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Radionuclides at locations used for biological research and tourist visitation, Montebello Islands, WA: soil and sediment results from 2019-2020

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Radionuclides at locations used for biological research and tourist visitation, Montebello Islands, WA:Soil and sediment results from 2019-2020

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SUMMARY

During the 1950s, three nuclear tests (Hurricane, Mosaic G1 and G2) deposited radioactive fallout onto local waters and islands of the Montebello archipelago, Western Australia. In the 60+ years since, many of the short-lived radionuclides that were elevated in the 1950s and 1960s have now decayed to low levels and are now difficult to detect using standard methods. However, in many areas of the islands medium- and long-lived radionuclides such as strontium-90 (^{90}Sr) and plutonium isotopes ($^{239, 240, 241}Pu$) remain at levels that range from very low in some areas (e.g., difficult to detect) to levels that surpass 10,000 Bq/kg in areas near the detonation/fallout zones. These higher levels are well above those found at other sites in Australia that have radioactive wastes (Maralinga, mining waste sites) (Child and Hotchkis, 2013; Johansen et al., 2019; Johansen et al., 2014), and, in the case of plutonium, are the highest levels reported for current sites in Australia. These levels surpass those established for cleanup at international sites (e.g., 1000-3000 Bq/kg at US sites) and reference levels for release of materials (e.g., 100 Bq/kg for unconditional release of material, IAEA 2004b). However, the measurement of these levels does not necessarily indicate cleanup or similar actions are required at Montebello. What they do call for is an update of the 1990 dose assessment (ARL 1990) that considers current (2020-22) levels of visitation, uses, and exposures. Such a dose assessment will determine if any additional protective actions are needed beyond those currently in place. [A concurrent dose assessment has been conducted by ARPANSA as this report was being finalised].

This legacy of radionuclides creates a need for ongoing awareness and monitoring. Despite the investigation efforts of the past, gaps exist today in the information on the nature and extent of radionuclides in the Montebello Islands. Prior to this study, no radionuclide measurements have been made at designated mammal research areas on the islands. Another previous data gap is that no measurements have been made on soils, beach sands, and sediments at specific island locations that are used for public visitation such as camping.

Knowing the levels of radionuclides at these sites is important for understanding the potential for impacts from radionuclide exposure to the human researchers and members of the public that visit the sites. In addition, data are needed to evaluate potential impacts to island flora and fauna including the mammals that have been placed on the islands as part of threatened species conservation and island ecological restoration programs. Previous similar work was conducted by the Australian Radiation Laboratory. However, their data reports from the 1970s-80s and their final report, ARL 1990, are now dated, and visitation patterns have changed over recent decades. This study adds to the measurements already available for other areas visited by the public (e.g., data at “ground-zero” locations of the 1950s detonations in Johansen et al. (2019)).

The overall goal of this project is to fill the data gaps on radionuclide levels in the soils at mammal research sites as well as current and potential visitor camping sites.

This report provides:

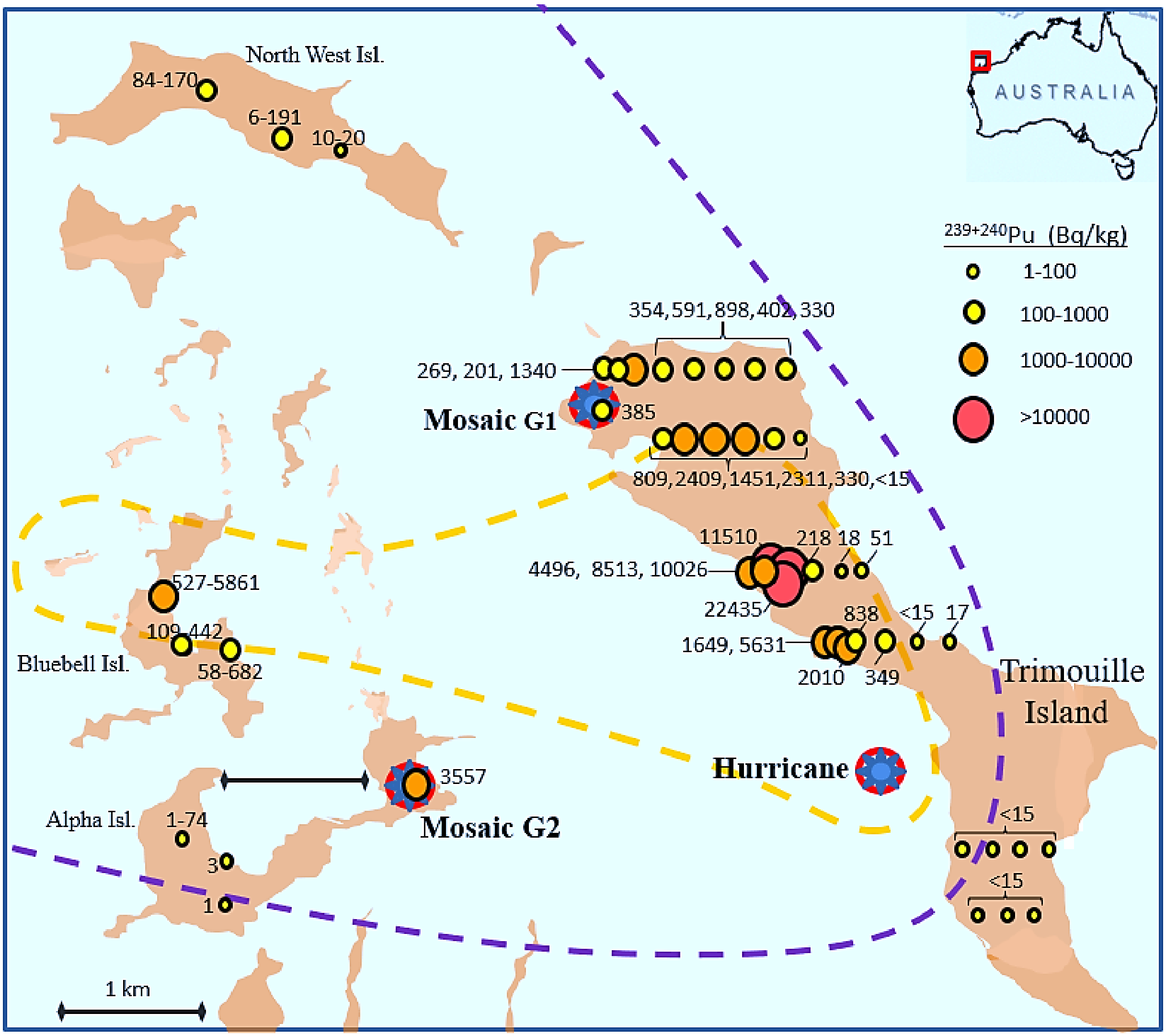
- Measurement in a range of sample types (shallow sediments, beach sands, dune/soils, inland soils) at mammal study sites as well as near public visitation areas.
- A focused attention on Pu isotopes because they are the most likely concern for potential human and biota impacts (ARL 1990).
- Results for a wide range of radionuclides which emphasise Pu, but also include ^{60}Co, ^{90}Sr, and ^{137}Cs, ^{152}Eu, ^{154}Eu, Th isotopes, U isotopes and ^{241}Am (see Appendix B for full list).

The main findings of this work are:

- The activity concentrations of radionuclides nearest the Hurricane deposition areas typically rank (highest to lowest): ^{total}Pu > ^{137}Cs > ^{90}Sr > ^{241}Am > ^{152}Eu > ^{total}U > ^{230}Th > ^{60}Co. However, variation in ranking exists at different locations across the islands. For example, in areas impacted by the Mosaic G1 and G2 sites ^{152}Eu activities can rank higher than ^{137}Cs.
- Pu levels vary greatly across the study sites. The Pu levels on the various recreational and research sites tested were (highest-to-lowest):
    - Trimouille (mammal research areas)
    - >Bluebell (northern beach campsites)
    - >Northwest (mammal research areas and beach campsite)
    - >Alpha (mammal research areas and beach campsite -western part of the island)
    - >Hermite (mammal research areas and beach campsite)
    - >Renewal (beach campsite).
- At sites generally south of the detonation areas (e.g., Hermite Island) the Pu levels range from near background, to slightly higher (< x10) than background levels from global fallout elsewhere in Australia (soil background ranges from 0.01 to ~1.0 Bq/kg) (Child and Hotchkis, 2013; Hancock et al., 2011; Smith et al., 2016).
- At sites generally north of the detonation sites (e.g., parts of Alpha Island, Bluebell, Northwest and Trimouille Islands) the Pu ranges from about x10 to x100,000 higher than background levels.
- In this study, the highest Pu levels exceeded 10,000 Bq/kg and were in samples from the western margin of Trimouille Island. These were from the same general area as the 2015 samples which had >20,000 Bq/kg maximums reported in Johansen et al. (2019). These levels are elevated relative to international norms for cleanup of radionuclide waste sites.

- Bluebell Island had not previously been sampled for Pu and the levels there were typically between 100 and 5,900 Bq/kg. The higher levels were at the northernmost of three sampling sites.
- The sampling on Hermite, and other relatively uncontaminated areas, did not find any new undiscovered areas of contamination and at these sites the activity concentrations of the natural radionuclides (e.g., most U and Th isotopes) dominate over the nuclear test radionuclides.
- At a typical camp site, the Pu tends to be higher in inland soils > dune soils > camp and beach areas. These results are consistent with those found nearer the detonation sites (Johansen et al., 2019) and generally reflect that over the decades since the radionuclides were deposited, there has been greater removal of Pu at and near beaches due to erosion from wave/water action and greater exposure to winds.
- Shallow sediments near the camp sites (gathered in 1-3 m deep water about 50-100m from high tide mark) typically had higher levels of Pu than beach and campsite samples, but lower levels than nearby island soils.
- Across all areas there is substantial spatial variation in radionuclide levels which reflects the original heterogeneous fallout patterns, subsequent erosion, and the presence of radioactive particles.
- On Trimouille Island, the sampling along transects (labelled west-to-east) across the island provided the largest set of Pu data on the island to date. In the southern/eastern portions of the island the Pu activity concentrations are above background, but relatively low. The highest Pu levels (>5000 Bq/kg) are from the same general area identified in the ARL documents which is an approximate 1 km^2 area that extends along the western shore, northward from the Main Beach area (see Figure 9). The data suggest some spreading of Pu by wind from this area, (to the north-east). However, this study was not designed to define the boundaries of the elevated area, or the amount that is being spread by wind. The available data suggest that despite some wind erosion, there remain highly persistent, elevated Pu levels in the surface soils at the original deposition areas.
- The Soil Depth Profile data indicate the Pu is mostly in the top 10 cm of island soils, but also that a fraction of the Pu has penetrated to beyond 30 cm depth (based on data from Trimouille Island and Alpha Island). The significance of this is that the areas of Pu fallout should be regarded as a 0-30+ cm layer of contamination that will persist into the future and provide an ongoing source of Pu available for mobilization by wind and water.
- The sampling on Trimouille Island met its goal of providing an island-wide survey of Pu levels. However, the sampling was not intended to provide detailed resolution of the highly-elevated Pu deposits in the mid-western region of the island. In those areas, additional data collection is needed to complete the mapping of Pu on Trimouille.

- Based on the above, the Pu remains elevated on portions of northern Trimouille Island, and on northern Bluebell Island (Summary Figure). This pattern is consistent with the historical deposition pattern from the Hurricane Test (dashed lines, Summary Figure). This pattern also suggests elevated Pu on several small islands in the deposition path that have not been sampled (e.g., Kingcup, Boronia, and others). Pu also remains elevated near the Mosaic G2 site and, at a lower level, at the Mosaic G1 site.



Summary Figure. ^{239,240}Pu levels (Bq/kg) remain elevated above 1000 Bq/kg at the Mosaic G2 site and on portions of northern Trimouille and northern Bluebell Islands. Shown are results of 2015-2019 sampling of soils (see text and data tables for beach sands and sediment data). The purple dashed line indicates the approximate area of elevated 1950s fallout from all three tests (based on 1960-70s data: Figure 1D). The yellow dashed line bounds the approximate area of highest 1952 Hurricane Test deposition (based on 1952 data; Figure 1C). Some island areas within the yellow dashed line have not been sampled and may also have elevated Pu (e.g., parts of Kingcup, Boronia and other islands). As a comparative reference, the general background ^{239,240}Pu levels in Australian soils are typically about 0.1 Bq/kg (range 0.02-0.5 Bq/kg) (Johansen et al., 2019).

- For the identified areas, ANSTO has recommended a process of using the current data to evaluate potential risk (e.g., a human health radiological dose assessment), fill data gaps if needed, and use the precautionary principle as necessary to reduce exposures to public and workers who may be exposed to the Pu in these areas via inhalation. Based on the outcome of the dose assessment, the current management strategy can be reviewed for completeness and consideration given to any needed updates for public and worker protection.
- This study did not specifically investigate radioactive particles ("hot particles") but the results are consistent with contamination that is particle-rich. Specifically, the results from split/duplicate samples, or samples gathered near each other, had substantial variation which is consistent with the expected random occurrence of particles in the samples.
- The higher radionuclide levels of this study present a long-term exposure concern to human visitors and wildlife that should be further evaluated.

The above summary points are limited to the 2019 study sites. It should not be assumed that the above summary applies at the areas close to the detonation sites (i.e. the ground zero locations) where higher levels of contamination including greater amounts of radioactive particles exist. Information on the detonation sites can be found in (Child and Hotchkis, 2013; Johansen et al., 2019; Johansen et al., 2014)

BACKGROUND

In October 1952, a nuclear weapon with a plutonium core was detonated in the hull of the HMS Plym, which was anchored in shallow waters within the Montebello Islands archipelago off Western Australia. The 25 kt detonation initially caused a gamma burst, quickly followed by pressure and heat waves, which drew vaporised and molten materials from the ship, seawater and seafloor sediments up into a rising thermal cloud. The subsequent radioactive fallout was deposited first onto local waters and islands, then, with less intensity, regionally and ultimately across northern Australia (Butement et al., 1957; Child and Hotchkis, 2013; Lal et al., 2017; Tims et al., 2013; Tims et al., 2016).

This test, code-named Hurricane, initiated the British nuclear testing program and was the first major atmospheric release of anthropogenic radionuclides in the Southern Hemisphere (Figure 1). Two additional nearby nuclear detonations followed four years later, Mosaic G1 and Mosaic G2, the latter being the largest of all nuclear detonations of the British tests in Australia (the proposed yield was 60 kt, estimates of the actual yield approach 100 kt: Child and Hotchkis, 2013; UNSCEAR, 2000).

In the 60+ years since the detonations many of the short-lived radionuclides have decayed to low levels and are now difficult to detect using standard methods. A number of medium- and long-lived radionuclides remain such as strontium-90 (^{90}Sr) and plutonium isotopes ($^{239, 240, 241}Pu$). This legacy of radionuclides creates a need for ongoing awareness and monitoring. There were government surveys conducted in the 1960s-1980s (Australian Radiation Laboratory [ARL] Report Series; ARL1979; ARL, 1980; ARL, 1982; ARL, 1983; ARL, 1990). Following the ARL 1990 publication, there was a period of time in which few Montebello radionuclide data were reported (Child and Hotchkis, 2013; Tims et al., 2013). Recently, some new data have been published (Johansen et al. 2019). However, these data were few and focused mainly near the detonation areas.

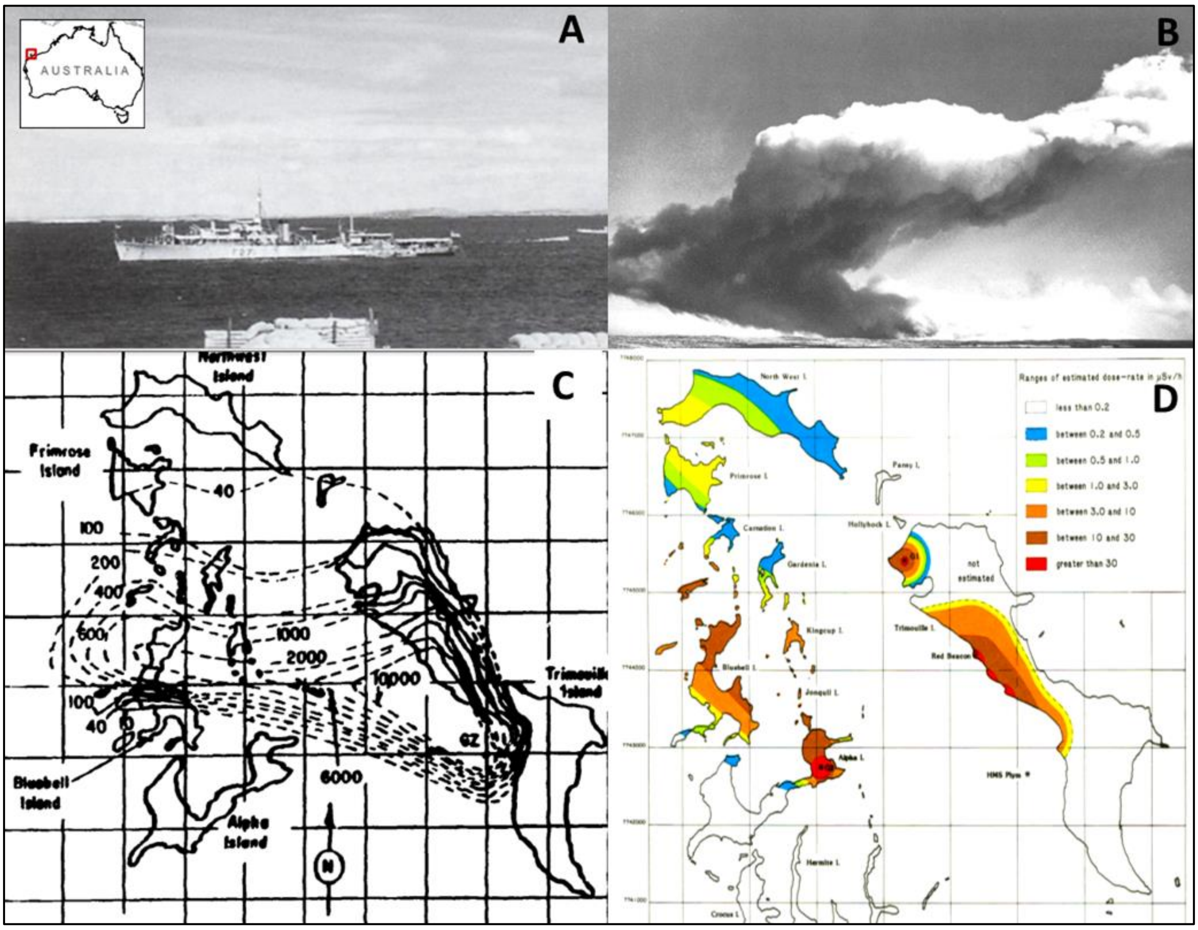


Figure 1. (A) The HMS Plym prior to the Hurricane test in October 1952. (B) The thermal cloud after detonation. (C) The resulting surface dose rate contours at 1 hour (from 40 to 10,000 rad hr^{-1}, approximately 0.4 to 100 Gy hr^{-1}). (D) 1962 gamma dose rate contours from the combined fallout from the Hurricane and Mosaic tests (yellow-to-red increasing gamma emissions; ARL, 1982). Sources are: (A,B) National Archives of Australia; (C) "*Local fallout from nuclear test detonations, compilation of fallout patterns and related test data, foreign nuclear tests.*" US Army Nuclear Defence Laboratory, 1964. Declassified 17 June 1992 by the US Defence Technical Information Center; (D) Australian Radiation Laboratory (ARL), 1982.

Despite the efforts of the past, major data gaps exist relevant to uses of the Montebello Islands today. One gap is that no radionuclide measurements have been made at designated mammal research areas on the islands near the nuclear detonation sites. These islands are being utilised as refuge locations for a number of threatened and endangered Australian mammal species. Knowing the levels of radionuclides at these is important for understanding any potential impacts to the mammals themselves, as well as for ensuring development of appropriate health and safety protocols and safe work practices for the human researchers that regularly visit the sites and interact with the soils (and therefore the radionuclides).

Prior to this study, no measurements have been made on soils, beach sands, and sediments at numerous island locations that are currently used (or proposed in the future) for camping by public visitors. Camping in the islands is allowed in certain areas and prohibited in others (near the detonation locations). This designation has been based on the best available information (e.g., the ARL surveys). However, the available data have become dated, and there have been no site-specific, recent or historical data at most of the locations used by campers. Gathering data at the camping locations will provide assurance that the radionuclide levels are low, and/or provide a basis for any further restrictions needed. Such data from the camping sites are intended to be useful for further health and safety assessments (e.g., dose assessment for camping activities).

The overall goal of this project is to fill the data gaps on radionuclide levels at mammal research sites as well as visitor camping sites. The data in this report are intended to be useful for assessing work exposure conditions, informing safe work practices for researchers and others who may perform routine work duties in the islands, as well as providing a basis for assessing and ensuring visitor safety.

METHODS

Sampling

The field sampling followed standard best practice methods for environmental assessment of radionuclides as described in (Johansen et al. 2019). These included:

- Samples of soils, beach sands and shallow sediments, were from the surface layer (<10 cm) unless specified otherwise consistent with current IAEA and other international approaches.
- Samples were collected using clean 30 mm PVC tubes. Fresh tubes were used at different locations.
- All samples were composites of a minimum of 3 tube pushes (typically gathered within a few meters of each other at ~120° angles from a centre-point). The 3 samples were mixed in a plastic bag by rotation and shaking with care to avoid stratification or loss. Any excess was eliminated at the sample location.
- Soil depth profiles were gathered at some locations. These were gathered by digging a large U-shape hole, leaving an undisturbed central section that was progressively sampled downward in 4 cm lifts. Before each sampling, the exposed faces of the soil were shaved to eliminate the potential for cross-contamination.

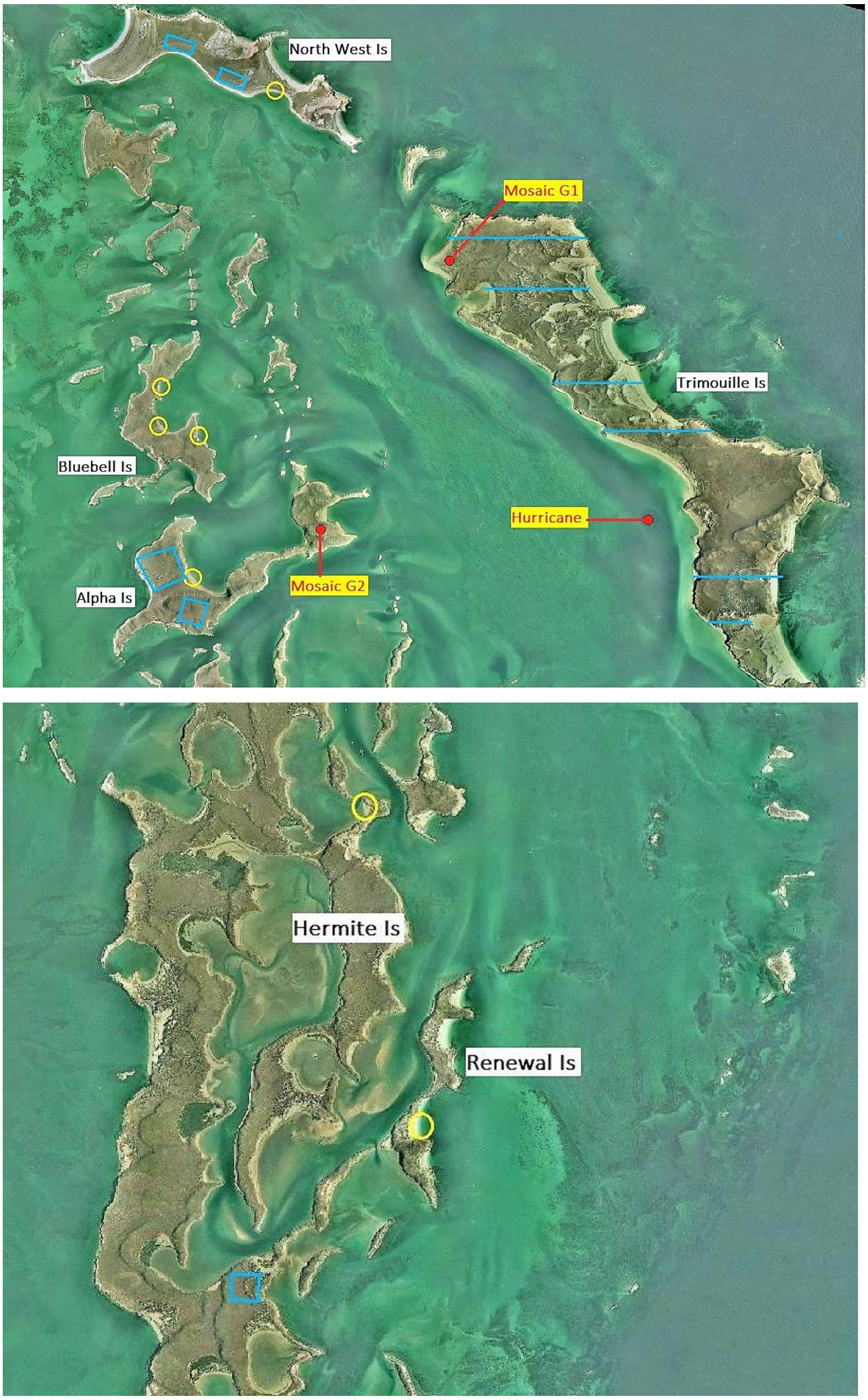


Figure 2. Study locations at mammal research areas (blue) and selected current or potential public visitation/camping sites (yellow) at the Montebello Islands.

Study approach for mammal research areas

At gridded mammal sites, samples were typically gathered at all four corners and near the grid centre (Figure 3). For some grids (where detail across the grid was not needed), fewer samples were gathered, or, samples were composited.

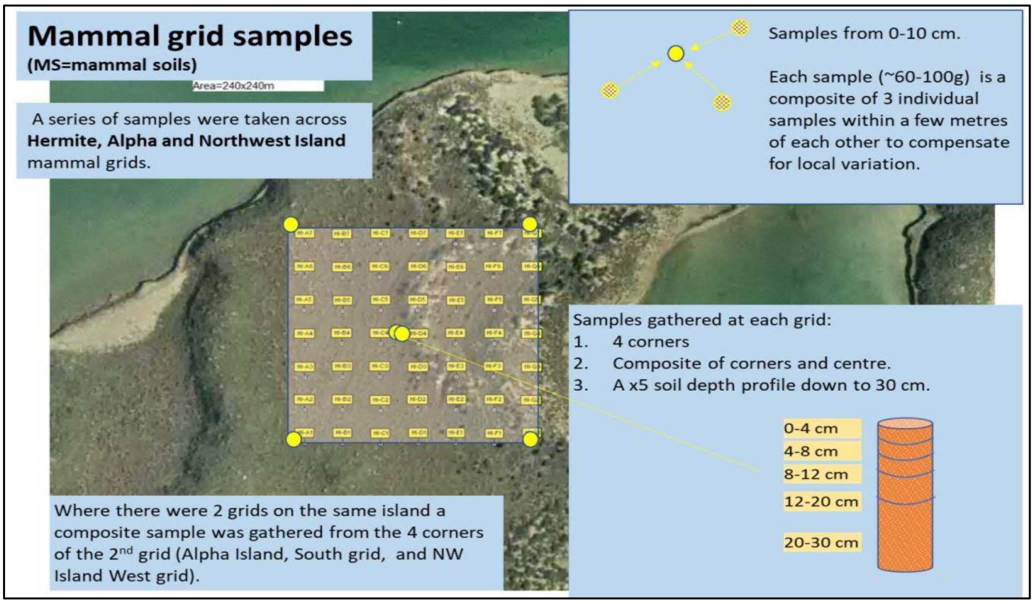


Figure 3. Typical sampling design at the mammal research grids (e.g., Hermite Island), Montebello Islands.

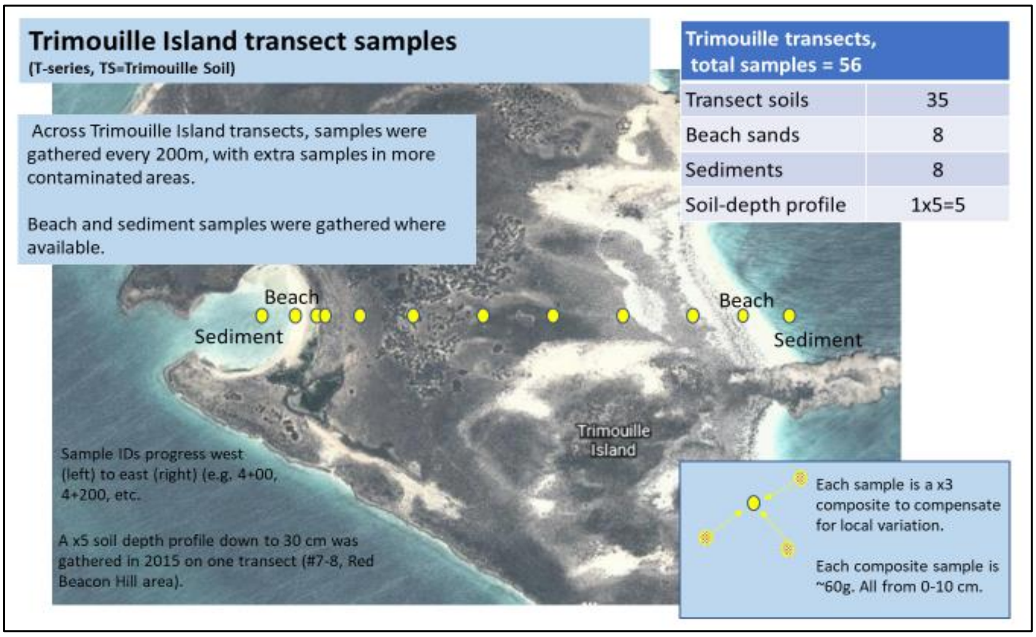


Figure 4. Typical sampling design for a Trimouille Island transect (e.g., Transect 3-4), Montebello Islands.

On Trimouille Island, the existing mammal survey transects were used to guide sampling at every 200m across most of the transect with some finer sampling near the transect ends (Figure 4) as well as beach and sediment samples when available. Due to practical time constraints, four (out of ten) transects (5-6, 11-12, 13-14, 19-20) were not sampled.

Study approach for camp sites

In addition to the general field sampling methods described above, at camp sites, the following also applies:

- The locations of the camp sites to be sampled were established in consultation with the DBCA Marine Program Coordinator responsible for management of the Montebello Islands Marine Park and Conservation Park.
- Camp site sampling transects typically consisted of (Figure 5): shallow sediments from ~50-100 m from the high tide level, beach sands (~midpoint between low and high water levels), camp sands/soils from just inland/above the high water mark in likely camping areas (mostly areas that were clearly used), and "dune soils" which were locations inland from the camp sites, typically within ~100m and likely areas where people would disturb the soils while making a camping toilet (e.g., digging a 30cm hole).
- Some soil depth profiles were gathered at dune soil sites.
- At Alpha Island and Northwest Island, the camp and the mammal grids were adjacent and allowed for use of common samples.
- At Bluebell Island, additional samples were gathered because this island appears to have been in the path of fallout from the Hurricane test as the available historical fallout map suggests (see Appendix). The fallout map suggests there may be variable fallout across the island and therefore 3 camp sites were sampled (Figure 6).

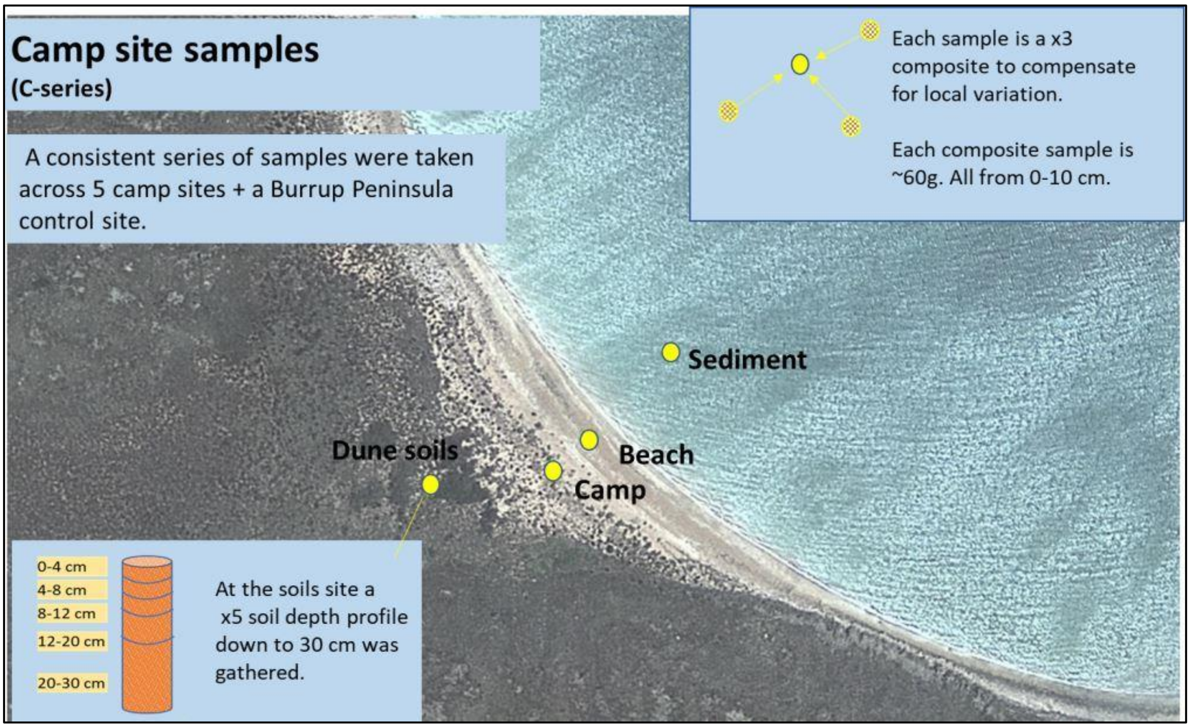


Figure 5. 2019 sampling design at camp sites within the Montebello Islands (e.g., Chartreuse Bay on Alpha Island).

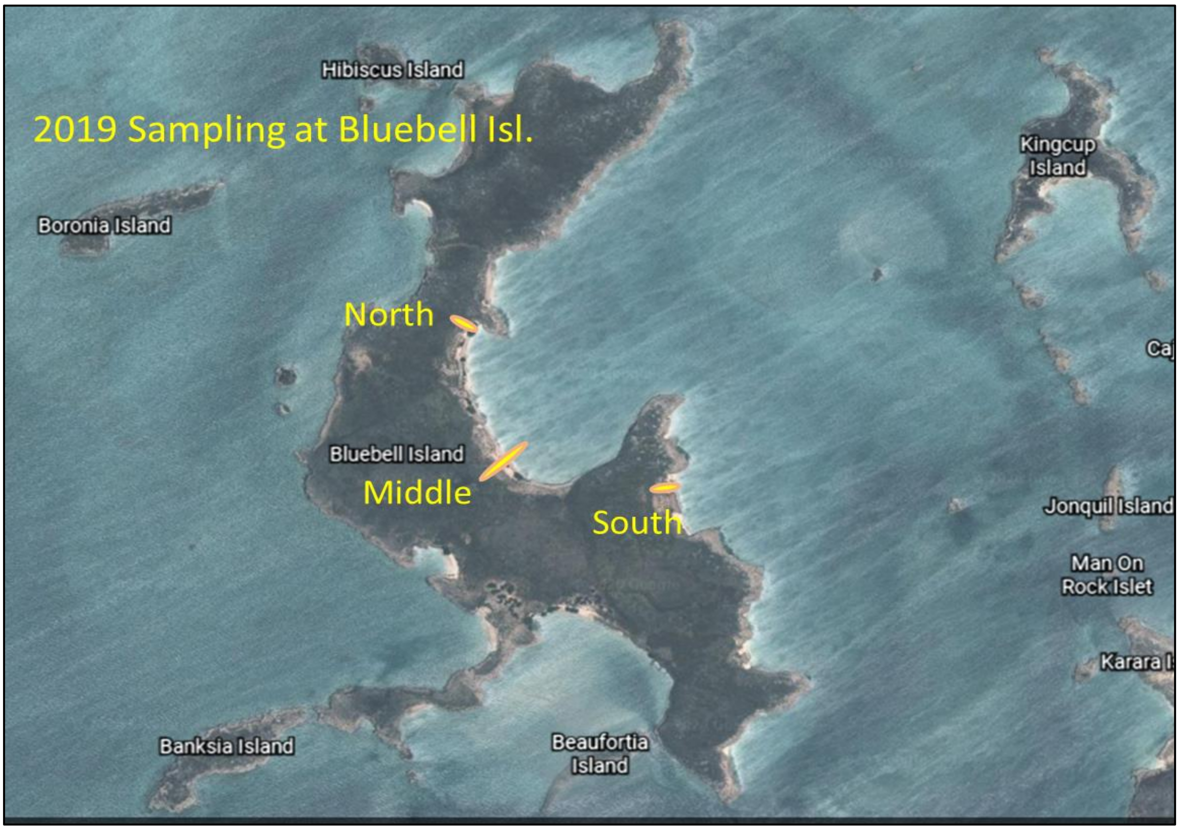


Figure 6. Locations of campsite sampling on Bluebell Island, Montebello Islands.

Radionuclide Analysis

Radionuclide analysis methods are explained in detail in Johansen et al. (2019); some text below is excerpted from these papers and summarized briefly here.

Alpha spectrometry

Surface soils and marine sediments were screened to remove fragments, coarse pebbles and vegetation (>500 µm). The bulk soil was then homogenised, dried, and subsamples (~10 g) were digested using a three-step digestion process: aqua regia reflux (solid:liquid ratio 1:20, 108 °C, 4 hours); open hotplate digestion using hydrofluoric acid; and fusion digestion of residual solids (IAEA, 2010b). Any residue remaining after digestion was collected on a filter paper and screened for total radioactivity (ISO, 2009). Radioactivity was not detected above instrument background in these residues indicating adequate dissolution of the sample matrices.

Sample digests were spiked with yield tracers ^{232}U (EZA Source 83609-657), ^{229}Th (EZA Cat. No. 7229), ^{242}Pu (NIST SRM 4334I), ^{243}Am (EZA Cat. No. 7243). Samples were chemically processed as described in Harrison et al. (2011). Uranium (^{238}U, ^{234}U), thorium (^{230}Th; to assess for potential U components to the 1950s testing), plutonium ($^{239+240}$Pu, ^{238}Pu) and americium (^{241}Am) were measured by alpha spectrometry on a Canberra Alpha Analyst using Passivated Implanted Planar Silicon (PIPS®) detectors as described in Harrison et al. (2016).

Beta analysis

Digests for beta analysis were conducted as described for alpha spectrometry and stable Sr was used for the control spike. Autochthonous stable Sr concentrations in each sample were measured by ICP-AES and taken into consideration in the Sr yield assessment. Strontium-90 (^{90}Sr) was quantified by Cherenkov counting (L'Annunziata and Kessler, 2012) on a Perkin-Elmer Tri-Carb 3100TR liquid scintillation counter. Instrumentation settings and count methodology are described in Harrison et al. (2011).

Gamma spectroscopy

Gamma-emitting radionuclides in soils and sediments were measured in standard-geometry containers using an ORTEC High-Purity Germanium (HPGe) n-type reduced background detector (relative efficiency of 45%) coupled to an ORTEC DSPEC Pro with MAESTRO software. An equivalent geometry, soil matrix, mixed gamma calibration source (15 x 55 mm, EZA SRS 94204) was used for energy and efficiency calibration across an energy range of 46.5–1836.1 keV. Dried and homogenous samples were counted between 24 – 72 hours each to achieve adequate counting statistics. The detectors were calibrated using a multi gamma calibration standard.

RESULTS

Mammal Research Areas

At mammal research sites, the activity concentrations of key radionuclides typically rank (highest to lowest): ^{total}Pu > ^{137}Cs > ^{90}Sr > ^{241}Am > ^{152}Eu > ^{total}U > ^{230}Th > ^{60}Co near the Hurricane deposition areas. For Pu, the levels at the mammal research areas, ranked (highest-to-lowest): Trimouille >Northwest >Alpha >Hermite (Figures 7 and 8). However, variation in ranking exists at different locations, for example in areas impacted by the Mosaic G1 and G2 sites; ^{152}Eu can rank higher than ^{137}Cs. On Hermite Island, and background areas, the natural radionuclides, such as the U and Th series isotopes, have higher activity concentrations than radionuclides from the 1950s tests.

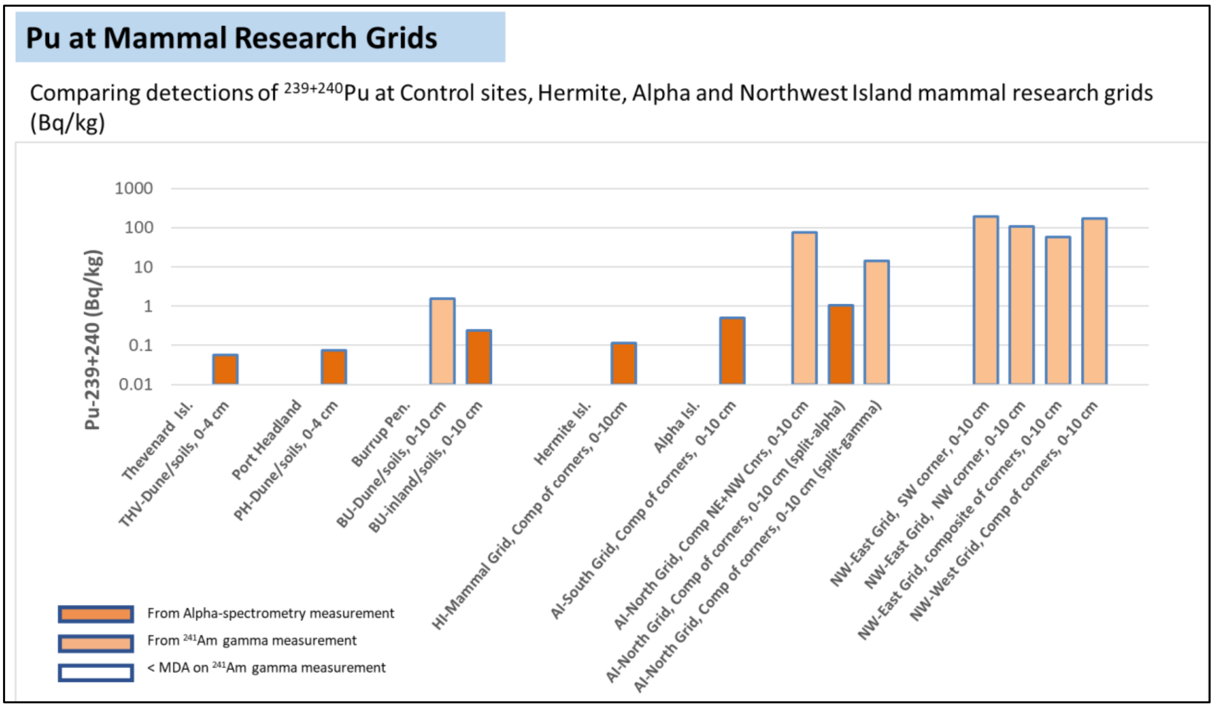


Figure 7. Summary Pu activity concentrations at mammal research areas on Hermite, Alpha and Northwest Islands within the Montebello Islands, in comparison to other areas within the WA Pilbara Region (Thevenard Island, Port Hedland, and Burrup Peninsula).

At the Hermite mammal grid site, the Pu levels range from about the same to slightly higher (< x10) than background levels from global fallout elsewhere in Australia (soil background ranges from 0.01 to ~1.0 Bq/kg) (Child and Hotchkis, 2013; Hancock et al., 2011; Smith et al., 2016). The sampling on Hermite, and other relatively uncontaminated areas, did not find any new undiscovered areas of contamination and at these sites the natural radionuclides (e.g., most U and Th series isotopes) dominate over the nuclear test radionuclides.

On Alpha Island, there is a large difference between radionuclide levels at the South mammal grid (<<lower) than the north grid (>>higher). At the north grid, the Pu results ranged from about 1 to 74 Bq/kg (about x10 to x100 higher than typical background levels). The higher levels were at the northernmost corners of the north grid.

On Northwest Island, of the two mammal research areas, the higher levels of Pu were at the western grid (174 Bq/kg for the composite of four grid corners) as compared with 57 Bq/kg composite result for the eastern grid. However, levels varied significantly with one sample from the eastern grid at 191 Bq/kg (see later discussion on variation).

Trimouille Island Pu

In this study, the highest Pu levels exceeded 10,000 Bq/kg and were in samples from the western margin of Trimouille Island. These were lower than, but from the same general area as the 2015 samples which had >20,000 Bq/kg maximums. On Trimouille Island, the transect sampling (west-to-east) across the island provided the largest set of Pu data to date on the island and showed that the activity concentrations in the eastern/southern margins of the island are orders of magnitude lower than in the western/northern areas. On transect soils (0-10cm):

- Mean=1430 Bq/kg,
- Geomean=141 Bq/kg,
- Minimum detection=2 Bq/kg (with many <MDAs)
- Maximum=16973 Bq/kg.
- # > 1000 Bq/kg = 22% of stations tested.

The data of this study greatly improve the understanding of the Pu on Trimouille Island which has had limited direct testing for Pu in past studies. Figure 9 is a partially-completed map of the Pu levels on Trimouille Island. While this map provides the most extensive set of Pu measurements gathered on the island to date (2019), some key areas of the island with known contamination have yet to be sampled/characterized for Pu (areas marked with “no data”).

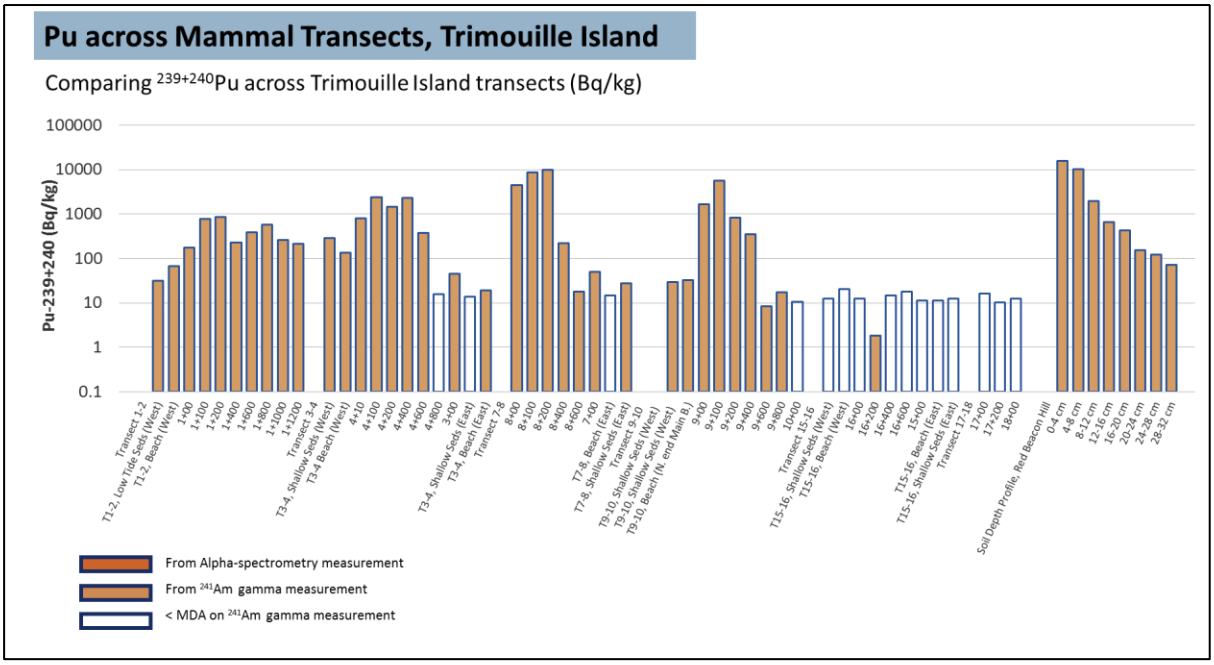


Figure 8. Pu activity concentrations across Trimouille Island transects (all progress west to east), Montebello Islands.

Despite these gaps, the results address the question of –"in the past 60+ years, has the Pu spread across the island?" The island soils are subject to frequent high winds and periodic storm events, which can cause scour, erosion and mobilization of the Pu. The 2019 data mainly suggest persistence in the original deposition areas despite the erosive forces. This may partly be explained by the Soil Depth Profile data which indicate the Pu is mostly in the top 10 cm of island soils, but that some Pu has penetrated to beyond 30 cm depth (Fig 8, rightmost data). Most of this buried Pu is not easily mobilized by wind, which accounts for its stability over the past decades. However, the topmost layer is available for ongoing mobilization. The significance of this is that the areas with the highest elevated Pu should be regarded as a 0-30+cm layer of contamination that is relatively stable, but, over time provides an ongoing source of Pu available for mobilization by wind and water.

Consistent with the above, some mobilization of the Pu from inland soils appears to be occurring due to wind. Contours on the most recent data suggest northward and eastward mobilization from the main deposition area (e.g., some Pu is spreading NE inland from the contaminated areas on the western margin). However, the amount mobilized appears to be a small fraction of the Pu that is highly persistent in the original deposition areas.

Given that the Pu contamination is persistent and acts as an ongoing source, further sampling is recommended in the areas shown in Figure 9 (around the Mosaic G1 site and the gaps to the north and south of the elevated contamination on the western margin of Trimouille Island). Options to fill these data gaps include: 1) additional soil samples (~30-50), and/or 2) field gamma measurements that can be correlated to Pu (hand-held, backpack, or drone detectors with highly sensitive gamma capabilities). During the 2019 study, field gamma measurements were gathered at transect points using a hand-held detector. Measurements were taken at 10 cm and 100 cm above ground surface. The detections likely reflect mainly ^{137}Cs emissions, and also 2^{41}Am which is associated with Pu. The ^{137}Cs levels may be somewhat correlated with Pu levels as Cs and Pu have somewhat similar soil adsorption characteristics.

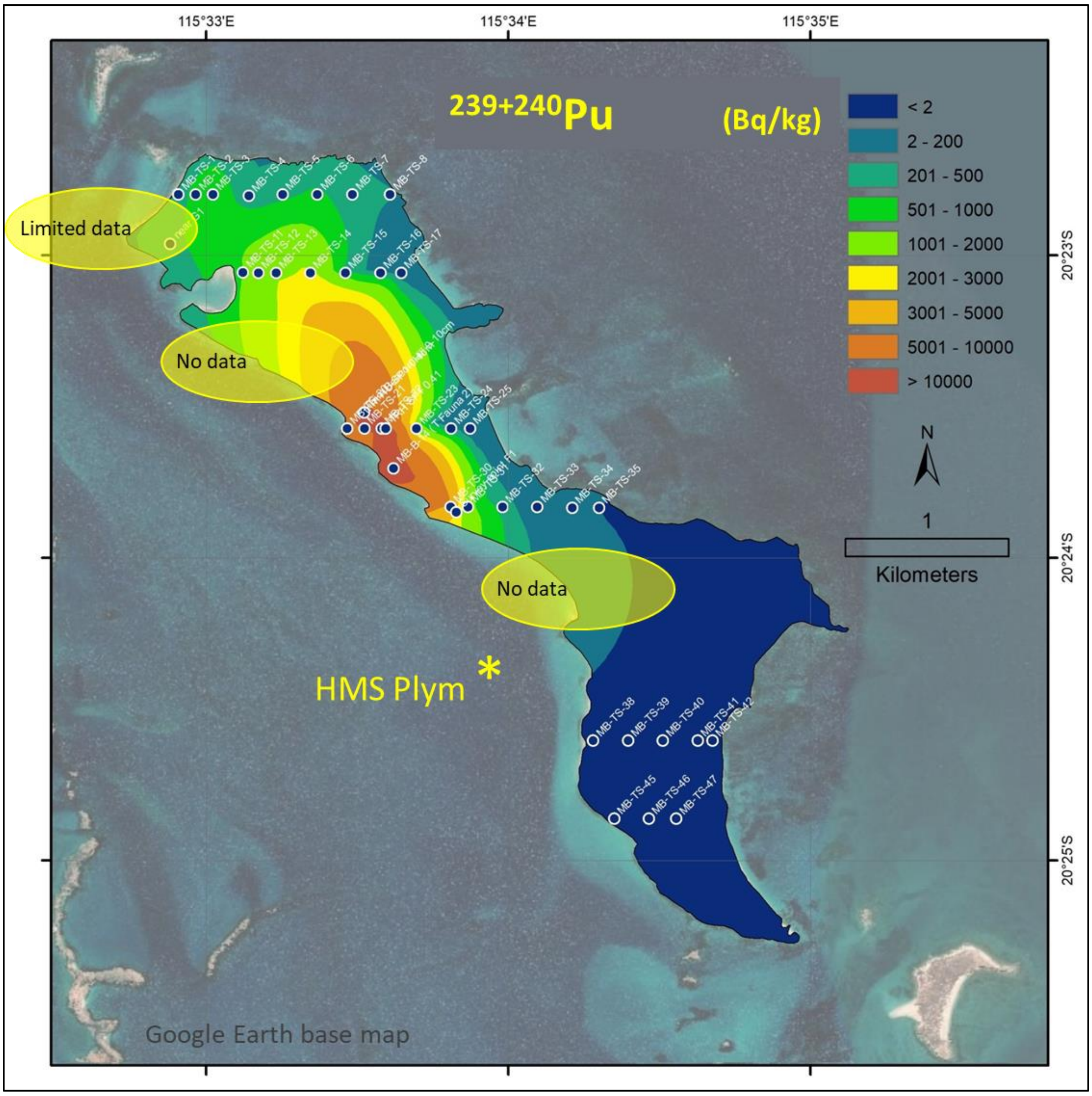


Figure 9. Spatial mapping of Pu activity concentrations on Trimouille Island, Montebello Islands, based on all soils data collected through 2019. The lack of data in some areas prohibits accurate bounding of contours and more data are needed to improve mapping in those areas (e.g., between transects and across southern Trimouille Island).

Camping/visitation Sites

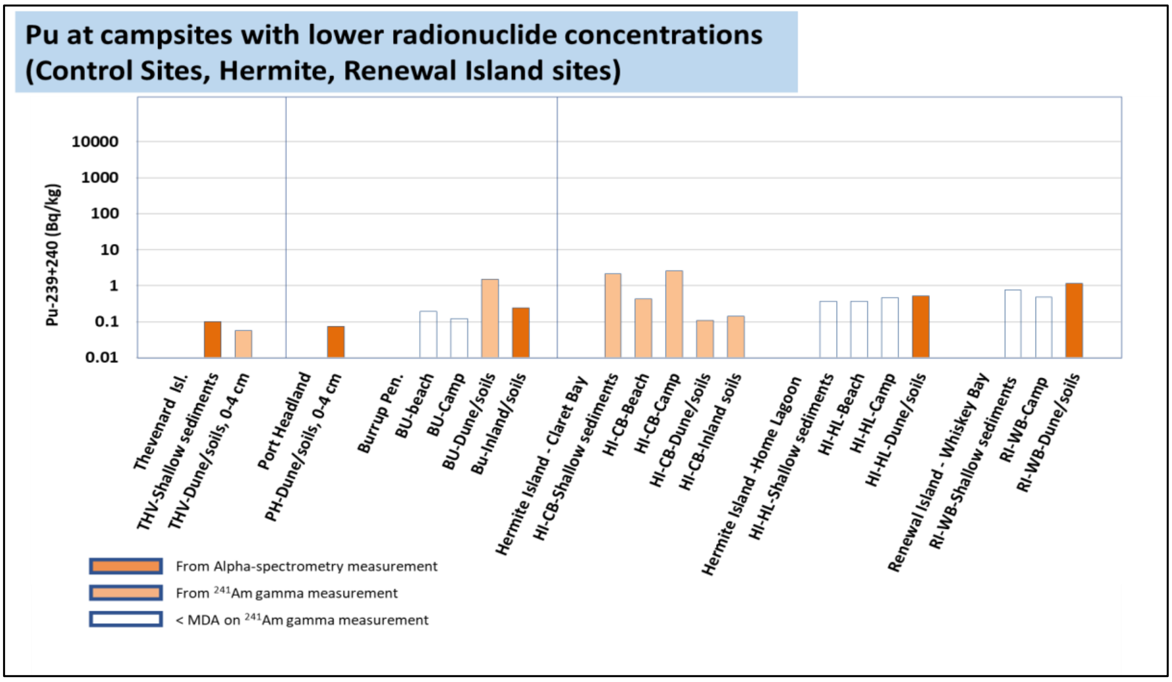
The levels of Pu and other radionuclides from the 1950s tests vary greatly across the public visitation/camping study sites with (highest-to-lowest): Bluebell > Northwest > Alpha (western part) > Hermite > Renewal (Figures 10 and 11). The study areas are a series of camping locations and tend to have lower activity concentrations than other nearby areas that could be visited (e.g., ground zero locations and other areas closer to the detonation sites as discussed in Johansen et al. (2019)).

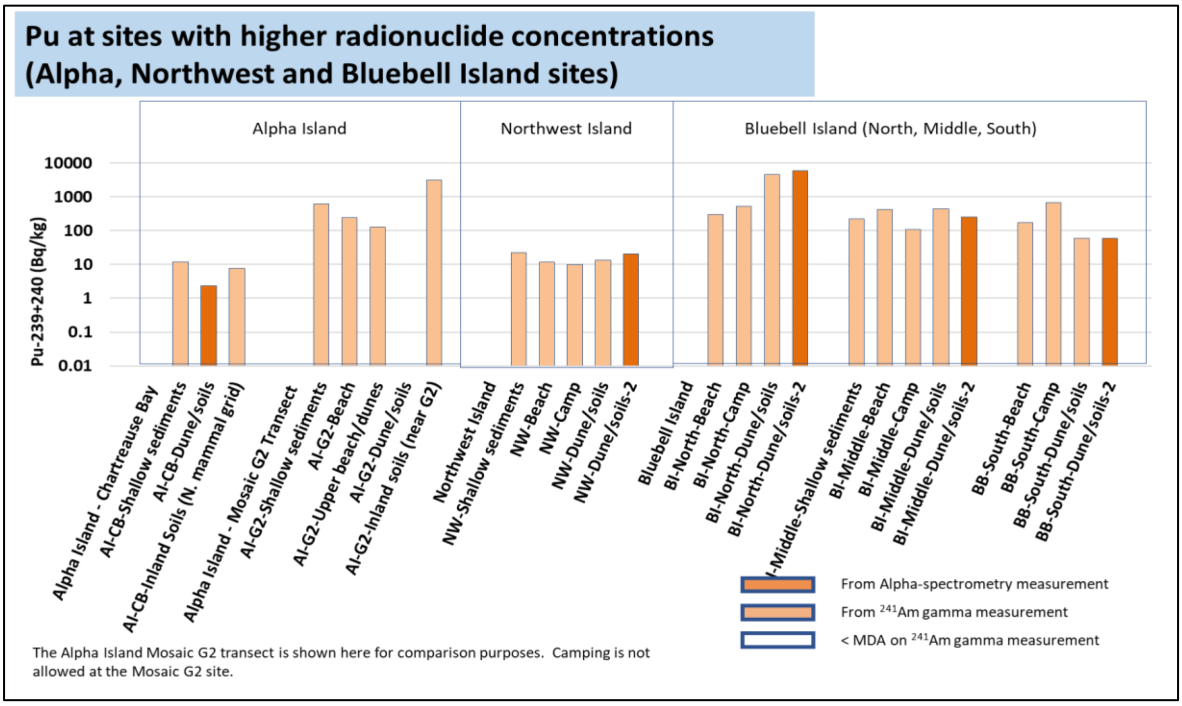
At sites generally south of the detonation areas (Hermite Island, Renewal Island) the Pu levels range from about the same to slightly higher (< x10) than background levels from global fallout elsewhere in Australia (soil background ranges from 0.01 to <1.0 Bq/kg) (Child and Hotchkis, 2013; Hancock et al., 2011; Smith et al., 2016).

The site on Alpha Island (Chartreuse Bay), also has relatively low Pu levels (about 1-2 Bq/kg in sands and soils, and 12 Bq/kg in shallow sediments). However, it appears to be located near the edge of the main fallout deposition as the Pu levels on the mammal research grid just to the northwest are orders of magnitude higher. All Pu results from the Chartreuse Bay beach area, and adjacent mammal monitoring area are below the 100 Bq/kg IAEA reference level for unconditional release of materials (IAEA 2004b) and therefore do not indicate a radiation risk to infrequent visitors.

Bluebell Island had not previously been sampled for Pu and the levels ranged from about 60 to 5900 Bq/kg. The contamination gradient on Bluebell increases from south to north and the limited sampling (limited to within 100 m at each of the three camp areas; Figure 6) likely did not discover the highest deposition areas on the island. The averages at the three sampling sites on Bluebell Island (Figure 6) were 2780 Bq/kg (north site), 310 Bq/kg (middle site), and 240 Bq/kg (south site) (average of samples of beach sands, camp and dune sands/soils). As at other sites, the lowest levels are on beach sands with order of magnitude increases in dunes and island soils. The island is relatively small and public persons would not need to walk far to be exposed to these potentially higher levels indicating the need for considering this area under a dose assessment.

On Northwest Island, the Pu levels at the camp site ranged from 10 to 21 Bq/kg. Similar to Alpha and Bluebell Islands, the Pu varies across the island, with in this case, the higher levels to the west. The highest level at the western mammal grid was 191 Bq/kg. This implies that a party camping on the south-western side of the island would encounter higher radionuclide levels than those camping on the south-eastern side where the sampling site for this study was located.





Figures 10 and 11. Pu (Bq/kg) at current and potential camping/visitation sites within the Montebello Islands, compared to other sites within the WA Pilbara Region (Thevenard Island, Port Hedland, and Burrup Peninsula)

At camp sites in general, the Pu tends to be higher in inland soils> dune soils> camp and beach areas which reflects generally greater erosion at and near the beach of Pu attached to fine particles (consistent with earlier publications). However, some variation exists likely due to the presence of radioactive particles in samples (see Radioactive Particles section below). Shallow sediments near the camp sites (50-100m from high tide mark) often had higher levels of Pu than beach and campsite samples.

The downward trend in activity concentrations, from island soils to beach areas, is consistent with general knowledge of how adsorbing radionuclides behave in the environment. Over the past 60+ years, erosion and mixing have occurred for island soils mainly via wind and rainfall/runoff. Greater erosion and mixing occurs in beach and tidal areas, which receive daily scour and erosion from waves and tides, are exposed to winds, and have heightened scour and mixing during storms and cyclones. The key radionuclides present are known to bind readily to soil particles (Bellenger and Staunton, 2008; IAEA, 2004, 2010a). Proportionally more radionuclides typically bind to smaller-sized particles (IAEA, 2010a). The Pu attached to these small particles is more easily mobilised and transported away when subjected to erosion. Mobilisation rates in shoreline areas during cyclones would be particularly high. A portion of this eroded Pu appears to settle and persist somewhat in the shallow sediments near the beach areas. Some of the Pu is also likely transported to more distant locations. Such sediment transport in the Montebello Islands has yet to be investigated.

During study preparation, the question was raised about public members walking inland from the beach areas and digging in soils (e.g., toilet). This activity would likely result in higher radionuclide exposures, mainly due to dust/disturbance of the inland soils. The Soil Depth Profile data for all areas indicate the Pu remains mostly in the top layers of the island soils, (mostly 0-10 cm) which are relatively easy to access by someone digging with hands, shoes or with a small implement.

The higher radionuclide levels of this study present a long-term exposure concern to human visitors and wildlife that should be further evaluated using radiological dose assessment methods combined with gap filling of any needed data (a concurrent dose assessment has been conducted by ARPANSA as this report was being finalised). The persistence of Pu also indicates the need for an ongoing monitoring and periodic evaluation plan.

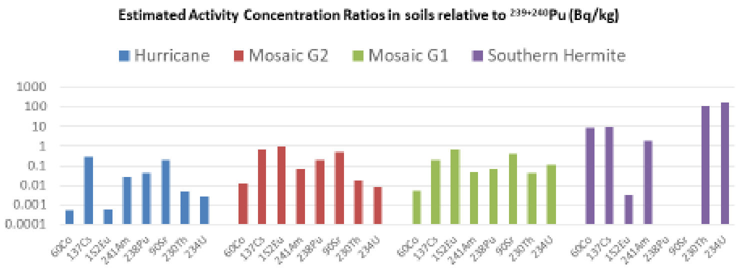
The discussion here is limited to the 2019 study sites which are located in the vicinity of the three nuclear detonation sites, but not in the areas of highest contamination. It should not be assumed that the above summary applies at the areas close to the detonation sites (e.g., ground zero locations) where the public may visit for short periods and where higher levels of contamination including greater amounts of radioactive particles exist. Some information on the detonation sites can be found in (Child and Hotchkis, 2013; Johansen et al., 2019; Johansen et al., 2014).

Activity Concentration Ratios across the varied study sites.

Describing the radiological contamination in the Montebello Islands presents a major challenge in that the three different nuclear tests produced different amounts of various radionuclides. Also, the deposition from their airborne plumes varied in direction and extent. This is significant in that the correlation among the differing radionuclides varies from place to place across the islands. Ratios among the key radionuclides may vary, even within close proximity, due to differing decay rates over time, variation due to hot particles, and variation due to limited data. While some uncertainty exists, such activity ratios can be highly useful in projecting expected radionuclide levels where measurements don't exist or are sparse. Figure 12 provides a set of such ratios. Note that these ratios should be updated over time (due to decay and environmental dilution) and also should be improved over time with more measurements.

Projected activity concentration ratios relative to $^{239+240}Pu$

*means were used where data were sufficient. Some ratios are based on limited data and may be improved in the future.



Estimated Activity Concentration Ratios in soils relative to $^{239+240}Pu$ (Bq/kg)

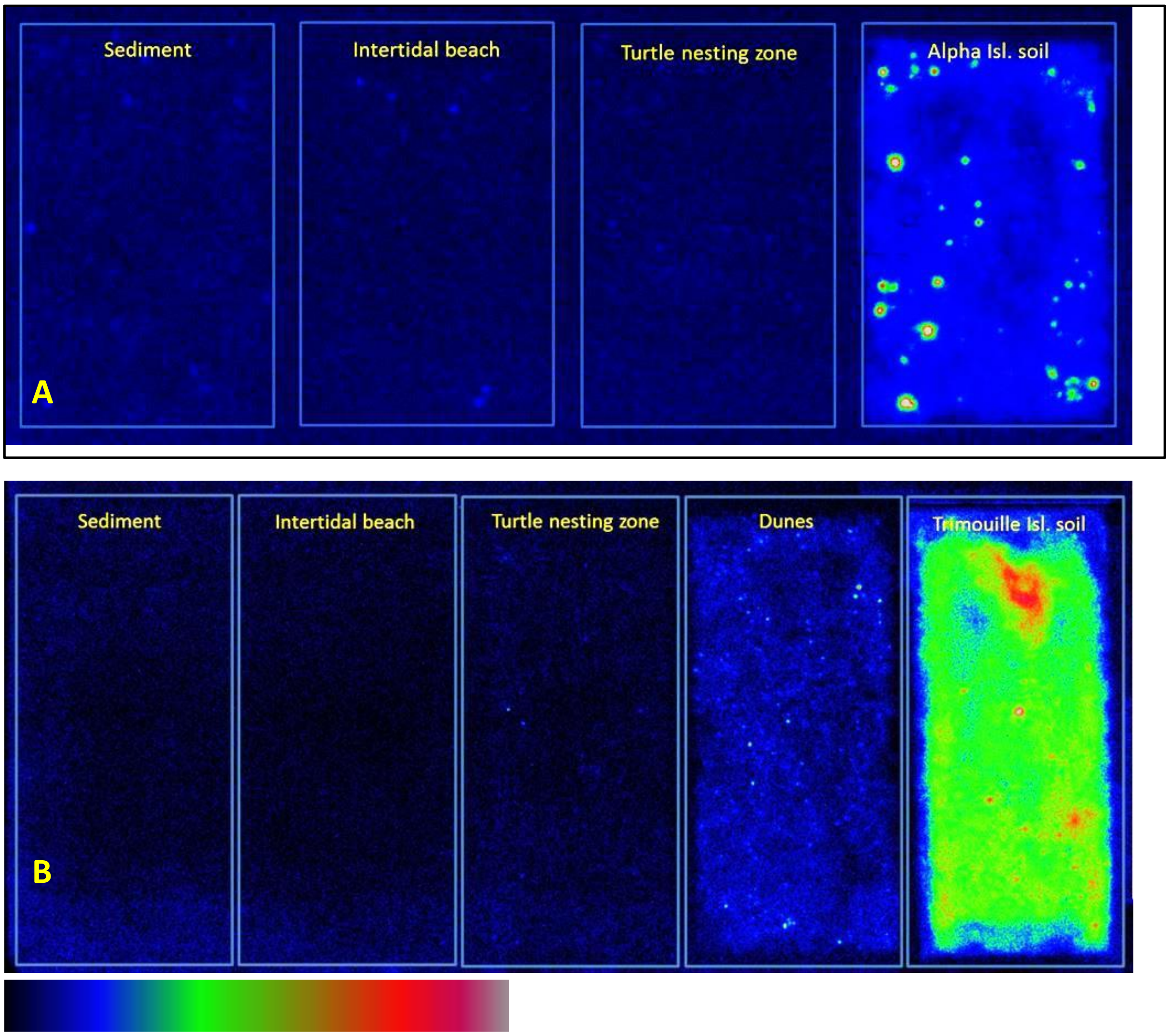
Hurricane		Mosaic G2		Mosaic G1		Southern Hermite		
60Co	0.001	60Co	0.012	60Co	0.005	60Co	<	8.8
137Cs	0.285	137Cs	0.691	137Cs	0.201	137Cs		9.9
152Eu	0.001	152Eu	0.994	152Eu	0.674	152Eu	<	0.003
241Am	0.027	241Am	0.068	241Am	0.048	241Am		1.92
238Pu	0.041	238Pu	0.201	238Pu	0.070	238Pu		7.95E-05
90Sr	0.195	90Sr	0.513	90Sr	0.431	90Sr		BDL
230Th	0.005	230Th	0.019	230Th	0.042	230Th		120
234U	0.003	234U	0.009	234U	0.107	234U		164

Figure 12. Estimated ratios of activity concentrations relative to $^{239+240}Pu$ (ratios of the Bq/kg of each listed radionuclide to that of the Bq/kg of $^{239+240}Pu$ at the specified locations within the Montebello Islands). Any future use of these ratios should consider the uncertainty associated with: decay over time, variation due to hot particles, variation due to limited data for some ratios and spatial variation between the specified reference points.

Radioactive Particles

The ANSTO sampling in 2015 found numerous radiological particles in deposition areas (Figure 13a, 13b). In some soil samples, particles were the dominant form of radionuclides. Their small size (< 2 mm) makes them difficult to see without magnification, but they are numerous in some soils, sands and sediments.

This current study did not specifically investigate radioactive particles ("hot particles") but the results are consistent with contamination that is particle-rich. Specifically, the results from split/duplicate samples, or samples gathered near each other, had substantial variation which is consistent with the expected random occurrence of particles in the samples. From recent studies by ANSTO (Johansen et al., 2022), it is known that the Mosaic G2 test (Figure 13a) resulted in relatively large, concentrated particles as compared with soils in the deposition plume from the Hurricane test (Figure 13b) which contained generally finer particles. This is potentially significant for Bluebell Island in that most of the contamination there originated from the Hurricane test.



Lowest ------------------------------- highest relative activity concentrations

Figure 13a and 13b. PSL Autoradiography of sediment-sand-soil panels of 5 g samples each. Top (A) is from near the Mosaic G2 site, bottom (B) is from near HMS Plym site to the Red Beacon Hill area of Trimouille Island (from Johansen et al. 2019).

The particles from the Hurricane Test tend to be smaller and are therefore of greater concern for health and safety as these particles are likely to be within the respirable range (<5 µm), which, if inhaled, may become lodged in the lung (see Johansen et al. 2019 for further information). The long-term fate of these particles has yet to be determined. The Mosaic G2 particles appear to have greater potential for long-term persistence than the Hurricane particles based on their higher Si and Ca content (Johansen et al., 2022). Conversely, this implies that the Hurricane particles will dissipate and release their radionuclides in more bioaccessible forms sooner. A dose assessment for the Montebello sites that specifically evaluates various exposures from radioactive particles has not been performed.

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Appendix A Sample locations, descriptions, Sample IDs. Samples are 0-10cm soils unless indicated.

STUDY SAMPLE DESCRIPTION	Sample ID	Lat.	Long.
Thevenard Island			
THV-Dune/soils, 0-4 cm	THV-1	-21.4535	115.0023
Port Headland			
PH-Dune/soils, 0-4 cm	MB-C-45	-20.32388	118.66181
PH-Dune/soils, 4-12 cm	MB-C-46-47	-20.32388	118.66181
PH-Dune/soils, 12-20 cm	MB-C-48	-20.32388	118.66181
PH-Dune/soils, 0-4 cm	MB-C-45	-20.32388	118.66181
Burrup Peninsula			
BU-Beach, 0-10 cm	MB-C-37	-20.57045	116.79341
BU-Camp, 0-10 cm	MB-C-38	-20.56981	116.79356
BU-Dune/soils, 0-10 cm	MB-C-39	-20.56978	116.79294
BU-inland/soils, 0-10 cm	MB-C-40	-20.56555	116.7921
Hermite Isl			
HI-Mammal Grid, Comp of corners, 0-10cm	MB-MS-1	-20.48659	115.52956
HI-Mammal Grid, Comp of corners, 0-10cm	MB-MS-1 recount	-20.48659	115.52956
HI-Mammal grid (centre), 0-10cm	MB-MS-2	-20.48659	115.52956
HI-Mammal Grid (centre), SDP 0-4cm	MB-MS-3	-20.48659	115.52956
HI-Mammal Grid (centre), SDP 4-12cm	MB-MS-4-5	-20.48659	115.52956
HI-Mammal Grid (centre), SDP 12-20cm	MB-MS-6	-20.48659	115.52956
HI-Comp (comp 4 corners), 0-10cm (alpha)	MB-MS-1	-20.48659	115.52956
Home Lagoon			
HI-Home Lagoon	MB-C-10	-20.44412	115.54078
HI-HL-sediment, 0-10cm	MB-C-11	-20.44405	115.54131
HI-HL-beach (0-10cm)	MB-C-12	-20.44391	115.54177
HI-HL-camp (0-10cm)	MB-C-13	-20.44391	115.54211
HI-HL-dune/soils,(0-10cm)	MB-C-14	-20.44391	115.54211
HI-HL-dune/soils, SDP 0-4cm	MB-C-15-16	-20.44391	115.54211
HI-HL-dune/soils, SDP 4-12cm	MB-C-17	-20.44391	115.54211
HI-HL-dune/soils, SDP 12-20cm	MB-C-13	-20.44391	115.54211
Whisky bay (Renewal Is)			
WB-sediments (0-10cm)	MB-C-1	-20.47229	115.54609
WB- beach sands, 0-10cm	MB-C-2	-20.47216	115.54554
WB-Camp (0-10cm)	MB-C-3	-20.47312	115.54546

MB-C-4 Camp dune soils-WB	MB-C-4	-20.4732	115.54458
WB-Dune/soils, SDP 0-4cm	MB-C-5	-20.4732	115.54458
WB-Dune/soils, SDP 4-12cm	MB-C-6-7	-20.4732	115.54458
WB-Dune/soils, SDP 12-20cm	MB-C-8	-20.4732	115.54458
WB-Camp dune soils (0-10cm) (alpha)	MB-C-4	-20.4732	115.54458
Alpha Isl.			
AI-Boodie grid SE Cnr (0-10cm) same as camp soils/dune	MB-C-22	-20.41064	115.52281
AI-Boodie grid SW Cnr (0-10cm)	MB-MS-12	-20.41056	115.52023
AI-Boodie grid NE+NW Cnrs combined (0-10cm)	MB-MS-13-14	-20.40779	115.51865
AI-North Mammal Grid (corners), 0-10cm	MB-MS-12-14	-20.40765	115.52163
AI-North grid, Comp (0-10 cm) (alpha)	MB-MS-12-14	-20.40765	115.52163
AI-South Grid (corners), 0-10cm	MB-MS-15	-20.4129	115.5228
AI-South Grid (corners), 0-10cm (alpha)	MB-MS-15	-20.4129	115.5228
Chartreuse Bay Camp			
AI-CB-Shallow sediments	MB-C-19	-20.41018	115.52407
AI-CB-Dune/soils (0-10cm)	MB-C-22	-20.41064	115.52281
AI-CB-Dune/soils (0-4cm)	MB-C-23	-20.44391	115.54211
AI-CB-Dune/soils (4-12cm)	MB-C-24-25	-20.44391	115.54211
AI-CB-Dune/soils (12-20cm)	MB-C-26	-20.44391	115.54211
AI-CB-Dune/soils (0-10cm) (alpha)	MB-C-22	-20.44391	115.54211
Northwest Isl.			
NW-East Grid, SE corner, 0-10 cm	MB-MS-8	-20.36658	115.52813
NW-East Grid, SW corner, 0-10 cm	MB-MS-9	-20.36601	115.52642
NW-East Grid, NW corner, 0-10 cm	MB-MS-10	-20.36586	115.52843
NW-East Grid, Comp. of corners, 0-10 cm	MB-C-31	-20.3658	115.5276
NW-East Grid, Comp. of corners, 0-10 cm (alpha)	MB-MS-8-10 (composite)	-20.3658	115.5276
NW-West Grid, Comp of corners, 0-10 cm	MB-MS-8-10 (composite)	-20.3658	115.5276
NW-West Grid, Comp of corners, 0-10 cm (alpha)	MB-MS-11	-20.3622	115.5222
MB-MS-11 NW-W-Comp	MB-MS-11	-20.3622	115.5222
NW-sediment, 0-10cm	MB-C-28	-20.36655	115.52556
NW-beach (0-10cm)	MB-C-29	-20.36675	115.53082
NW-Camp (0-10cm)	MB-C-30	-20.36663	115.53088
NW-dune/soils,(0-10cm)	MB-C-31	-20.36588	115.531
NW-dune/soils,(0-10cm) (alpha)	MB-C-31	-20.36588	115.531

Bluebell Island			
BI-North-Beach	MB-C-59	-20.39334	115.52032
BI-North-Camp	MB-C-60	-20.39327	115.52013
BI-North-Dune/soils	MB-C-61	-20.39246	115.52011
BI-North-Dune/soils-2 (alpha)	MB-C-61	-20.39246	115.52011
BI-Middle-Shallow sediments	MB-C-50	-20.39634	115.52101
BI-Middle-Beach	MB-C-51	-20.39661	115.52061
BI-Middle-Camp	MB-C-52	-20.39696	115.52065
BI-Middle-Dune/soils	MB-C-53	-20.39679	115.51982
BI-Middle-Dune/soils-2 (alpha)	MB-C-53	-20.39679	115.51982
BB-South-Beach	MB-C-62	-20.39751	115.52399
BB-South-Camp	MB-C-63	-20.39745	115.52385
BB-South-Dune/soils	MB-C-64	-20.39713	115.52364
BB-South-Dune/soils-2 (alpha)	MB-C-64	-20.39713	115.52364
Trimouille Island. Samples are 0-10cm soils unless indicated. Transect 1 is at north end of island. All points along transects progress West to East (e.g. station 4 is on west. So that transect progresses eastward 4+00, 4+10, 4+100, etc.)			
Transect 1-2 Low Tide Seds (West)	MB-TS-MBLTS		
Transect 1-2 Beach (West)	MB-TS-0		
1+00	MB-TS-1	-20.37999	115.54847
1+100	MB-TS-2	-20.37999	115.54942
1+200	MB-TS-3	-20.37999	115.55037
1+400	MB-TS-4	-20.37999	115.5523
1+600	MB-TS-5	-20.37999	115.55421
1+800	MB-TS-6	-20.37999	115.55614
1+1000	MB-TS-7	-20.37999	115.55807
1+1200	MB-TS-8	-20.37999	115.56015
Transect 3-4 Low Tide Seds (West)	MB-TS-9	-20.38513	115.55118
Transect 3-4 Beach (West)	MB-TS-10	-20.38509	115.55175
4+10	MB-TS-11	-20.38428	115.55203
4+100	MB-TS-12	-20.3843	115.55288
4+200	MB-TS-13	-20.3843	115.55385
4+400	MB-TS-14	-20.3843	115.55574
4+600	MB-TS-15	-20.3843	115.55768
4+800	MB-TS-16	-20.3843	115.55961
3+00	MB-TS-17	-20.3843	115.56076
Transect 3-4 Low Tide Seds (East)	MB-TS-18	-20.3832	115.56159
Transect 3-4 Beach (East)	MB-TS-19	-20.38316	115.56124
8+00	MB-TS-20	-20.39288	115.55777
8+100	MB-TS-21	-20.39288	115.55873

8+200	MB-TS-22	-20.39288	115.55969
8+400	MB-TS-23	-20.39288	115.56161
8+600	MB-TS-24	-20.39288	115.56352
7+00	MB-TS-25	-20.39288	115.56456
Transect 7-8 Beach (East)	MB-TS-26	-20.39209	115.56521
Transect 7-8 Low Tide Seds (East)	MB-TS-27	-20.39161	115.56558
Transect 9-10 Low Tide Seds (West)	MB-TS-28	-20.39815	115.56255
North end or Main Beach (from 2015 data)		-20.39766	115.56275
9+00	MB-TS-29	-20.39721	115.56253
9+100	MB-TS-30	-20.39721	115.56348
9+200	MB-TS-31	-20.39721	115.56443
9+400	MB-TS-32	-20.39721	115.56635
9+600	MB-TS-33	-20.39721	115.56827
9+800	MB-TS-34	-20.39725	115.57019
10+00	MB-TS-35	-20.39725	115.57168
Transect 15-16 Low Tide Seds (West)	MB-TS-36	-20.41016	115.57061
Transect 15-16 Beach (West)	MB-TS-37	-20.41016	115.57092
16+00	MB-TS-38	-20.41009	115.57135
16+200	MB-TS-39	-20.41009	115.57327
16+400	MB-TS-40	-20.41009	115.5752
16+600	MB-TS-41	-20.41009	115.57712
15+00	MB-TS-42	-20.41009	115.57793
Transect 15-16 Beach (East)	MB-TS-43	-20.41249	115.57827
Transect 15-16 Low Tide Seds (East)	MB-TS-44	-20.41251	115.57849
17+00	MB-TS-45	-20.41438	115.57251
17+200	MB-TS-46	-20.41438	115.57442
18+00	MB-TS-47	-20.41439	115.57594
Soil Depth Profile from Red Beacon Hill			
TRH SP1 0-4	TRH SP1 0-4	-20.39207	115.5587
TRH SP1 4-8	TRH SP1 4-8	-20.39207	115.5587
TRH SP1 8-12	TRH SP1 8-12	-20.39207	115.5587
TRH SP3 12-16	TRH SP3 12-16	-20.39207	115.5587
TRH SP4 16-20	TRH SP4 16-20	-20.39207	115.5587
TRH SP5 28-32	TRH SP5 28-32	-20.39207	115.5587
TRH SP6 20-24	TRH SP6 20-24	-20.39207	115.5587
TRH SP7 24-28	TRH SP7 24-28	-20.39207	115.5587

Appendix B. Activity Concentrations (three tables below). Data are on a September 2020 basis. Ratios of ^{241}Am to ^{230,240}Pu are from Figure 12 and Johansen et al., 2019).

				Estimated Pu from Am																		
	Pu-239+240			Est. Pu-239+240 (from Am241)			Pu-238			^{241}Am				^{137}Cs activity	at 661.7 keV			^{60}Co				
	Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		Bq/kg	at 59	+/-	MDA	Bq/kg	+/-		MDA	Bq/kg	+/-			MDA
Thevenard Isl.																						
THV-Dune/soils, 0-4 cm											<	0.4		0.7	±	0.1	0.47					
THV-Dune/soils, 0-4 cm	0.07	+/-	0.02				0.04	+/-	0.02	0.2	+/-	0.03										
Port Headland																						
PH-Dune/soils, 0-4 cm										-			0.62	-		-	0.74	-			-	0.7
PH-Dune/soils, 4-12 cm										-			0.86	-		-	0.96	-			-	1.2
PH-Dune/soils, 12-20 cm										-			0.55	-		-	0.54	-			-	0.7
PH-Dune/soils, 0-4 cm	0.07	+/-	0.02					<	0.03	0.2	+/-	0.03										
Burrup Pen.																						
BU-Beach, 0-10 cm										-			0.80	3.3		0.30	0.91	-			-	0.9
BU-Camp, 0-10 cm										-			0.87	-		-	1.08	-			-	1.1
BU-Dune/soils, 0-10 cm				1.5	+/-	0.3				1.3	±	0.23		0.8	±	0.1	0.65					
BU-inland/soils, 0-10 cm	0.24	+/-	0.03				0.04	+/-	0.01	0.2	+/-	0.03										
Hermite Isl.																						
HI-Mammal Grid, Comp of corners, 0-10cm											<	0.33			<	0.3						
HI-Mammal Grid, Comp of corners, 0-10cm											<	0.47			<	0.7						
HI-Mammal grid (centre), 0-10cm											<	0.46			<	0.5						
HI-Mammal Grid (centre), SDP 0-4cm											<	0.32			<	0.47						
HI-Mammal Grid (centre), SDP 4-12cm											<	0.34		0.4	±	0.1	0.36					
HI-Mammal Grid (centre), SDP 12-20cm											<	0.36			<	0.5						
HI-Comp (comp 4 corners), 0-10cm (A-spc)	0.11	+/-	0.03					<	0.04	0.2	+/-	0.04										
Home Lagoon																						
HI-HL-sediment, 0-10cm											<	0.30			<	0.27						
HI-HL-beach (0-10cm)										-		-	0.30	-		-	0.60	-			-	0.6
HI-HL-camp (0-10cm)										-		-	0.38	-		-	0.54	-			-	0.6
HI-HL-dune/soils,(0-10cm)										-		-	0.59	-		-	0.90	-			-	0.8
HI-HL-dune/soils, SDP 0-4cm											<	0.55		3.2	±	0.81	0.39					
HI-HL-dune/soils, SDP 4-12cm											<	0.28			<	0.4						
HI-HL-dune/soils, SDP 12-20cm											<	0.48			<	0.6						
MB-C-13 Camp dune soils (0-10 cm) (A-spc)	0.51	+/-	0.05				0.07	+/-	0.02	0.2	+/-	0.03										
Renewal Island-Whisky bay Camp																						
WB-sediments (0-10cm)										-		-	0.63	-		-	0.76	-			-	0.9
WB- beach sands, 0-10cm											<	0.47			<	0.62						
WB-Camp (0-10cm)										-		-	0.40	-		-	0.53	-			-	0.5
MB-C-4 Camp dune soils-WB										-		-	0.72	-		-	1.17	-			-	1.1
WB-Dune/soils, SDP 0-4cm											<	0.27			<	0.3						
WB-Dune/soils, SDP 4-12cm											<	0.56			<	0.7						
WB-Dune/soils, SDP 12-20cm											<	0.49			<	0.7						
WB-Camp dune soils (0-10cm) (alpha)	1.15	+/-	0.08				0.09	+/-	0.02	0.2	+/-	0.04										
Alpha Island																						
AI-Boodie grid SE Cnr (0-10cm) same as camp soils/dune										-		-	0.72	-		-	0.91	-			-	0.7
AI-Boodie grid SW Cnr (0-10cm)										-		-	0.46	-		-	0.69	-			-	0.8
AI-Boodie grid NE+NW Cnrs combined (0-10cm)				74	+/-	3.7				7.1	±	0.35		1.4	+/-	0.32	0.68	-			-	0.7
AI-North Mammal Grid (corners), 0-10cm				14	+/-	1.1				1.3	±	0.10		0.6	±	0.1	0.38					
AI-North grid, Comp (0-10 cm) (alpha)	1.03	+/-	0.09					<	0.1	0.3	±	0.04										
AI-South Grid (corners), 0-10cm										-		-	0.78	-		-	0.95	-			-	0.8
AI-South Grid (corners), 0-10cm (alpha)	0.51	+/-	0.08					<	0.09	0.2	±	0.04										
Chartreuse Bay Camp																						
AI-CB-Shallow sediments				12	+/-	2.0				1.1	±	0.19		-		-	0.72	-			-	0.7
AI-CB-Dune/soils (0-10cm)										-		-	0.72	-		-	0.91	-			-	0.7
AI-CB-Dune/soils (0-4cm)											<	0.52		1.3	±	0.41	0.27					
AI-CB-Dune/soils (4-12cm)											<	0.37			<	0.42						
AI-CB-Dune/soils (12-20cm)											<	0.43		2.9	±	0.92	0.43					
AI-CB-Dune/soils (0-10cm) (alpha)	2.4	+/-	0.1				0.31	+/-	0.04	0.3	+/-	0.04										

	Pu-239+240			Est. Pu-239+240 (from Am241)			Pu-238			^{241}Am				^{137}Cs activity	at 661.7 keV			^{60}Co			
	Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		Bq/kg	at 5	+/-	MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA
Northwest Island																					
NW-East Grid, SE corner, 0-10 cm				49	+/-	5.9				2.5	±	0.30		-		-	0.64	-		-	0.6
NW-East Grid, SW corner, 0-10 cm				191	+/-	9.6				9.7	±	0.48		2.6		0.44	0.92	-		-	1.1
NW-East Grid, NW corner, 0-10 cm				106	+/-	8.5				5.4	±	0.43		2.1		0.25	0.70	-		-	0.7
										-		-		-		-	0.88	-		-	0.8
NW-East Grid, Comp. of corners, 0-10 cm				57	+/-	2.9				2.9	±	0.15		1.2	±	0.1	0.56				
NW-East Grid, Comp. of corners, 0-10 cr	6.0	+/-	0.2				0.38	+/-	0.03	0.6	+/-	0.06									
NW-West Grid, Comp of corners, 0-10 cm				170	+/-	10.2				8.6	±	0.52		3.7		0.30	0.74	-		-	0.7
NW-West Grid, Comp of corners, 0-10 ci	84	+/-	2				5.9	+/-	0.3	5.1	+/-	0.25									
NW Island Camp																					
NW-sediment, 0-10cm				22	+/-	4.4				1.1	±	0.22		-		-	0.78	-		-	0.8
NW-beach (0-10cm)				12	+/-	3.1				0.6	±	0.16		-		-	0.45	-		-	0.5
NW-Camp (0-10cm)				10	+/-	3.3				0.5	±	0.17		-		-	0.53	-		-	0.2
NW-dune/soils,(0-10cm)										-		-	0.68	-		-	0.88	-		-	0.8
NW-dune/soils,(0-10cm) (alpha)	20.5	+/-	0.6				1.32	+/-	0.09	1.1	+/-	0.07									
Bluebell Island																					
BI-North-Beach				299	+/-	15.0				12.7	±	0.63		3.1	+/-	0.31	0.63	-		-	0.8
BI-North-Camp				527	+/-	26.3				22.3	±	1.11		36.2	+/-	1.81	0.69	-		-	0.7
BI-North-Dune/soils				4456	+/-	222.8				188.6	±	9.43		1260.3	+/-	63.02	1.25	3.43	+/-	0.4	0.9
BI-North-Dune/soils-2 (alpha)	5861	+/-	166				286	+/-	11	209.3	+/-	6.40									
BI-Middle-Shallow sediments				225	+/-	11.2				9.5	±	0.48		-		-	0.78	-		-	0.8
BI-Middle-Beach				419	+/-	21.0				17.7	±	0.89		-		-	0.82	-		-	0.6
BI-Middle-Camp				109	+/-	8.7				4.6	±	0.37		-		-	0.70	-		-	0.2
BI-Middle-Dune/soils				442	+/-	22.1				18.7	±	0.94		42.9	+/-	2.14	1.18	-		-	1.0
BI-Middle-Dune/soils-2 (alpha)	252	+/-	7				23.1	+/-	0.9	11.8	+/-	0.54									
BI-South-Beach				174	+/-	10.4				7.4	±	0.44		1.1	+/-	0.24	0.51	-		-	0.5
BI-South-Camp				682	+/-	34.1				28.9	±	1.44		3.1	+/-	0.22	0.58	-		-	0.5
BI-South-Dune/soils				59	+/-	6.5				2.5	±	0.28		2.7	+/-	0.24	0.64	-		-	0.7
BI-South-Dune/soils-2 (alpha)	58	+/-	2				8.4	+/-	0.3	3.7	+/-	0.17									

Estimated Pu from Am

	Pu-239+240		Estimated Pu from Am Est. Pu-239+240 (from Am241)			Pu-238		^{241}Am				^{137}Cs activity	at 661.7 keV			^{60}Co			
	Bq/kg	+/-	Bq/kg	+/-		Bq/kg	+/-	Bq/kg	at 59	+/-	MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA
Trimouille Island																			
T1-2, Sediments(West)			**49**	+/-	6.8			**1.6**	±	0.23		**2.3**	+/-	0.25	0.68	**-**		-	0.6
T1-2, Beach (West)			**103**	+/-	6.2			**3.5**	±	0.21		**1.6**	+/-	0.30	0.57	**-**		-	0.5
1+00			**269**	+/-	13.4			**9.1**	±	0.46		**11.6**	+/-	0.58	0.58	**-**		-	0.4
1+100			**1201**	+/-	60.0			**40.7**	±	2.04		**36.4**	+/-	1.82	0.52	**-**		-	0.6
1+200			**1340**	+/-	67.0			**45.4**	±	2.27		**33.0**	+/-	1.65	1.06	**-**		-	1.1
1+400			**354**	+/-	17.7			**12.0**	±	0.60		**22.1**	+/-	1.11	0.80	**-**		-	0.7
1+600			**591**	+/-	29.5			**20.0**	±	1.00		**16.9**	+/-	0.84	0.58	**-**		-	0.7
1+800			**898**	+/-	44.9			**30.4**	±	1.52		**51.4**	+/-	2.57	0.79	**-**		-	0.7
1+1000			**402**	+/-	20.1			**13.6**	±	0.68		**15.9**	+/-	0.79	0.75	**-**		-	0.7
1+1200			**330**	+/-	16.5			**11.2**	±	0.56		**2.7**	+/-	0.24	0.58	**-**		-	0.5
Transect 3-4																			
T3-4, Shallow Seds (West)			**287**	+/-	17.2			**9.7**	±	0.58		**2.5**	+/-	0.25	0.66	**-**		-	0.7
T3-4 Beach (West)			**133**	+/-	9.3			**4.5**	±	0.32		**4.4**	+/-	0.35	0.60	**-**		-	0.6
4+10			**809**	+/-	40.5			**27.4**	±	1.37		**6.3**	+/-	0.38	0.82	**-**		-	1.0
4+100			**2409**	+/-	120.4			**81.7**	±	4.08		**85.2**	+/-	4.26	0.65	**-**		-	0.7
4+200			**1451**	+/-	72.6			**49.2**	±	2.46		**11.0**	+/-	0.55	0.77	**-**		-	0.7
4+400			**2311**	+/-	115.5			**78.3**	±	3.92		**224.2**	+/-	11.21	0.73	**-**		-	0.6
4+600			**380**	+/-	19.0			**12.9**	±	0.64		**9.5**	+/-	0.47	0.90	**-**		-	1.1
4+800								**-**			0.52	**1.9**	+/-	0.49	0.77	**-**		-	0.2
3+00			**46**	+/-	7.3			**1.6**	±	0.25		**2.3**	+/-	0.23	0.63	**-**		-	0.5
T3-4, Shallow Seds (East)								**-**			0.47	**-**		-	0.49	**-**		-	0.5
T3-4, Beach (East)			**19**	+/-	5.4			**0.7**	±	0.18		**-**		-	0.87	**-**		-	1.2
Transect 7-8																			
8+00			**4496**	+/-	224.8			**152.4**	±	7.62		**2044.5**	+/-	102.23	1.35	**2.30**	+/-	0.3	0.5
8+100			**8513**	+/-	425.6			**288.6**	±	14.43		**3296.0**	+/-	164.80	1.69	**5.14**	+/-	0.8	1.0
8+200			**10026**	+/-	501.3			**339.9**	±	16.99		**3543.6**	+/-	177.18	1.46	**5.38**	+/-	0.8	1.0
8+400			**218**	+/-	13.1			**7.4**	±	0.44		**96.6**	+/-	4.83	0.68	**-**		-	0.6
8+600			**18**	+/-	4.7			**0.6**	±	0.16		**4.8**	+/-	0.43	0.76	**-**		-	0.8
7+00			**51**	+/-	10.2			**1.7**	±	0.34		**9.4**	+/-	0.56	0.79	**-**		-	0.4
T7-8, Beach (East)								**-**			0.49	**-**		-	0.62	**-**		-	0.6
T7-8, Shallow Seds (East)			**27**					**0.9**	±	0.26		**0.9**	+/-	0.25	0.77	**-**		-	0.9
Transect 9-10																			
T9-10, Shallow Seds (West)								**-**			0.51	**1.3**	+/-	0.20	0.58	**-**		-	0.7
T9-10, Beach (N. end Main B., 2015)																			
9+00			**1649**	+/-	82.4			**55.9**	±	2.79		**446.0**	+/-	22.30	0.83	**1.16**	+/-	0.16	0.7
9+100			**5631**	+/-	281.6			**190.9**	±	9.54		**2647.0**	+/-	132.35	1.29	**3.22**	+/-	0.23	0.7
9+200			**838**	+/-	41.9			**28.4**	±	1.42		**295.5**	+/-	14.77	0.90	**-**		-	1.1
9+400			**349**	+/-	17.5			**11.8**	±	0.59		**112.2**	+/-	5.61	0.80	**-**		-	0.6
9+600								**-**			0.46	**3.7**	+/-	0.26	0.68	**-**		-	0.6
9+800			**17**	+/-	5.0			**0.6**	±	0.17		**4.3**	+/-	0.22	0.47	**-**		-	0.6
10+00								**-**			0.36	**1.6**	+/-	0.17	0.52	**-**		-	0.5
Transect 15-16																			
T15-16, Shallow Seds (West)								**-**			0.42	**-**		-	0.58	**-**		-	0.3
T15-16, Beach (West)								**-**			0.69	**-**		-	0.84	**-**		-	0.9
16+00								**-**			0.43	**-**		-	0.65	**-**		-	0.6
16+200								**-**			0.59	**0.8**	+/-	0.22	0.68	**-**		-	0.9
16+400								**-**			0.50	**-**		-	0.64	**-**		-	0.7
16+600								**-**			0.60	**-**		-	0.81	**-**		-	0.9
15+00								**-**			0.38	**-**		-	0.39	**-**		-	0.6
T15-16, Beach (East)								**-**			0.38	**-**		-	0.44	**-**		-	0.6
T15-16, Shallow Seds (East)								**-**			0.42	**-**		-	0.45	**-**		-	0.6
Transect 17-18																			
17+00								**-**			0.55	**-**		-	0.66	**-**		-	0.9
17+200								**-**			0.34	**-**		-	0.54	**-**		-	0.6
18+00								**-**			0.42	**-**		-	0.68	**-**		-	0.9
Soil Depth Profile, Red Beacon Hill																			
0-4 cm			**15774**	+/-	788.7			**534.7**	±	26.74		**6062.7**	+/-	303.14	3.15	**6.36**	+/-	0.64	1.2
4-8 cm			**10317**	+/-	515.9			**349.7**	±	17.49		**5304.2**	+/-	265.21	2.58	**4.35**	+/-	0.43	1.2
8-12 cm			**1983**	+/-	99.2			**67.2**	±	3.36		**931.5**	+/-	46.57	1.31	**-**		-	1.4
12-16 cm			**665**	+/-	33.2			**22.5**	±	1.13		**275.0**	+/-	13.75	0.85	**-**		-	0.5
16-20 cm			**428**	+/-	21.4			**14.5**	±	0.72		**152.1**	+/-	7.60	0.58	**-**		-	0.7
20-24 cm			**72**	+/-	6.5			**2.4**	±	0.22		**23.5**	+/-	1.17	0.61	**-**		-	0.5
24-28 cm			**153**	+/-	10.7			**5.2**	±	0.36		**65.9**	+/-	3.29	0.74	**-**		-	0.7
28-32 cm			**122**	+/-	14.6			**4.1**	±	0.49		**33.5**	+/-	1.68	0.67	**-**		-	0.8

Appendix B (continued)

	U-238			U-235			U-233+234			^{90}Sr			^{152}Eu			MDA	^{154}Eu				^{234}Th (proxy for ^{238}U)			
													activity at 122 keV				activity at 123 keV				activity at 63.3 keV			
on gamma	Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		
Thevenard Isl.																								
THV-Dune/soils, 0-4 cm														<	0.8			<	0.6		23.7	±	3.1	4.6
THV-Dune/soils, 0-4 cm	25	+/-	1	1.1	+/-	0.1	29	+/-	2		<	111												
Port Headland																								
PH-Dune/soils, 0-4 cm													-		-	0.9	-		-	0.6	13.1	+/-	3.0	7.0
PH-Dune/soils, 4-12 cm													-		-	1.2	-		-	0.8	12.3	+/-	2.8	9.0
PH-Dune/soils, 12-20 cm													-		-	0.8	-		-	0.5	10.5	+/-	2.4	6.3
PH-Dune/soils, 0-4 cm	2.8	+/-	0.2	0.15	+/-	0.03	3.2	+/-	0.2		<	7												
Burrup Pen.																								
BU-Beach, 0-10 cm													-		-	1.1	-		-	0.6	35.7	+/-	3.9	8.6
BU-Camp, 0-10 cm													-		-	1.2	-		-	0.8	29.4	+/-	4.4	10.0
BU-Dune/soils, 0-10 cm														<	1.1			<	0.8		70.2	±	6.2	10.5
BU-inland/soils, 0-10 cm	14.6	+/-	0.9	0.7	+/-	0.1	17	+/-	1		<	8												
Hermite Isl.																								
HI-Mammal Grid, Comp of corners, 0-10cm														<	0.7			<	0.5		16.3	±	2.3	3.9
HI-Mammal Grid, Comp of corners, 0-10cm														<	1.1			<	0.8		23.7	±	4.0	7.3
HI-Mammal grid (centre), 0-10cm														<	1.1			<	0.8		16.4	±	1.3	6.3
HI-Mammal Grid (centre), SDP 0-4cm														<	0.69			<	0.37		63.6	±	8.6	3.6
HI-Mammal Grid (centre), SDP 4-12cm														<	0.8			<	0.6		14.3	±	0.7	4.4
HI-Mammal Grid (centre), SDP 12-20cm														<	0.8			<	0.6		14.2	±	1.0	4.6
HI-Comp (comp 4 corners), 0-10cm (A-spc)	17.8	+/-	1.0	0.77	+/-	0.08	20	+/-	1		<	154												
Home Lagoon																								
HI-HL-sediment, 0-10cm														<	0.57			<	0.40		42.2	±	4.7	3.1
HI-HL-beach (0-10cm)													-		-	0.7	-		-	0.5	24.5	+/-	2.4	5.6
HI-HL-camp (0-10cm)													-		-	0.6	-		-	0.4	27.9	+/-	2.8	5.4
HI-HL-dune/soils,(0-10cm)													-		-	0.9	-		-	0.7	26.3	+/-	3.2	7.5
HI-HL-dune/soils, SDP 0-4cm														<	1.01			<	0.68		40.9	±	15.0	6.3
HI-HL-dune/soils, SDP 4-12cm														<	0.6			<	0.5		19.3	±	2.5	3.6
HI-HL-dune/soils, SDP 12-20cm														<	1.1			<	0.8		19.7	±	1.3	6.1
MB-C-13 Camp dune soils (0-10 cm) (A-spc)	22	+/-	1	1.2	+/-	0.1	26	+/-	1		<	234												
Renewal Island-Whisky bay Camp																								
WB-sediments (0-10cm)													-		-	0.8	-		-	0.6	26.4	+/-	2.9	6.8
WB- beach sands, 0-10cm														<	0.98			<	0.80		78.6	±	11.2	3.6
WB-Camp (0-10cm)													-		-	0.5	-		-	0.4	26.1	+/-	2.6	4.4
MB-C-4 Camp dune soils-WB													-		-	0.9	-		-	0.8	33.4	+/-	3.7	8.1
WB-Dune/soils, SDP 0-4cm														<	0.6			<	0.5		25.0	±	2.5	3.4
WB-Dune/soils, SDP 4-12cm														<	1.3			<	0.9		23.9	±	1.4	6.5
WB-Dune/soils, SDP 12-20cm														<	1.2			<	0.9		23.3	±	3.9	7.0
WB-Camp dune soils (0-10cm) (alpha)	26	+/-	1	1.4	+/-	0.1	29	+/-	2		<	267												
Alpha Island																								
AI-Boodie grid SE Cnr (0-10cm) same as camp soils/dune													-		-	1.0	-		-	0.7	19.3	+/-	3.1	7.1
AI-Boodie grid SW Cnr (0-10cm)													-		-	0.7	-		-	0.4	25.1	+/-	2.8	6.8
AI-Boodie grid NE+NW Cnrs combined (0-10cm)													-		-	0.7	-		-	0.5	20.2	+/-	2.6	6.6
AI-North Mammal Grid (corners), 0-10cm														<	0.7			<	0.5		21.6	±	1.4	4.0
AI-North grid, Comp (0-10 cm) (alpha)	21	+/-	1	1.1	+/-	0.1	24	+/-	1		<	56												
AI-South Grid (corners), 0-10cm													-		-	1.1	-		-	0.7	23.9	+/-	2.6	8.3
AI-South Grid (corners), 0-10cm (alpha)	17.3	+/-	1.0	0.77	+/-	0.08	19	+/-	1		<	313												
Chartreuse Bay Camp																								
AI-CB-Shallow sediments													-		-	0.7	-		-	0.4	29.2	+/-	2.9	5.9
AI-CB-Dune/soils (0-10cm)													-		-	1.0	-		-	0.7	19.3	+/-	3.1	7.1
AI-CB-Dune/soils (0-4cm)														<	0.57			<	0.40		52.0	±	10.3	5.2
AI-CB-Dune/soils (4-12cm)														<	0.51			<	0.54		41.7	±	8.2	5.1
AI-CB-Dune/soils (12-20cm)														<	0.71			<	0.69		41.7	±	6.9	4.3
AI-CB-Dune/soils (0-10cm) (alpha)	21	+/-	1	1.3	+/-	0.1	24	+/-	1		<	56												

	U-238			U-235			U-233+234			^{90}Sr			^{152}Eu			MDA	^{154}Eu				^{234}Th (proxy for ^{238}U)			
													activi	at 122 keV			activi	at 123 keV			activity	at 63.3 keV		
on gamma	Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		Bq/kg	+/-		MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		
NW Island Camp																								
NW-sediment, 0-10cm													**-**		-	0.8	**-**		-	0.6	**29.9**	+/-	3.3	6.9
NW-beach (0-10cm)													**-**		-	0.5	**-**		-	0.4	**24.0**	+/-	2.4	4.4
NW-Camp (0-10cm)													**-**		-	0.6	**-**		-	0.3	**21.6**	+/-	2.2	5.4
NW-dune/soils,(0-10cm)													**-**		-	1.0	**-**		-	0.6	**25.3**	+/-	3.3	7.0
NW-dune/soils,(0-10cm) (alpha)	**24**	+/-	1	**1.4**	+/-	0.1	**27**	+/-	1		<	62												
Bluebell Island																								
BI-North-Beach													**-**		-	0.7	**-**		-	0.5	**20.0**	+/-	2.8	6.5
BI-North-Camp													**-**		-	0.8	**-**		-	0.5	**27.0**	+/-	2.7	6.6
BI-North-Dune/soils													**-**		-	1.7	**-**		-	1.3	**24.7**	+/-	5.2	12.4
BI-North-Dune/soils-2 (alpha)	**21**	+/-	2	**1.4**	+/-	0.5	**22**	+/-	2	167.0	+/-	31.0												
BI-Middle-Shallow sediments													**-**		-	0.8	**-**		-	0.6	**36.1**	+/-	3.6	6.5
BI-Middle-Beach													**-**		-	0.8	**-**		-	0.6	**20.2**	+/-	2.2	5.3
BI-Middle-Camp													**-**		-	0.7	**-**		-	0.5	**27.8**	+/-	2.8	6.2
BI-Middle-Dune/soils													**-**		-	1.0	**-**		-	0.6	**19.8**	+/-	2.2	6.9
BI-Middle-Dune/soils-2 (alpha)	**21**	+/-	2	**1.2**	+/-	0.2	**23**	+/-	2		<	73												
BI-South-Beach													**-**		-	0.5	**-**		-	0.4	**18.3**	+/-	1.8	4.3
BI-South-Camp													**0.8**	+/-	0.2	0.7	**-**		-	0.5	**21.1**	+/-	2.1	4.6
BI-South-Dune/soils													**-**		-	0.8	**-**		-	0.6	**26.7**	+/-	3.2	7.0
BI-South-Dune/soils-2 (alpha)	**20**	+/-	1	**0.9**	+/-	0.1	**23**	+/-	1		<	55												

	U-238		U-235		U-233+234		^{90}Sr			^{152}Eu			MDA	^{154}Eu				^{234}Th (proxy for ^{238}U)			
										activi	at 122 keV			activi	at 123 keV			activity	at 63.3 keV		
on gamma	Bq/kg	+/-	Bq/kg	+/-	Bq/kg	+/-	Bq/kg	+/-		Bq/kg	+/-		MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		
Trimouille Island																					
T1-2, Sediments(West)										-		-	0.7	-		-	0.6	**22.6**	+/-	2.5	5.8
T1-2, Beach (West)										-		-	0.6	-		-	0.4	**26.2**	+/-	2.6	4.7
1+00										-		-	1.2	-		-	0.4	**24.4**	+/-	2.4	4.3
1+100										**4.4**	+/-	0.4	0.7	-		-	0.5	**21.6**	+/-	2.2	4.6
1+200										**2.5**	+/-	0.3	1.1	-		-	0.8	**21.6**	+/-	2.4	7.5
1+400										-		-	0.8	-		-	0.6	**22.7**	+/-	2.9	6.7
1+600										-		-	0.6	-		-	0.4	**23.2**	+/-	2.3	5.5
1+800										-		-	0.9	-		-	0.6	**22.7**	+/-	2.5	6.2
1+1000										-		-	0.7	-		-	0.6	**21.7**	+/-	2.2	5.9
1+1200										-		-	0.7	-		-	0.5	**23.1**	+/-	3.0	6.4
Transect 3-4																					
T3-4, Shallow Seds (West)										-		-	0.8	-		-	0.6	**24.1**	+/-	2.7	6.2
T3-4 Beach (West)										-		-	0.6	-		-	0.4	**22.8**	+/-	2.3	5.2
4+10										-		-	0.9	-		-	0.5	**21.3**	+/-	2.1	6.8
4+100										**1.3**	+/-	0.2	0.8	-		-	0.5	**27.2**	+/-	2.7	5.6
4+200										-		-	0.7	-		-	0.4	**23.5**	+/-	2.3	5.6
4+400										**1.1**	+/-	0.2	0.7	-		-	0.5	**23.1**	+/-	2.3	5.8
4+600										-		-	1.0	-		-	0.5	**21.6**	+/-	2.4	7.4
4+800										-		-	0.7	-		-	0.5	**23.5**	+/-	2.3	5.1
3+00										-		-	0.7	-		-	0.5	**26.1**	+/-	2.9	6.2
T3-4, Shallow Seds (East)										-		-	0.6	-		-	0.4	**26.7**	+/-	2.7	5.1
T3-4, Beach (East)										-		-	0.9	-		-	0.6	**27.2**	+/-	3.0	6.5
Transect 7-8																					
8+00										-		-	1.5	-		-	1.1	**24.1**	+/-	4.3	12.2
8+100										-		-	2.3	-		-	1.5	-		-	18.9
8+200										-		-	2.2	-		-	1.7	**29.4**	+/-	5.3	17.0
8+400										-		-	0.7	-		-	0.5	**27.5**	+/-	2.7	6.1
8+600										-		-	0.7	-		-	0.4	**23.2**	+/-	2.3	5.2
7+00										-		-	0.8	-		-	0.5	**29.7**	+/-	3.0	6.3
T7-8, Beach (East)										-		-	0.7	-		-	0.5	**23.9**	+/-	2.4	5.2
T7-8, Shallow Seds (East)										-		-	0.7	-		-	0.6	**22.1**	+/-	2.7	6.6
Transect 9-10																					
T9-10, Shallow Seds (West)										-		-	0.6	-		-	0.5	**24.8**	+/-	3.0	6.2
T9-10, Beach (N. end Main B., 2015)																					
9+00										-		-	0.8	-		-	0.5	**24.1**	+/-	2.4	6.4
9+100										-		-	1.6	-		-	0.9	**28.6**	+/-	5.1	14.0
9+200										-		-	1.2	-		-	0.8	**31.4**	+/-	4.4	9.7
9+400										-		-	0.7	-		-	0.4	**25.1**	+/-	2.8	6.3
9+600										-		-	0.7	-		-	0.4	**23.9**	+/-	2.4	5.6
9+800										-		-	0.5	-		-	0.4	**22.1**	+/-	2.4	5.3
10+00										-		-	0.5	-		-	0.4	**21.5**	+/-	2.1	4.6
Transect 15-16																					
T15-16, Shallow Seds (West)										-		-	0.5	-		-	0.4	**23.0**	+/-	2.3	4.4
T15-16, Beach (West)										-		-	1.0	-		-	0.7	**24.2**	+/-	3.6	7.9
16+00										-		-	0.8	-		-	0.4	**22.3**	+/-	2.2	6.3
16+200										-		-	0.8	-		-	0.5	**24.8**	+/-	2.5	6.1
16+400										-		-	0.7	-		-	0.5	**23.1**	+/-	2.5	6.1
16+600										-		-	0.9	-		-	0.6	**27.0**	+/-	2.7	6.0
15+00										-		-	0.6	-		-	0.4	**21.9**	+/-	2.2	4.9
T15-16, Beach (East)										-		-	0.5	-		-	0.4	**22.2**	+/-	2.2	4.7
T15-16, Shallow Seds (East)										-		-	0.5	-		-	0.4	**26.8**	+/-	2.7	5.0
Transect 17-18																					
17+00										-		-	0.9	-		-	0.6	**28.6**	+/-	2.9	6.8
17+200										-		-	0.5	-		-	0.4	**22.6**	+/-	2.3	4.2
18+00										-		-	0.7	-		-	0.5	**21.8**	+/-	2.2	5.2
Soil Depth Profile, Red Beacon Hill																					
0-4 cm										-		-	3.7	-		-	2.8	-		-	31.6
4-8 cm										-		-	3.5	-		-	2.6	-		-	29.9
8-12 cm										-		-	1.5	-		-	0.8	**26.8**	+/-	5.4	12.0
12-16 cm										-		-	0.8	-		-	0.5	**25.8**	+/-	2.8	6.8
16-20 cm										-		-	0.7	-		-	0.5	**23.9**	+/-	2.6	6.3
20-24 cm										-		-	0.7	-		-	0.4	**20.3**	+/-	2.0	5.4
24-28 cm										-		-	0.9	-		-	0.6	**23.0**	+/-	2.8	6.7
28-32 cm										-		-	0.9	-		-	0.6	**24.3**	+/-	2.4	7.5

Appendix B (continued)

	^{214}Pb (proxy for ^{226}			MDA	^{214}Bi (proxy for ^{226}Ra)				^{210}Pb				^{212}Pb (proxy for ^{228}Th)				^{40}K			
	activity	at 351.9 keV			activit	at 609.3 keV			activit	at 46.5 keV			activit	at 238.6 keV			activit	at 1460.8 keV		
	Bq/kg	+/-		MDA c	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA c	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA c
Thevenard Isl.																				
THV-Dune/soils, 0-4 cm	9.4	±	0.4	1.3	9.6	±	0.5	1.4	19.8	±	2.7	8.2	6.5	±	0.6	0.5	49.5	±	3.0	5.87
THV-Dune/soils, 0-4 cm																				
Port Headland																				
PH-Dune/soils, 0-4 cm	4.9	+/-	0.8	1.4	5.6	+/-	1.1	1.8	21.2	+/-	2.3	7.0	13.5	+/-	1.3	1.0	773.6	+/-	77.4	24.60
PH-Dune/soils, 4-12 cm	5.6	+/-	0.8	1.7	4.6	+/-	1.0	2.2	-	+/-		11.1	16.6	+/-	1.7	1.3	784.6	+/-	78.5	32.70
PH-Dune/soils, 12-20 cm	5.8	+/-	0.6	1.2	7.1	+/-	0.9	1.6	-	+/-		6.7	12.5	+/-	1.3	0.9	811.2	+/-	81.1	15.40
PH-Dune/soils, 0-4 cm																				
Burrup Pen.																				
BU-Beach, 0-10 cm	18.7	+/-	1.9	2.0	18.1	+/-	1.8	2.4	43.1	+/-	4.3	9.0	32.8	+/-	3.3	1.2	572.3	+/-	57.2	30.30
BU-Camp, 0-10 cm	7.1	+/-	0.9	1.9	6.9	+/-	1.1	2.4	17.2	+/-	3.1	9.6	12.0	+/-	1.2	1.4	331.1	+/-	33.1	37.20
BU-Dune/soils, 0-10 cm	43.4	±	0.6	1.9	44.4	±	0.7	2.2	66.3	±	3.2	15.3	78.2	±	2.7	0.8	108.6	±	59.0	9.09
BU-inland/soils, 0-10 cm																				
Hermite Isl.																				
HI-Mammal Grid, Comp of corners, 0-10cm	15.9	±	0.4	1.1	15.8	±	0.5	1.2	25.2	±	2.7	8.3	5.8	±	0.4	0.5	34.9	±	2.6	5.34
HI-Mammal Grid, Comp of corners, 0-10cm	17.7	±	0.4	1.8	16.8	±	0.5	2.1	26.9	±	2.1	13.7	4.6	±	0.2	0.8	33.1	±	2.5	8.50
HI-Mammal grid (centre), 0-10cm	15.9	±	0.4	1.8	16.3	±	0.4	2.0	23.9	±	1.9	12.5	4.4	±	0.5	0.7	35.2	±	2.5	6.95
HI-Mammal Grid (centre), SDP 0-4cm	7.1	±	1.7	1.0	12.6	±	3.8	2.0	36.8	±	6.0	3.3	6.1	±	0.9	0.5		<		
HI-Mammal Grid (centre), SDP 4-12cm	19.6	±	1.6	1.2	15.2	±	0.5	1.4	22.4	±	1.5	8.4	4.5	±	0.4	0.6	34.6	±	2.2	5.91
HI-Mammal Grid (centre), SDP 12-20cm	15.1	±	0.3	1.4	15.6	±	0.4	1.5	16.6	±	1.4	9.0	4.7	±	0.2	0.6	34.6	±	2.3	6.45
HI-Comp (comp 4 corners), 0-10cm (A-spc)																				
Home Lagoon																				
HI-HL-sediment, 0-10cm	6.4	±	1.7	0.9	4.2	±	2.2	1.6	19.8	±	5.0	3.0	4.5	±	0.5	0.4		<	16.1	
HI-HL-beach (0-10cm)	11.7	+/-	1.2	1.4	11.5	+/-	1.2	1.8	12.7	+/-	2.2	5.4	2.2	+/-	0.4	0.8	-			15.75
HI-HL-camp (0-10cm)	13.5	+/-	1.4	1.2	13.0	+/-	1.3	1.3	18.7	+/-	2.1	4.9	3.0	+/-	0.4	0.7	-			14.67
HI-HL-dune/soils,(0-10cm)	12.6	+/-	1.3	1.8	13.7	+/-	1.5	2.5	27.2	+/-	4.1	8.8	2.6	+/-	0.5	1.2	-			30.72
HI-HL-dune/soils, SDP 0-4cm	8.8	±	2.1	1.3	14.0	±	5.3	2.9	55.5	±	7.9	4.2	5.9	±	0.9	0.6		<	30.2	
HI-HL-dune/soils, SDP 4-12cm	13.8	±	0.4	1.1	13.7	±	0.3	1.2	22.8	±	2.5	7.4	2.7	±	0.3	0.4	19.8	±	1.4	5.11
HI-HL-dune/soils, SDP 12-20cm	14.4	±	0.4	1.6	13.9	±	0.7	2.0	13.7	±	1.6	10.8	2.8	±	0.2	0.7	19.1	±	1.8	8.09
MB-C-13 Camp dune soils (0-10 cm) (A-spc)																				
Renewal Island-Whisky bay Camp																				
WB-sediments (0-10cm)	-		-	1.6	-		-	2.0	16.8		-	7.3	-		-	1.1	-		-	20.99
WB- beach sands, 0-10cm		<	1.5			<				<			12.4	±		1.0		<		
WB-Camp (0-10cm)	7.0	+/-	0.7	1.2	7.8	+/-	0.9	1.5	14.0	+/-	1.5	4.7	1.5	+/-	0.4	0.8	-			14.86
MB-C-4 Camp dune soils-WB	9.0	+/-	1.2	2.0	8.8	+/-	1.5	2.5	16.9	+/-	4.1	9.3	2.2	+/-	0.6	1.3	-			34.66
WB-Dune/soils, SDP 0-4cm	9.5	±	0.2	1.0	9.3	±	0.2	1.2	16.9	±	1.2	7.2	1.9	±	0.3	0.4	9.7	±	1.0	4.32
WB-Dune/soils, SDP 4-12cm	7.7	±	0.3	1.7	7.9	±	0.4	2.1	22.4	±	3.8	11.9	2.1	±	0.5	0.8		<	8.3	
WB-Dune/soils, SDP 12-20cm	8.9	±	0.3	1.8	8.1	±	0.4	2.3	15.5	±	1.8	13.2	2.0	±	0.2	0.8		<	7.9	
WB-Camp dune soils (0-10cm) (alpha)																				
Alpha Island																				
AI-Boodie grid SE Cnr (0-10cm) same as cam	13.4	+/-	1.3	1.8	15.9	+/-	1.7	2.6	17.1	+/-	3.4	7.3	2.6	+/-	0.5	1.1	-			33.60
AI-Boodie grid SW Cnr (0-10cm)	21.0	+/-	2.1	1.6	20.5	+/-	2.1	2.0	26.3	+/-	2.6	6.1	5.9	+/-	0.6	1.0	51.2	+/-	8.7	18.50
AI-Boodie grid NE+NW Cnrs combined (0-10(	20.5	+/-	2.1	1.5	22.1	+/-	2.2	1.7	32.4	+/-	3.2	6.9	5.3	+/-	0.5	0.9	-			17.16
AI-North Mammal Grid (corners), 0-10cı	18.2	±	0.4	1.2	18.4	±	0.4	1.4	25.1	±	2.7	8.1	4.6	±	0.4	0.5	29.1	±	1.9	5.57
AI-North grid, Comp (0-10 cm) (alpha)																				
AI-South Grid (corners), 0-10cm	21.2	+/-	2.1	2.1	23.7	+/-	2.4	2.8	29.4	+/-	3.8	8.8	7.5	+/-	0.8	1.3	70.0	+/-	14.7	33.50
AI-South Grid (corners), 0-10cm (alpha)																				
Chartreuse Bay Camp																				
AI-CB-Shallow sediments	12.4	+/-	1.2	1.5	10.7	+/-	1.1	1.8	19.6	+/-	2.7	6.5	2.6		0.5	1.0	-			25.50
AI-CB-Dune/soils (0-10cm)	13.4	+/-	1.3	1.8	15.9	+/-	1.7	2.6	17.1	+/-	3.4	7.3	2.6		0.5	1.1	-			33.60
AI-CB-Dune/soils (0-4cm)	8.9	±	1.6	1.1	10.8	±		2.5	37.1	±	5.7	4.1	6.6	±	0.9	0.6		<	24.2	
AI-CB-Dune/soils (4-12cm)	8.5	±	3.0	1.3	11.2	±	3.3	2.4	53.9	±	12.2	4.4	6.4	±	1.0	0.6		<	28.8	
AI-CB-Dune/soils (12-20cm)	8.5	±	2.7	1.4	14.1	±	5.3	2.8	45.4	±	10.3	5.3	6.5	±	0.8	0.6		<	28.8	
AI-CB-Dune/soils (0-10cm) (alpha)																				

	^{214}Pb (proxy for ^{226}			MDA	^{214}Bi (proxy for ^{226}Ra)				^{210}Pb				^{212}Pb (proxy for ^{228}Th)				^{40}K			
	activity	at 351.9 keV			activit	at 609.3 keV			activit	at 46.5 keV			activit	at 238.6 keV			activit	at 1460.8 keV		
	Bq/kg	+/-		MDA c	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA c	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA c
Northwest Island			0.0				0.0				0.0				0.0				0.0	
NW-East Grid, SE corner, 0-10 cm	**8.3**	+/-	0.9	1.6	**8.1**	+/-	1.1	2.1	**15.9**	+/-	3.0	6.9	**-**			0.9	**-**			18.18
NW-East Grid, SW corner, 0-10 cm	**8.1**	+/-	1.1	1.9	**8.0**	+/-	1.3	2.2	**24.7**	+/-	3.5	8.2	**-**			1.2	**-**			32.71
NW-East Grid, NW corner, 0-10 cm	**10.1**	+/-	1.0	1.4	**9.9**	+/-	1.0	1.8	**20.7**	+/-	2.5	5.9	**-**			1.0	**-**			18.43
	8.5	+/-	1.1	1.9	**8.3**	+/-	1.2	2.2	**15.0**	+/-	2.7	6.3	**-**			1.1	**-**			31.70
NW-East Grid, Comp. of corners, 0-10 cr	**9.6**	±	0.3	1.6	**9.2**	±	0.3	1.8	**18.5**	±	1.6	11.0	**1.1**	±	0.1	0.6	**6.8**	±	1.2	6.42
NW-East Grid, Comp. of corners, 0-10 cm (alpha)																				
NW-West Grid, Comp of corners, 0-10 c	**6.8**	+/-	0.9	1.6	**8.3**	+/-	1.0	1.8	**24.1**	+/-	3.1	7.1	**-**			1.1	**-**			20.14
NW-West Grid, Comp of corners, 0-10 cm (alpha)																				
NW Island Camp																				
NW-sediment, 0-10cm	**5.4**	+/-	0.9	1.7	**5.7**	+/-	1.2	2.2	**8.7**	+/-	2.1	5.8	**-**			1.1	**-**			20.78
NW-beach (0-10cm)	**9.4**	+/-	0.9	1.0	**10.0**	+/-	1.0	1.4	**15.7**	+/-	2.0	4.7	**-**			0.7	**-**			13.40
NW-Camp (0-10cm)	**11.3**	+/-	1.1	1.2	**12.8**	+/-	1.3	1.6	**17.6**	+/-	2.1	5.3	**1.7**	+/-	0.4	0.8	**-**			15.74
NW-dune/soils,(0-10cm)	**8.5**	+/-	1.1	1.9	**8.3**	+/-	1.2	2.2	**15.0**	+/-	2.7	6.3	**-**			1.1	**-**			31.70
NW-dune/soils,(0-10cm) (alpha)																				
Bluebell Island																				
BI-North-Beach	**13.2**	+/-	1.3	1.4	**14.1**	+/-	1.4	1.9	**24.0**	+/-	2.4	6.0	**2.8**	+/-	0.4	0.9	**-**			17.08
BI-North-Camp	**15.9**	+/-	1.6	1.5	**15.8**	+/-	1.6	2.0	**38.7**	+/-	3.9	7.7	**3.5**	+/-	0.5	1.0	**-**			19.26
BI-North-Dune/soils	**22.0**	+/-	2.2	2.7	**25.3**	+/-	2.5	2.9	**50.4**	+/-	6.5	15.6	**9.8**	+/-	1.0	1.8	**58.7**	+/-	7.6	17.60
BI-North-Dune/soils-2 (alpha)																				
BI-Middle-Shallow sediments	**13.9**	+/-	1.4	1.7	**13.7**	+/-	1.4	2.0	**24.4**	+/-	2.4	7.0	**2.7**	+/-	0.5	1.0	**-**			26.85
BI-Middle-Beach	**11.6**	+/-	1.2	1.5	**10.4**	+/-	1.0	1.6	**15.2**	+/-	2.1	6.1	**1.9**	+/-	0.4	1.0	**-**			20.33
BI-Middle-Camp	**15.4**	+/-	1.5	1.4	**16.1**	+/-	1.6	1.8	**21.7**	+/-	2.4	5.9	**2.7**	+/-	0.4	1.0	**-**			18.18
BI-Middle-Dune/soils	**17.0**	+/-	1.7	1.8	**18.0**	+/-	1.8	2.3	**19.3**	+/-	2.9	6.7	**3.8**	+/-	0.5	1.1	**-**			30.84
BI-Middle-Dune/soils-2 (alpha)																				
BI-South-Beach	**11.9**	+/-	1.2	1.0	**12.3**	+/-	1.2	1.4	**15.9**	+/-	1.8	4.7	**2.7**	+/-	0.4	0.7	**29.7**	+/-	6.2	13.60
BI-South-Camp	**15.4**	+/-	1.5	1.3	**15.7**	+/-	1.6	1.7	**24.3**	+/-	2.4	5.4	**2.1**	+/-	0.4	0.8	**34.9**	+/-	8.4	15.30
BI-South-Dune/soils	**18.5**	+/-	1.9	1.5	**19.2**	+/-	1.9	2.2	**30.3**	+/-	3.6	7.8	**2.9**	+/-	0.5	1.0	**-**			16.60
BI-South-Dune/soils-2 (alpha)																				

	^{214}Pb (proxy for ^{226}			MDA	^{214}Bi (proxy for ^{226}Ra)				^{210}Pb				^{212}Pb (proxy for ^{228}Th)				^{40}K			
	activity	at 351.9 keV			activit	at 609.3 keV			activit	at 46.5 keV			activit	at 238.6 keV			activit	at 1460.8 keV		
	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA	Bq/kg	+/-		MDA
Trimouille Island																				
T1-2, Sediments(West)	**5.8**	+/-	0.8	1.5	**6.1**	+/-	1.2	2.0	**10.5**	+/-	1.4	6.1	-			1.0	-			18.80
T1-2, Beach (West)	**11.1**	+/-	1.1	1.2	**12.6**	+/-	1.3	1.4	**15.7**	+/-	2.0	4.9	-			0.7	-			13.70
1+00	**11.5**	+/-	1.1	1.0	**12.3**	+/-	1.2	1.4	**18.9**	+/-	2.1	5.2	-			0.7	-			13.13
1+100	**10.5**	+/-	1.0	1.1	**10.1**	+/-	1.0	1.5	**19.2**	+/-	1.9	5.4	**1.5**	+/-	0.3	0.7	-			13.40
1+200	**9.5**	+/-	0.9	1.5	**9.6**	+/-	1.4	2.3	**17.8**	+/-	2.7	8.4	-			1.2	-			30.73
1+400	**15.4**	+/-	1.5	1.5	**16.9**	+/-	1.7	2.1	**19.7**	+/-	2.9	7.4	**3.5**	+/-	0.5	1.0	**33.6**	+/-	8.4	17.90
1+600	**13.2**	+/-	1.3	1.5	**11.0**	+/-	1.1	1.7	**21.2**	+/-	2.3	5.8	**1.8**	+/-	0.4	0.8	-			15.97
1+800	**12.4**	+/-	1.2	1.9	**11.1**	+/-	1.4	2.3	**20.8**	+/-	2.5	7.7	-			1.1	-			17.68
1+1000	**10.8**	+/-	1.1	1.5	**10.5**	+/-	1.2	2.1	**19.1**	+/-	2.5	6.2	**1.6**	+/-	0.4	1.0	-			18.76
1+1200	**10.8**	+/-	1.1	1.4	**9.5**	+/-	1.0	1.6	**23.1**	+/-	3.2	7.1	-			0.9	-			15.48
Transect 3-4																				
T3-4, Shallow Seds (West)	**6.0**	+/-	0.7	1.3	**7.0**	+/-	1.1	1.9	**16.3**	+/-	2.8	6.7	-			1.0	-			19.24
T3-4 Beach (West)	**7.0**	+/-	0.8	1.5	**6.2**	+/-	0.7	1.5	**10.2**	+/-	2.2	5.6	-			0.8	-			16.42
4+10	**6.9**	+/-	1.0	1.6	**6.5**	+/-	1.2	2.0	**20.0**	+/-	3.4	7.9	-			1.1	-			28.20
4+100	**11.3**	+/-	1.1	1.2	**11.9**	+/-	1.2	1.9	**29.7**	+/-	3.6	8.1	**1.5**	+/-	0.4	0.9	-			14.15
4+200	**8.4**	+/-	0.9	1.5	**8.7**	+/-	0.9	1.6	**15.2**	+/-	2.7	6.7	-			0.9	-			15.06
4+400	**8.1**	+/-	0.8	1.4	**8.2**	+/-	0.9	1.5	**18.3**	+/-	2.0	5.9	**1.7**	+/-	0.4	0.9	-			14.65
4+600	**6.4**	+/-	1.0	1.7	**10.4**	+/-	1.5	2.4	**15.7**	+/-	3.6	8.5	-			1.2	-			31.71
4+800	**6.9**	+/-	0.7	1.2	**5.6**	+/-	0.7	1.6	**15.3**	+/-	3.4	7.3	-			0.9	-			15.43
3+00	**7.7**	+/-	0.8	1.3	**8.8**	+/-	1.1	1.9	**9.8**	+/-	1.8	5.7	-			0.9	-			16.86
T3-4, Shallow Seds (East)	**9.0**	+/-	0.9	1.1	**7.9**	+/-	0.9	1.5	**11.1**	+/-	2.2	5.6	-			0.8	-			16.23
T3-4, Beach (East)	**-**		-	1.5	**-**		-	2.0	**-**		-	7.5	-			1.1	-			29.74
Transect 7-8																				
8+00	**13.4**	+/-	1.5	3.5	**12.3**	+/-	1.2	2.5	**21.6**	+/-	4.5	14.5	-			2.1	-			16.05
8+100	**15.9**	+/-	2.4	4.8	**13.1**	+/-	2.3	4.0	**24.2**	+/-	6.0	19.6	-			2.7	-			15.77
8+200	**10.3**	+/-	1.5	4.7	**13.0**	+/-	2.2	4.1	-	+/-		21.3	-			3.1	-			19.35
8+400	**11.1**	+/-	1.1	1.6	**11.3**	+/-	1.1	1.8	**14.6**	+/-	2.2	6.1	-			0.9	-			16.24
8+600	**9.2**	+/-	0.9	1.2	**9.7**	+/-	1.1	1.6	**17.5**	+/-	2.6	6.2	-			0.9	-			23.46
7+00	**10.7**	+/-	1.1	1.6	**10.2**	+/-	1.1	1.9	**13.1**	+/-	2.0	6.1	-			1.0	-			15.87
T7-8, Beach (East)	**6.3**	+/-	0.8	1.5	**6.2**	+/-	0.9	1.8	**11.5**	+/-	2.6	6.3	-			1.0	-			17.79
T7-8, Shallow Seds (East)	**3.3**	+/-	0.7	1.5	**3.7**	+/-	1.0	1.9	**16.2**	+/-	2.6	6.9	-			1.1	-			21.75
Transect 9-10																				
T9-10, Shallow Seds (West)	**6.2**	+/-	0.6	1.2	**8.3**	+/-	1.1	1.8	**12.1**	+/-	3.4	7.3	-			0.9	-			15.21
T9-10, Beach (N. end Main B., 2015)																				
9+00	**9.9**	+/-	1.0	1.6	**10.2**	+/-	1.0	1.7	**20.5**	+/-	3.1	8.0	-			1.1	-			14.78
9+100	**10.5**	+/-	1.6	3.7	**12.5**	+/-	1.5	2.9	-	+/-		15.5	-			2.2	-			15.31
9+200	**9.4**	+/-	0.9	1.8	**14.5**	+/-	1.4	2.5	**19.1**	+/-	4.2	10.1	-			1.4	-			30.89
9+400	**13.1**	+/-	1.3	1.6	**13.1**	+/-	1.3	1.7	**16.4**	+/-	2.0	6.1	-			0.9	-			12.80
9+600	**14.2**	+/-	1.4	1.3	**15.3**	+/-	1.5	1.7	**19.5**	+/-	2.5	6.2	-			0.9	-			23.41
9+800	**16.8**	+/-	1.7	1.2	**15.9**	+/-	1.6	1.3	**24.0**	+/-	2.4	5.4	**1.7**	+/-	0.4	0.7	**25.4**	+/-	6.4	12.40
10+00	**16.6**	+/-	1.7	1.0	**19.3**	+/-	1.9	1.4	**20.7**	+/-	2.1	4.7	**3.0**	+/-	0.4	0.7	**27.7**	+/-	7.2	13.50
Transect 15-16																				
T15-16, Shallow Seds (West)	**9.8**	+/-	1.0	1.2	**9.8**	+/-	1.0	1.5	**15.0**	+/-	1.9	4.8	-			0.7	-			14.39
T15-16, Beach (West)	**7.6**	+/-	1.0	1.7	**8.6**	+/-	1.5	2.4	**13.4**	+/-	3.2	7.7	-			1.2	-			31.05
16+00	**16.1**	+/-	1.6	1.8	**15.4**	+/-	1.5	2.1	**22.0**	+/-	3.5	7.8	**2.2**	+/-	0.4	1.0	-			16.83
16+200	**11.3**	+/-	1.1	1.4	**11.5**	+/-	1.2	1.8	**26.0**	+/-	3.1	7.3	**2.4**	+/-	0.4	1.0	-			19.77
16+400	**10.5**	+/-	1.1	1.3	**11.8**	+/-	1.2	1.7	**22.1**	+/-	2.4	5.9	**1.8**	+/-	0.4	0.9	-			17.38
16+600	**6.9**	+/-	0.8	1.4	**8.3**	+/-	1.2	1.9	**17.8**	+/-	2.5	6.2	-			1.0	-			27.72
15+00	**8.3**	+/-	0.8	0.9	**8.0**	+/-	0.8	1.3	**11.6**	+/-	1.7	4.4	-			0.7	-			12.14
T15-16, Beach (East)	**9.5**	+/-	1.0	1.1	**8.5**	+/-	0.8	1.3	**13.4**	+/-	1.7	4.4	-			0.7	-			13.75
T15-16, Shallow Seds (East)	**8.8**	+/-	0.9	1.3	**8.9**	+/-	1.0	1.5	**8.7**	+/-	1.7	4.4	-			0.7	-			14.09
Transect 17-18																				
17+00	**12.1**	+/-	1.2	1.7	**12.7**	+/-	1.4	2.2	**25.3**	+/-	2.5	7.5	-			1.1	-			29.33
17+200	**11.3**	+/-	1.1	1.0	**12.9**	+/-	1.3	1.5	**18.0**	+/-	1.8	4.5	**1.4**	+/-	0.4	0.7	-			13.61
18+00	**10.2**	+/-	1.0	1.2	**11.4**	+/-	1.1	1.6	**10.0**	+/-	1.9	6.1	-			0.9	-			23.61
Soil Depth Profile, Red Beacon Hill																				
0-4 cm	**12.4**	+/-	2.7	8.9	**15.3**	+/-	3.7	7.2	-	+/-		37.4	-			5.8	-			26.36
4-8 cm	**13.4**	+/-	3.1	7.6	**11.8**	+/-	2.7	5.9	-	+/-		33.3	-			4.9	-			25.01
8-12 cm	**10.1**	+/-	1.0	2.2	**10.6**	+/-	1.3	2.3	-	+/-		12.7	-			1.6	-			28.88
12-16 cm	**9.6**	+/-	1.0	1.3	**8.2**	+/-	0.8	1.5	**13.1**	+/-	2.2	7.3	-			0.9	-			12.75
16-20 cm	**9.4**	+/-	0.9	1.3	**9.2**	+/-	0.9	1.5	**12.0**	+/-	2.4	6.5	-			0.9	-			14.61
20-24 cm	**10.7**	+/-	1.1	1.1	**11.0**	+/-	1.1	1.4	**10.0**	+/-	2.0	5.7	**1.8**	+/-	0.3	0.7	-			12.52
24-28 cm	**9.2**	+/-	0.9	1.5	**10.2**	+/-	1.0	1.7	**11.7**	+/-	3.5	8.1	-			1.0	-			23.77
28-32 cm	**11.8**	+/-	1.2	1.8	**8.8**	+/-	0.9	1.7	**11.6**	+/-	2.7	8.6	-			1.0	-			15.66