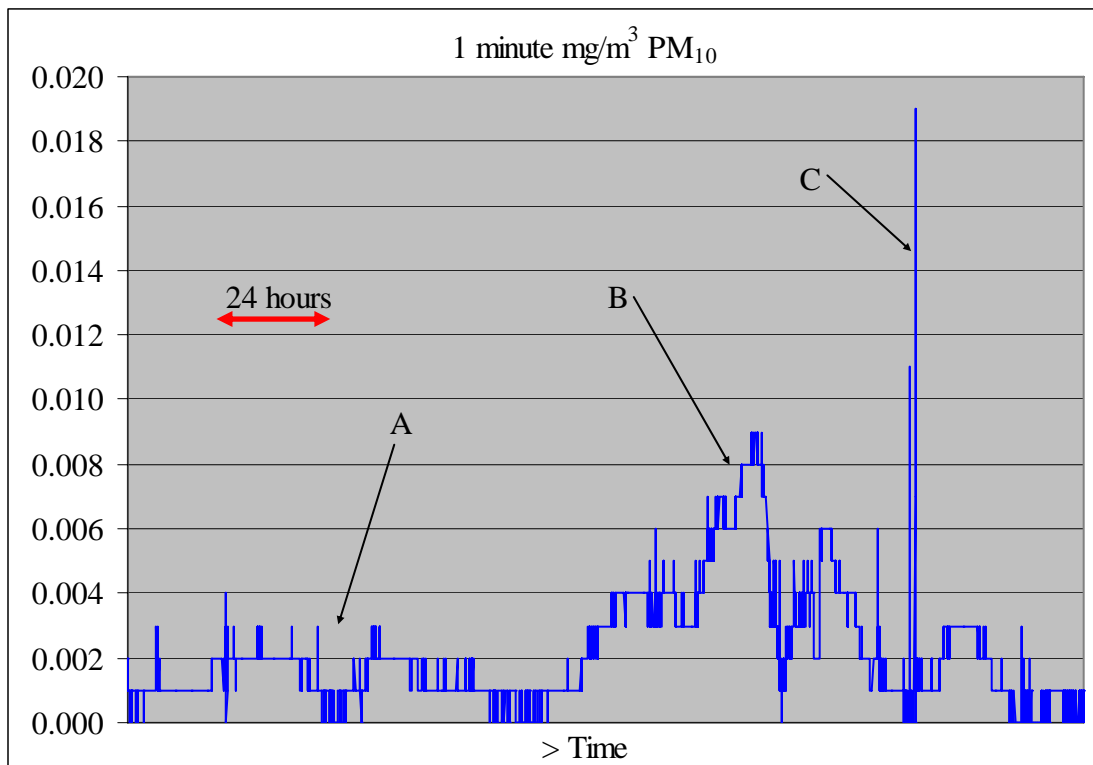


Figure 7

The data presented in Table 1 and Figures 1 to 6 is consistent with the following conclusions:

- 1) The typical dust level at two of the sensitive receptors (Mullaquana and Nonowie homesteads) is low and peak dust levels are dominated by local meteorological conditions and local vehicular traffic.
- 2) There is probably the potential for regional meteorological conditions to impact on dust levels over a wide area but this phenomenon was not observed during the monitoring period covered by this report.
- 3) As would be expected dust levels are generally lower during and just after rain (see Figure 6) than in dry periods.



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Appendix 5

Radon and Radon Daughters

Grab Sampling

Grab samples were collected in lucas cells for spot determination of radon.

Radon daughters were determined using the “Rolle SCAMP” method on a 100l sample collected over a ten minute period.

Sample collection dates, locations and results are provided in Table 1.

Date	Time	Location	Rn ²²² Bq/m ³	Rn Daughters nJ/m ³ PAEC
1/09/2010	15:00	Cowleds Landing	6	6
3/09/2010	11:00	Cowleds Landing	6	8
12/11/2010	17:00	Cowleds Landing	13	14
23/12/2010	16:30	Cowleds Landing	6	10
3/09/2010		Mullaquana Homestead	Rained in, no access	
12/11/2010	12:15	Mullaquana Homestead	18	16
25/11/2010	11:10	Mullaquana Homestead	17	23
23/12/2010	11:10	Mullaquana Homestead	11	12
23/12/2010	12:10	Mullaquana Homestead	18	9
2/09/2010	10:30	Nonowie Homestead	7	10
3/09/2010	9:30	Nonowie Homestead	7	8
12/11/2010	10:30	Nonowie Homestead	19	27
25/11/2010	13:20	Nonowie Homestead	19	12
23/12/2010	10:30	Nonowie Homestead	16	17
2/09/2010	11:34	North Reference Dam	19	21
12/11/2010	15:00	North Reference Dam	14	16
23/12/2010	14:30	North Reference Dam	16	21
2/09/2010	15:11	Operational Area	19	12
12/11/2010	13:00	Operational Area	13	17
25/11/2010	12:00	Operational Area	17	26
23/12/2010	13:30	Operational Area	19	18
2/09/2010	14:30	Southern Reference Site	16	19

Table 1 Radon and Radon Daughter Grab Samples

Although the data set is relatively small there appears to be no statistically significant difference (with a 95% confidence coefficient) between any of the sites except the Cowleds landing site. At Cowleds Landing the radon and radon daughter levels are lower than at the other sites. This is probably consistent with the coastal location of this site.

Statistical analysis was undertaken using the Wilcoxon-Mann-Whitney test implemented by the US-EPA ProUCL4.0 software.

Continuous Monitoring

Continuous Radon monitoring was undertaken at Nonowie Homestead between 11/11/2010 and 26/11/2010 using a flow through lucas cell connected to a counter-timer set up to record counts over one hour periods.

Data was not collected after 26/11/2010 because the power was disconnected from the monitor on 26/11/2010.

Figure 1 provides one hour average Radon level at Nonowie homestead.

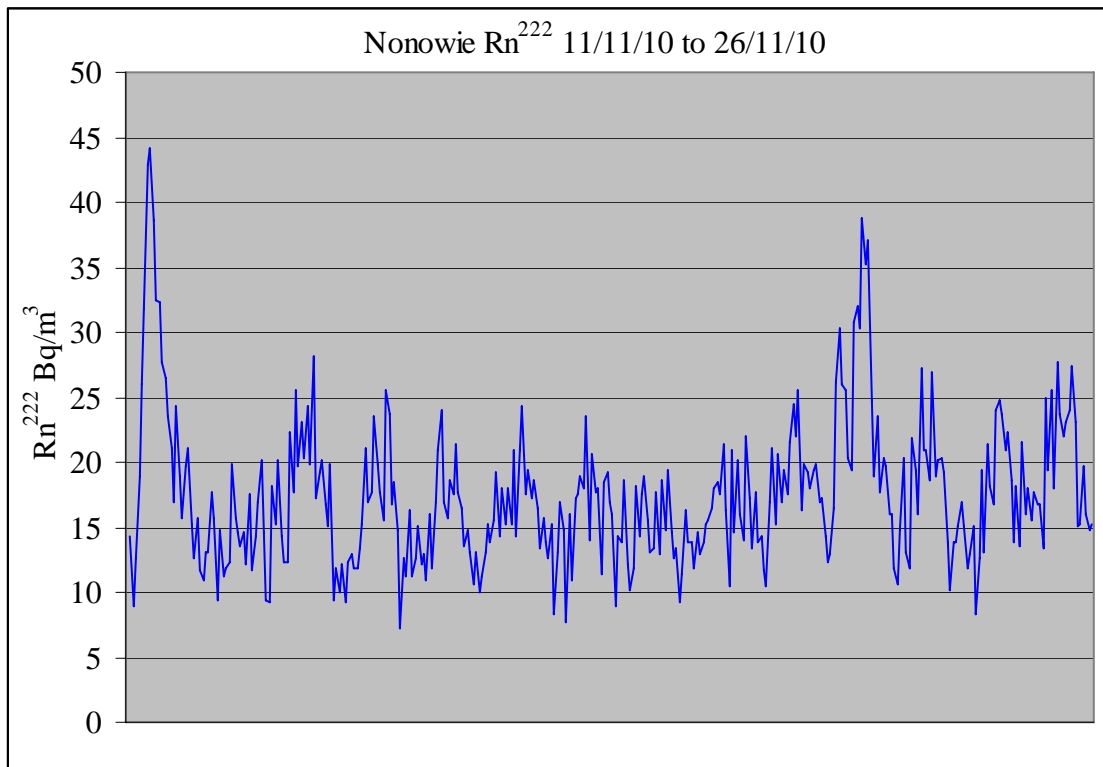


Figure 1 Rn²²² at Nonowie Homestead

The radon levels display the typical diurnal variation that is characteristic of ambient atmospheric radon concentration. This is shown more clearly in Figure 2 which shows the data from Figure 1 plotted against time of day.

In fact analysis of this data demonstrates that the most likely time of day for a high radon level is between 4am and 9am (centered on 6am) and the most likely time for a low radon level is between 3pm and 10pm (centered on 6pm).

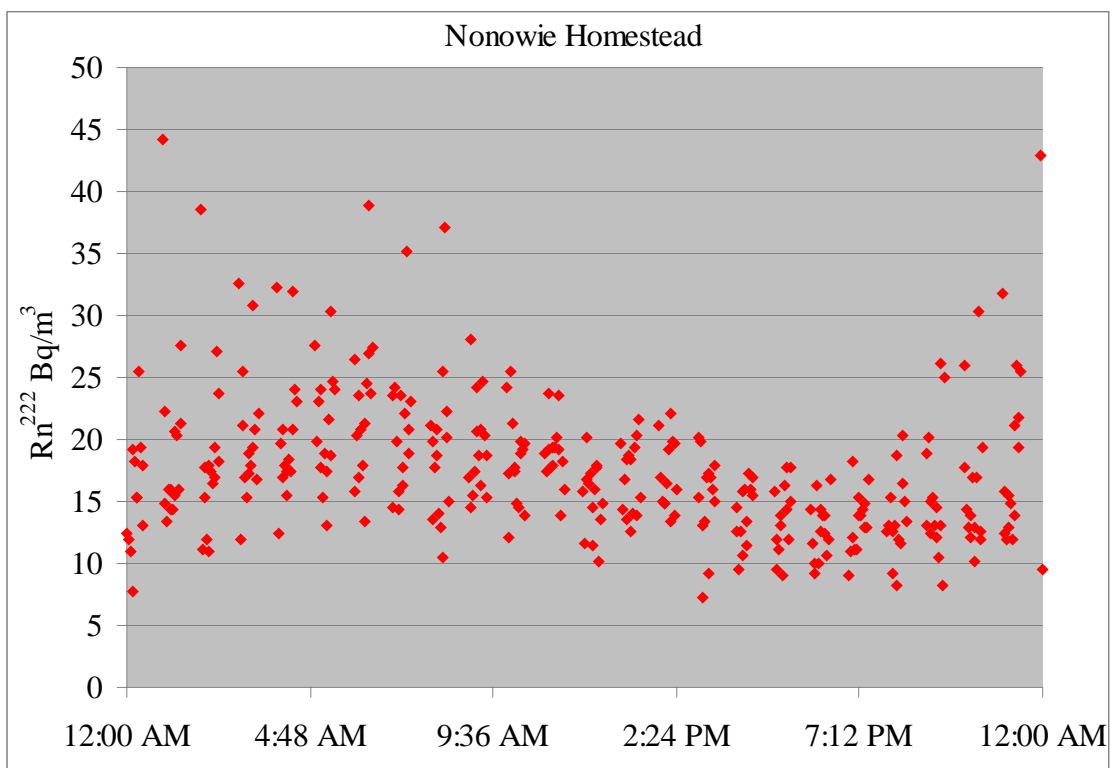


Figure 2 Diurnal Variation in Rn^{222} at Nonowie Homestead



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Appendix 6

Plant Analysis

Samples

Plant samples were collected from across the investigation area (at locations corresponding to soils samples reported in Appendix 3) on 2nd and 3rd September 2010. The plant selected is commonly referred to as “Blue Bush” (tentatively identified as *Maireana Sedifolia*) and was chosen for the following reasons:

- 1) The plant is found across the whole area of interest for this baseline study and is therefore easily collected in sufficient quantities for analysis.
- 2) The plant is available even after prolonged period of low or no rainfall.
- 3) Sheep (and probably native herbivorous animals) use the plant as a food source.
- 4) The plant consists of a soft “flesh” part that represents the last seasons growth and a “woody” part that represents a number of seasons growth. This would facilitate identifying recent changes in radionuclide levels in the plants.

The selected plant is shown in Figures 1 and 2.



Figure 1



Figure 2

Samples were washed to remove adhering soil and dust, air dried at 75°C and separated into “flesh” and “woody” sub samples before being pulverized for analysis.

Analysis for Pb²¹⁰ (beta counting) and Po²¹⁰ (alpha spectrometry) was undertaken on an acid digest (nitric, hydrochloric) of the dried sample.

Analysis for uranium and thorium (ICP-MS), Th²³⁰ (alpha spectrometry) and Ra²²⁶ (Gamma spectrometry) was undertaken on a sample that had been ashed in air at 500°C. U²³⁸ and Th²³² were calculated from the ICP-MS uranium and thorium values.

All results are reported on a dry weight basis, results are provided in Tables 1 and 2.

Results

Sample	Ash %	mN 53H	mE 53H	U µg/g	Th µg/g
Op Dam Flesh	23.3	6324759	723522	<0.1	0.53
Op Dam Wood	13.8	6324759	723522	0.15	2.05
WPT 386 Flesh	24.2	6335853	725973	<0.1	0.47
WPT 386 Wood	8.5	6335853	725973	<0.1	0.22
WPT 388 Flesh	23.7	6330425	723398	<0.1	0.73
WPT 388 Wood	10.1	6330425	723398	0.05	0.33
WPT 390 Flesh	20.0	6320736	723116	<0.1	0.50
WPT 390 Wood	10.2	6320736	723116	<0.1	0.24

Table 1 Sample Locations, Ash, Uranium and Thorium (dry weight basis)

Sample	U ²³⁸ Bq/g	Th ²³⁰ Bq/g	Ra ²²⁶ Bq/g	Pb ²¹⁰ Bq/g	Po ²¹⁰ Bq/g	Th ²³² Bq/g
Op Dam Flesh	<0.001	<0.005	<0.005	0.018	<0.02	0.002
Op Dam Wood	0.002	<0.002	<0.002	0.016	<0.02	0.008
WPT 386 Flesh	<0.001	<0.005	<0.005	0.037	0.02	0.002
WPT 386 Wood	<0.001	<0.002	<0.002	0.048	0.04	0.001
WPT 388 Flesh	<0.001	<0.005	<0.005	0.018	<0.02	0.003
WPT 388 Wood	0.001	<0.002	<0.002	0.019	0.020	0.001
WPT 390 Flesh	<0.001	<0.005	<0.005	0.052	0.03	0.002
WPT 390 Wood	<0.001	<0.002	<0.002	0.051	0.04	0.001

Table 2 Radionuclide Results (dry weight basis)