MANANUI MINERAL SANDS PROJECT

Radiation Baseline Report

Prepared for
Westland Mineral Sands Co. Limited

October 2023
Tom Ritchie

HARDIE
PACIFIC

1.0 INDEX

The Author:

I am the general manager and principal geologist of Hardie Pacific. I have a Bachelor of Science Hons (2013) and Master of Science (MSc) (2017) in geology from the University of Otago. I have been working in mineral exploration as a geologist since 2014, and on the West Coast for the last eight years. I am responsible for project management, technical assessment of projects, supervising field geologists, overseeing consultants, test work programs, and environmental management.

In early 2017, I completed a MSc dissertation thesis titled "Placer Garnet of the West Coast, New Zealand" at the University of Otago. This research evaluated the mineralogy, morphology, and source of heavy minerals from all prominent beaches between Haast and Westport. I published the findings of this study in the peer reviewed international journal, Economic Geology, (Ritchie, et al (2019), *Garnet Compositions Track Longshore Migration of Beach Placers in Western New Zealand*). I have presented this research at multiple national and international geology conferences.

I have worked on West Coast Mineral Sand projects for the past 8 years from the greenfield exploration stage through to the development of the first producing mine at Cape Foulwind.

2.0 Summary

Samples were collected to assess the Naturally Occurring Radioactive Materials (NORM) for the Mananui project site. Samples were processed to produce Heavy Mineral Concentrate (HMC) and tailings samples as an analogue for the proposed mineral processing on site. Samples were analysed at ESR environmental laboratory and SGS Westport. Results returned average combined radioactivity of 0.25Bq/g for tailings and 0.45Bq/g for HMC. These values are well below the legislative limits and half of the 1Bq/g limit below which the International Atomic Energy Agency (IAEA) considers inherently safe and non-radioactive. These data show the averages are half of that reported for the WMS Nine Mile mineral sand mine. Despite the results, baseline radiation data will continue to be collected and a precautionary approach will be taken with respect to potential radioactivity to ensure the health and safety of workers and stakeholders.

3.0 Background, geology, and legalisation

Westland's heavy mineral shoreline deposits are known to contain small quantities of heavy minerals such as monazite, uranothorite, thorite, xenotime, huttonite, zircon and allanite (Hutton, 1950, Nicholson, 1955, Bradley et al 2002, Ritchie et al 2019 and Tay et al 2021). These minerals naturally contain radioactive elements such as uranium, thorium, and radium and are often referred to as Naturally Occurring Radioactive Materials (NORM). The concentration of these minerals within the Westland deposits is generally accepted to increase towards the north and are in greatest abundance north of the Buller River (Tay et al 2020).

The proposed Mananui mining site is comprised of a sequence of shore-parallel to subparallel shoreline sediments deposited over the last 12,000 years (Holocene) and contains accumulations of heavy minerals as strands/laminations between 1-50cm thick. The heavy mineral fraction is dominated by garnet and ilmenite with only minor zircon and trace amounts of NORM minerals. Over 250 holes have been drilled into the deposit (Figure 1) with over 2,000 samples analysed for their heavy mineral content and over 200 QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy) analyses. The deposit is therefore well characterised with respect to mineralogy.

The processing of heavy mineral sands, as proposed at the Mananui project involves concentrating heavy minerals by separating them from the light minerals such as quartz. This process will concentrate the trace amounts of NORM minerals. If the concentration of the NORM minerals is greatly increased in the resulting concentrate above regulated radioactivity concentrations it can potentially pose a risk and is required to be managed.

In New Zealand, ionizing radiation (including the natural decay of K40, U235, Th323 and U238) safety is controlled by the Radiation Safety Act 2016 (RSA 2016) and the Radiation Safety Regulations 2016. The act applies to bulk materials that have a higher concentration of **30 Bq/g**. For import and export of radioactive materials the International Atomic Energy Agency (IAEA) sets limits for radioactive materials through their "Regulations for the Safe Transport of Radioactive Material, 2018 Edition" (IAEA, 2018). The limits given in Table 2 of these requirements for natural uranium and thorium are 1 and **10 Bq/g**, respectively.

In Australia where there is a large and established mineral sand mining industry, a code of practice (COP 2005) relevant to their legislation and regulation and IAEA documents informs the management of radioactive materials. This code uses the IAEA surety standard (IAEA, 2004) exclusion level of **1Bq/g**,

below which the radiation risks to individuals caused by production of mineral concentrates is sufficiently low as to be of no regulatory concern. The report also states “ores or mineral concentrates with head of chain uranium **or** thorium activity concentrations less than 1 Bq/g would generally be considered inherently safe” (COP, 2005, p.20).

The local community had raised concern regarding radiation exposure resulting from mining, and in response to this, a detailed investigation and review were undertaken during the WMS Nine Mile Mine consenting process. The review involved numerous samples, peer reviewed expert reports and expert evidence given at the hearing. As a result, it was agreed that the activity was safe and the risk low, however a precautionary approach was adopted with consent monitoring conditions agreed on. The mine has been operating for nine months and no breaches of those conditions have occurred. Results to date are as expected from the pre-mining investigation.

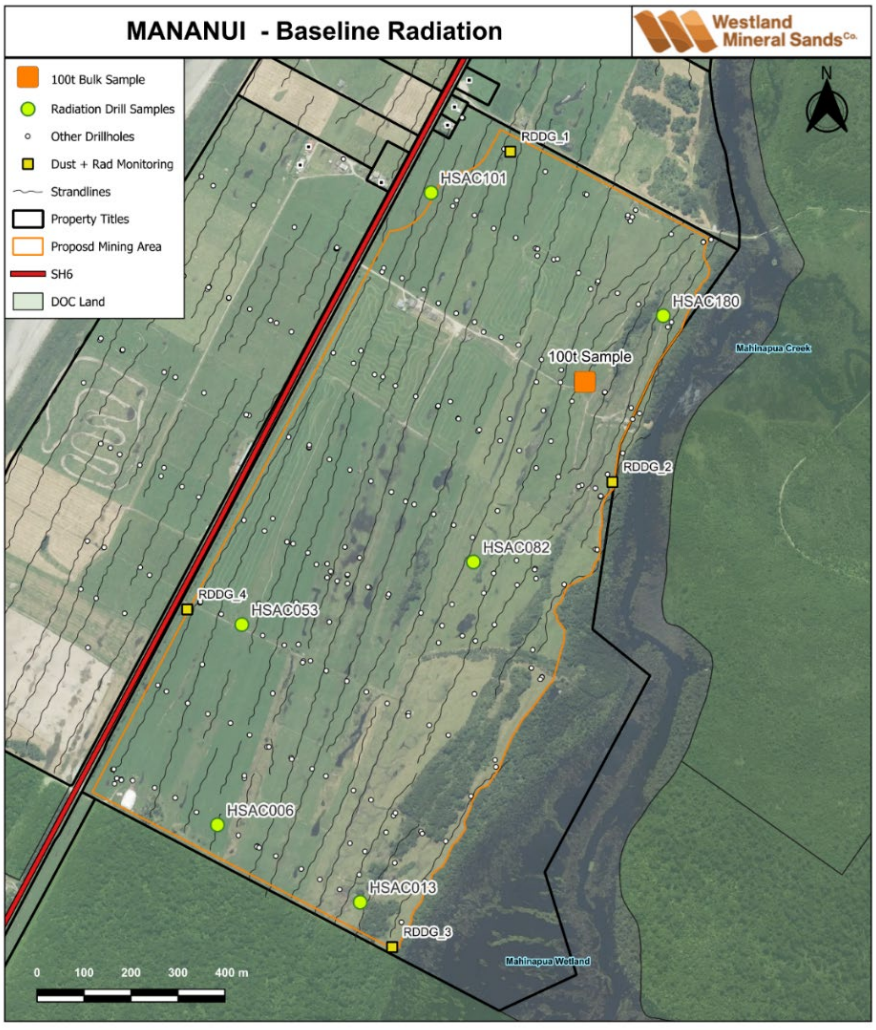

Figure 1 *Map showing location of the six drill hole composite samples HSAC006,13,53,82,101,180, 100ton bulk sample, baseline radiation monitors relative to the proposed mining area. Strandlines and other drillholes are shown.*

A similar investigation and precautionary approach has been taken with the Mananui Project. Westland Mineral Sands strives to operate under best practices to effectively manage radioactivity at their sites and ensure activities are well understood by stakeholders. This memorandum provides an overview of the sampling process, and the outcomes of baseline radioactivity assessments conducted at the Mananui site in relation to legislative limits.

4.0 Sample sites and sample preparation methodology

To characterise the NORM and potential radiation risk of the Mananui deposit a 100 ton bulk sample and six drill hole composite samples were collected and analysed. The sample locations are shown on Figure 1. Drill holes were selected to give geographic and geological representation of the ore body within the proposed mining area and the bulk sample to mimic the mining process. A total of 53 samples representing 1m intervals were combined to make the six composite samples. Each drillhole was sampled from surface to the base of the hole 1-2m into the underlying gravel unit. Appendix 1 gives the lithology, mineralogy and chemistry of the composite extracted from the drillhole database. Composite samples weighted average heavy mineral contents range between 13% and 40.8% which covers the natural grade variability of the ore body. Individual samples ranged between 5.9% and 58.8% heavy mineral content.

Sampling procedure Drill composites:

a. Drill holes were selected from the drill hole database to representatively sample the grade, lithology, and geographic variability of the ore body (Figure 1).
b. Drill samples laboratory split rejects for the selected drill holes which were stored at the onsite sample shed, were located and checked against the database.
c. Approximately 200g of dry un-sieved or "head" sand from 1m were composited into a labelled calico bag. Composite samples ranged in size between 1.7-3.5kg. (Figure 2)
d. Samples were transported to the New Zealand Institute for Minerals to Materials Research (NZIMMR) laboratory at Dunollie.
e. NZIMMR technicians weighted and sieved the samples at 2mm and 53um (size fraction results in Table 1). This mimics the process of screening the oversize and removing the fines.
f. The -2mm + 53um fraction was split using a cone splitter to 500g samples for heavy liquid separation (HLS)
g. HLS is a mineral processing technique used to separate minerals of different densities in a sample of mineral sands. Here it was used to simulate the concentration of heavy minerals (HMC) and separation from light minerals (tails) in the proposed wet concentrator plant. A lithium metatungstate heavy liquid known as LST with a density of 2.85g/cm^2 was used. Industry standard
methodology was used to separate the 500g composite samples into "float" – tails and "sink' – HMC fractions. Sink float proportions are given in Table 1.
h. Sink and float sample for each composited (12 total) were sent to ESR for analysis.
i. Once ESR completed the NORM analysis the 12 samples were sent to SGS Westport for XRF analysis for determining U and Th concentrations.

Sampling procedure 100 ton bulk sample:

a. A 20 ton excavator was used to collect the bulk sample. Three truck loads of approximately 33 tons each were filled. The pit was approximately 4x4x3m in dimension (Figure 2). Top soil was removed and set aside for rehabilitation.
b. The trucks transported the mineral sand bulk sample to a weighing station to confirm weights and then to the NZIMMR laboratory at Dunollie.
c. Samples were tipped into a bunded area on a clean concrete pad which was lined with polythene and bulk piled for processing. The sand was screened to 2mm and run through a spiral like the proposed WCP to produce an HMC. Details of the sample processing at NZIMMR are given in a letter written by Dr Shaun Hayton at Appendix 2.
d. A representative sample of the HMC was split down to 200g and sent to ESR for analysis.

Figure 2 *Photos of the sampling process. Left: Drill chip tray and 1m interval split samples for HSAC013. Centre: Composite samples made from the 1m interval split samples. Right: Bulk sampling test pit.*

5.0 Analysis

Samples were analysed at the ESR environmental laboratory in Christchurch using Gamma Spectrometry to determine NORMs. The ESR environmental laboratory has been accredited by International Accreditation New Zealand to ISO 17025. Drill samples were reported.
Samples were analysed for uranium and thorium at SGS Westport using XRF using the XRF75V method that has a detection limit of 2ppm and 4ppm for U and Th respectively.

6.0 Results

The results from the sample preparation and U and Th are provided in Table 1 and Appendix 4. ESR NORM results are given in Table 2 and summarised in Figure 3 (As reported – Appendix 3).

The average radioactivity concentration (U^{238} +Th^{232} + U^{235} and K^{40}) for tailings (float) produced from the Mananui project area is 0.25 Bq/g and ranged between 0.17 and 0.34 Bq/g. U and Th were below detection levels (<2pmm and <4ppm) on all samples except HSAC180 which reported 5ppm Th. These values mean that as the tailings that are to be retained on-site and used to backfill mined areas, are accordance with section 4 of the Radiation Safety Act 2016, the provisions of the Act do not apply. The maximum combined head-of-chain value for all (U + Th + K) measured decay chains and not just for thorium (which has a head-of-chain average value of 0.0177 Bq/g), of 0.25 Bq/g is well below the 1Bq/g value that is the IAEA safety standard exclusion level, used by the Australian Government code of

practice, below which the radiation risks to individuals caused by an exempted practice, such as the production of HMCs, is sufficiently low as to be of no regulatory concern.

Table 1 *Summary of composite drill samples, sieving, HLS and U + Th results. LOD lower than detection.*

Hole ID	n meters comp	Sample Wt g	2mm-53um %	Sink %	Float %	Float U ppm	Float Th ppm	Float U + Th ppm	Sink U ppm	Sink Th ppm	Sink U +Th PPM
HSAC006	7	1712	99.1%	18.9%	81.1%	<2	<4	LOD	5	50	55
HSAC013	10	1873	96.4%	39.0%	61.0%	<2	<4	LOD	6	64	70
HSAC053	7	2736	96.4%	42.7%	57.3%	<2	<4	LOD	4	47	51
HSAC082	10	3298	97.4%	25.9%	74.1%	<2	<4	LOD	4	49	53
HSAC101	9	2937	98.7%	18.2%	81.8%	<2	<4	LOD	3	37	40
HSAC180	10	3462	99.2%	10.3%	89.7%	<2	5	5	4	41	45
					Average;	<2	<4	-	4.3	48.0	52.3

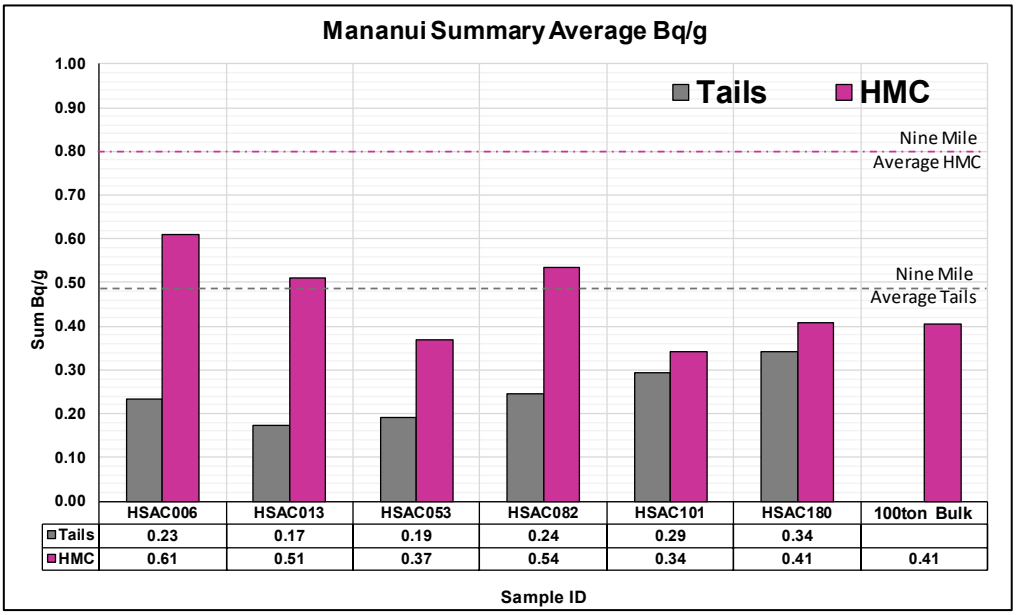

Figure 3 *Graph showing average Bq/g for Tails and HMC samples. Also shows the averages for samples collected from the Nine Mile deposit.*

The average radioactivity concentration (U^{238} +Th^{232} + U^{235} and K^{40}) for HMC (sink) produced from Mananui project area drill composites and bulk samples is 0.45 Bq/g and ranged between 0.34 and 0.61 Bq/g. U averaged 4.3ppm and Th 48ppm with the highest combined U + Th total of 70ppm. These values mean that the HMC produced and exported off site, are in accordance with section 4 of the Radiation Safety Act 2016, the provisions of the Act do not apply. The maximum combined head-of-chain value for all (U + Th + K) measured decay chains and not just for thorium (which has a head-of-chain average value of 0.206 Bq/g), of 0.45 Bq/g is well below the 1Bq/g value that is the IAEA safety standard exclusion level, used by the Australian Government code of practice, below which the radiation risks to individuals caused by an exempted practice, such as the production of HMCs, is sufficiently low as to be of no regulatory concern. The IAEA Transport Regulations (IAEA SSR6) also do not apply as the values are below the 10Bq/g limit (Figure 4)

The average combined radioactivity concentration for both tails and HMC at Mananui are approximately half of the measured values at the Nine Mile Mine which are 0.49Bq/g and 0.8Bq/g respectively (Figure 3). The Nine Mile mine has been operating for nine months without any radiation concerns or breaches from the consent condition-imposed monitoring regime.

Table 2: *ESR NORM results. See appendix 3 for as reported results.*

Sample Info		U-238 decay chain								Th-232 decay chain								U-235 decay chain						K-40 decay chain				Summary	
Sample ID	ESR Sample numbe	Bi-214 (Bq/kg)	Bi-214 ±	Pb-214 (Bq/kg)	Pb-214 ±	Th-234 (Bq/kg)	Th-234 ±	Average Measured	Average ±	Pb-212 (Bq/kg)	Pb-212 ±	Ra-224 (Bq/kg)	Ra-224 ±	Ac-228 (Bq/kg)	Ac-228 ±	Average Measured	Average ±	Th-227 (Bq/kg)	Th-227 ±	U-235 (Bq/kg)	U-235 ±	Average Measured	Average ±	K-40 (Bq/kg)	K-40 ±	Average Measured	Average ±	Sum of All Bq/kg	Sum Bq/g
RS1-B / HSAC006_Float	23-1411	12	*1.7*	11	*1.5*	12	*3.3*	**11.4**	*2.2*	17	*2.3*	18	*8.5*	15	*2.6*	**17.0**	*4.5*	2.8	*N/A*	0.6	*N/A*	**1.7**	*0.0*	203	*27*	**203**	*27.0*	233.1	**0.23**
RS2-B / HSAC013_Float	23-1412	9	*1.4*	9.4	*1.3*	7.4	*2.7*	**8.6**	*1.8*	14	*1.9*	11	*6.5*	14	*2.4*	**13.0**	*3.6*	2.6	*N/A*	0.6	*N/A*	**1.6**	*0.0*	151	*21*	**151**	*21.0*	174.2	**0.17**
RS3-B / HSAC053_Float	23-1413	9	*1.4*	9.8	*1.4*	8.7	*2.4*	**9.2**	*1.7*	16	*2.1*	17	*5.1*	14	*2.7*	**15.6**	*3.3*	1.6	*N/A*	0.5	*N/A*	**1.0**	*0.0*	165	*24*	**165**	*24.0*	190.8	**0.19**
RS4-B / HSAC082_Float	23-1414	12	*1.9*	12	*1.7*	13	*3.1*	**12.5**	*2.2*	19	*2.4*	15	*6*	16	*3*	**16.7**	*3.8*	1.8	*N/A*	0.6	*N/A*	**1.2**	*0.0*	214	*30*	**214**	*30.0*	244.4	**0.24**
RS5-B / HSAC101_Float	23-1415	12	*1.8*	14	*1.9*	14	*3.8*	**13.6**	*2.5*	21	*2.7*	25	*9.1*	19	*3.1*	**21.3**	*5.0*	3.1	*N/A*	0.6	*N/A*	**1.9**	*0.0*	258	*35*	**258**	*35.0*	294.8	**0.29**
RS6-B / HSAC180_Float	23-1416	15	*2.2*	17	*2.3*	20	*4.5*	**17.4**	*3.0*	25	*3.2*	19	*7.2*	23	*3.7*	**22.4**	*4.7*	3	*N/A*	0.8	*N/A*	**1.9**	*0.0*	301	*40*	**301**	*40.0*	342.7	**0.34**
RS1-A / HSAC006_Sink	23-1405	74	*9.2*	80	*9.8*	74	*13*	**76.1**	*10.7*	225	*28*	237	*37*	211	*30*	**224.3**	*31.7*	5.1	N/A	5	*1.8*	**5.1**	*1.8*	305	*40*	**305**	*40.0*	610.5	**0.61**
RS2-A / HSAC013_Sink	23-1406	86	*11*	97	*12*	84	*14*	**89.0**	*12.3*	264	*33*	281	*43*	247	*35*	**264.0**	*37.0*	5.1	N/A	4.2	*1.7*	**4.7**	*1.7*	152	*21*	**152**	*21.0*	509.7	**0.51**
RS3-A / HSAC053_Sink	23-1407	59	*7.4*	64	*7.8*	55	*9.2*	**59.3**	*8.1*	192	*24*	195	*28*	186	*27*	**191.0**	*26.3*	2.8	N/A	2.1	*1.1*	**2.5**	*1.1*	116	*17*	**116**	*17.0*	368.8	**0.37**
RS4-A / HSAC082_Sink	23-1408	76	*9.4*	82	*10*	77	*12*	**78.2**	*10.5*	220	*27*	244	*35*	208	*30*	**224.0**	*30.7*	3.3	*N/A*	4.2	*1.5*	**3.8**	*1.5*	230	*32*	**230**	*32.0*	535.9	**0.54**
RS5-A / HSAC101_Sink	23-1409	55	*6.8*	61	*7.4*	52	*9.4*	**55.8**	*7.9*	163	*20*	173	*28*	156	*22*	**164.0**	*23.3*	4.3	*N/A*	3.7	*1.4*	**4.0**	*1.4*	117	*16*	**117**	*16.0*	340.8	**0.34**
RS6-A / HSAC180_Sink	23-1410	63	*7.9*	70	*8.6*	62	*11*	**65.0**	*9.2*	170	*21*	171	*29*	162	*23*	**167.7**	*24.3*	4.8	*N/A*	2.5	*1.3*	**3.7**	*1.3*	172	*23*	**172**	*23.0*	408.3	**0.41**
HPR-210210-020	2021-946	93	*11*	102	*12*	70	*20*	**88.3**	*14.3*	237	*29*	250	*37*	225	*32*	**237.3**	*32.7*	0	N/A	4.2	*1.4*	**2.1**	*1.4*	78	*11*	**78**	*11.0*	405.8	**0.41**

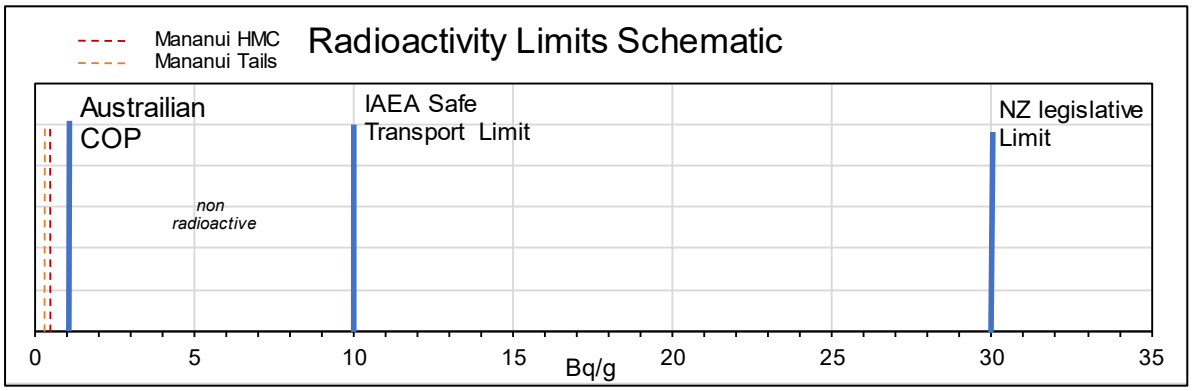

Figure 4 *Schematic line graph showing the legislative limits, Australian COP and the results from this study.*

7.0 Baseline Monitoring

Four radiation dosimeters have been installed at the Mananui site to record the baseline radiation levels. Locations of dosimeters are shown on Figure 1 and are situated along the North, South, East and West boundaries. These were installed in May 2023 and will provide 6-12 months of the sites background radiation prior to mine development. As a precautionary measure, it is recommended that WMS continue to monitor the radiation levels at these four sites as the operation is moved into production and the first 12 months of mining to confirm the findings of this study. It is also recommended that the 1mSv threshold imposed at the Nine Mile Site is also adopted for the Mananui site. At the Nine Mile mine site, 12 months of data across four monitoring sites has yielded average results of 0.281mSv with no observed increase from background levels pre mining.

8.0 References:

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9.0 APPENDICES

1: Drillhole composite results
2: NZIMMER sample preparation letter
3: ESR Results
4: SGS Results

APPENDIX 1 Drill hole sample composites.

Hole ID	From m	To m	Sample No	Lith	Garnet %	Ilmenite %	HM %	SiO2_%	Al2O3_%	Fe2O3_%	CaO_%	MgO_%	K2O_%	Na2O_%	MnO_%	TiO2_%	P2O5_%
HSAC006	0.00	1.00	10854	Sand_c	20.8	6.1	29.7	71.43	8.95	9.62	2.73	0.83	0.73	1.09	0.86	3.30	0.10
HSAC006	1.00	2.00	10855	Sand_c	9.9	2.6	15.4	78.22	8.22	5.15	1.85	0.85	1.00	1.55	0.34	1.56	0.10
HSAC006	2.00	3.00	10856	Gravel_m	5.1	0.9	9.4	81.61	8.07	3.35	1.42	0.76	1.00	1.88	0.19	0.68	0.09
HSAC006	3.00	4.00	10857	Sand_c	10.5	2.8	18.1	76.77	8.77	6.06	2.02	0.88	1.01	1.51	0.48	1.65	0.10
HSAC006	4.00	5.00	10858	Gravel_f	14.2	4.4	24.9	72.62	9.40	8.31	2.46	0.88	0.91	1.45	0.73	2.45	0.11
HSAC006	5.00	6.00	10859	Gravel_m	4.0	0.7	8.5	81.58	8.28	3.16	1.40	0.81	1.05	1.98	0.15	0.61	0.09
HSAC006	6.00	7.00	10861	Gravel_f	2.1	0.8	8.3	81.43	8.19	3.13	1.31	0.85	1.09	1.94	0.13	0.65	0.08
HSAC006	**0 m**	**7m**			**9.5**	**2.6**	**16.3**	**77.7**	**8.6**	**5.5**	**1.9**	**0.8**	**1.0**	**1.6**	**0.4**	**1.6**	**0.1**
HSAC013	0.00	1.00	10915	Sand_c	36.4	9.8	49.2	60.18	10.66	16.33	3.68	0.79	0.48	0.76	1.62	5.14	0.12
HSAC013	1.00	2.00	10916	Sand_c	31.8	9.8	44.6	63.58	9.40	15.05	3.29	0.70	0.43	0.67	1.45	5.12	0.09
HSAC013	2.00	3.00	10917	Sand_m	30.4	14.3	49.1	58.94	9.63	17.04	3.49	0.76	0.45	0.66	1.52	7.40	0.12
HSAC013	3.00	4.00	10918	Sand_c	35.9	16.0	55.4	54.29	10.60	19.12	3.89	0.84	0.50	0.65	1.68	8.20	0.14
HSAC013	4.00	5.00	10919	Sand_m	34.8	18.0	58.3	52.49	10.33	20.45	3.96	0.78	0.41	0.56	1.81	9.26	0.12
HSAC013	5.00	6.00	10921	Sand_c	34.3	19.1	58.8	53.25	10.04	19.80	3.87	0.76	0.42	0.58	1.76	9.41	0.13
HSAC013	6.00	7.00	10922	Sand_c	21.7	10.2	37.0	67.04	8.70	12.42	3.05	0.72	0.62	0.83	1.09	5.27	0.11
HSAC013	7.00	8.00	10923	Gravel_f	7.8	5.0	19.7	75.71	7.85	6.97	2.03	0.72	0.86	1.32	0.51	2.83	0.10
HSAC013	8.00	9.00	10924	Gravel_f	5.5	3.4	14.9	79.45	7.68	5.73	1.75	0.72	0.89	1.40	0.41	2.01	0.09
HSAC013	9.00	10.00	10925	Gravel_f	9.3	5.3	21.3	73.35	8.98	7.64	2.14	0.86	1.02	1.54	0.53	2.88	0.12
HSAC013	**0m**	**10m**			**24.8**	**11.1**	**40.8**	**63.8**	**9.4**	**14.1**	**3.1**	**0.8**	**0.6**	**0.9**	**1.2**	**5.8**	**0.1**
HSAC053	0.00	1.00	11287	Sand_m	25.0	6.7	36.0	68.66	9.11	11.54	3.01	0.77	0.57	0.88	1.07	3.60	0.10
HSAC053	1.00	2.00	11288	Sand_m	16.6	4.3	24.6	74.32	8.59	7.87	2.54	0.83	0.81	1.20	0.64	2.36	0.10
HSAC053	2.00	3.00	11289	silty sand	10.3	2.5	16.5	78.37	8.13	5.56	1.90	0.82	0.93	1.47	0.39	1.49	0.09
HSAC053	3.00	4.00	11291	sandy gravel	2.7	0.8	7.7	83.87	7.07	2.88	1.20	0.68	0.89	1.71	0.12	0.64	0.07
HSAC053	4.00	5.00	11292	gravelly sand	26.8	6.6	41.3	64.01	10.91	13.51	3.44	0.95	0.73	1.02	1.30	3.53	0.12
HSAC053	5.00	6.00	11293	sandy gravel	14.6	4.6	35.3	67.73	10.55	11.64	3.00	0.86	0.71	1.29	1.16	2.54	0.11
HSAC053	6.00	7.00	11294	sandy gravel	1.7	1.0	8.5	81.64	7.92	3.38	1.28	0.87	1.10	1.79	0.13	0.75	0.08
HSAC053	**0m**	**7m**			**13.9**	**3.8**	**24.3**	**74.1**	**8.9**	**8.1**	**2.3**	**0.8**	**0.8**	**1.3**	**0.7**	**2.1**	**0.1**
HSAC082	0.00	1.00	14528	Sand_c	26.1	9.3	42.0	65.20	9.32	14.22	3.08	0.71	0.44	0.75	1.36	4.88	0.10
HSAC082	1.00	2.00	14529	Sand_c	32.2	8.3	42.9	64.45	9.95	14.01	3.39	0.76	0.52	0.79	1.41	4.35	0.12
HSAC082	2.00	3.00	14531	Sand_c	24.8	5.9	34.9	67.88	10.21	11.10	3.26	0.89	0.79	1.09	1.06	3.18	0.13
HSAC082	3.00	4.00	14532	Sand_c	8.0	1.9	12.6	80.77	7.64	4.25	1.64	0.76	0.94	1.51	0.27	1.21	0.09
HSAC082	4.00	5.00	14533	Sand_c	5.6	1.2	9.7	82.40	7.40	3.34	1.45	0.73	0.96	1.60	0.18	0.83	0.08
HSAC082	5.00	6.00	14534	Sand_c	8.8	2.0	13.8	79.94	7.94	4.56	1.86	0.79	0.95	1.52	0.31	1.23	0.09
HSAC082	6.00	7.00	14535	Gravel_f	4.3	1.0	11.7	80.88	8.15	4.11	1.53	0.74	0.94	1.79	0.31	0.73	0.09
HSAC082	7.00	8.00	14536	Gravel_f	10.9	5.2	24.5	72.79	9.03	8.37	2.34	0.81	0.86	1.43	0.70	2.84	0.10
HSAC082	8.00	9.00	14537	Gravel_f	10.0	8.0	27.3	70.10	9.10	9.72	2.42	0.85	0.89	1.40	0.74	4.20	0.11
HSAC082	9.00	10.00	14538	Gravel_f	3.6	1.7	10.4	81.17	7.71	3.96	1.39	0.76	1.00	1.69	0.21	1.11	0.08
HSAC082	**0m**	**10m**			**13.4**	**4.4**	**23.0**	**74.6**	**8.6**	**7.8**	**2.2**	**0.8**	**0.8**	**1.4**	**0.7**	**2.5**	**0.1**
HSAC101	0.00	1.00	14688	Sand_c	16.4	2.6	22.2	76.18	8.40	6.82	2.20	0.82	0.76	1.27	0.58	1.58	0.10
HSAC101	1.00	2.00	14689	Sand_c	10.0	1.7	14.3	79.16	8.23	4.73	1.75	0.86	0.99	1.58	0.30	1.07	0.10
HSAC101	2.00	3.00	14691	Sand_c	6.7	1.6	12.9	79.06	8.59	4.64	1.61	0.84	1.03	1.83	0.29	1.06	0.09
HSAC101	3.00	4.00	14692	Sand_c	35.3	7.4	49.6	59.00	12.24	16.17	3.91	0.97	0.65	1.01	1.70	3.95	0.13
HSAC101	4.00	5.00	14693	Sand_c	12.5	2.2	20.9	75.19	9.41	6.90	2.17	0.82	0.88	1.68	0.62	1.36	0.10
HSAC101	5.00	6.00	14694	Sand_c	16.8	3.8	24.8	72.87	9.38	8.36	2.50	0.91	0.92	1.39	0.73	2.15	0.10
HSAC101	6.00	7.00	14695	Gravel_f	3.1	0.8	9.2	82.33	7.64	3.32	1.32	0.74	0.95	1.77	0.19	0.64	0.08
HSAC101	7.00	8.00	14696	Gravel_f	1.3	0.3	5.9	83.43	7.57	2.45	1.13	0.73	1.03	1.91	0.08	0.42	0.07
HSAC101	8.00	9.00	14697	Gravel_f	1.4	0.4	6.9	82.43	7.97	2.72	1.22	0.84	1.11	1.90	0.09	0.46	0.08
HSAC101	**0m**	**9m**			**11.5**	**2.3**	**18.5**	**76.6**	**8.8**	**6.2**	**2.0**	**0.8**	**0.9**	**1.6**	**0.5**	**1.4**	**0.1**
HSAC180	0.00	1.00	16319	Sand_c	5.9	0.8	10.0	82.48	7.39	3.47	1.37	0.73	0.95	1.54	0.18	0.65	0.08
HSAC180	1.00	2.00	16321	Sand_c	9.5	3.0	19.3	76.13	8.63	6.70	2.00	0.80	0.95	1.45	0.52	1.76	0.11
HSAC180	2.00	3.00	16322	Sand_c	6.9	2.3	13.7	79.25	8.05	5.13	1.57	0.75	0.94	1.68	0.34	1.38	0.09
HSAC180	3.00	4.00	16323	Sand_c	8.1	4.8	19.7	74.85	8.57	7.12	1.96	0.84	1.01	1.46	0.48	2.65	0.10
HSAC180	4.00	5.00	16324	Gravel_f	3.8	0.5	10.2	81.62	8.01	3.61	1.37	0.76	0.96	1.83	0.22	0.52	0.09
HSAC180	5.00	6.00	16325	Gravel_f	4.5	0.5	12.5	80.17	8.50	4.43	1.57	0.78	0.97	1.81	0.32	0.52	0.09
HSAC180	6.00	7.00	16326	Gravel_f	6.1	1.0	12.8	79.90	8.48	4.56	1.61	0.81	0.98	1.78	0.32	0.76	0.09
HSAC180	7.00	8.00	16327	Gravel_f	4.0	0.7	11.3	80.45	8.45	4.05	1.53	0.80	0.98	1.89	0.26	0.61	0.09
HSAC180	8.00	9.00	16328	Sand_c	6.5	2.2	13.4	74.55	10.46	5.32	1.78	1.19	1.64	1.83	0.29	1.34	0.11
HSAC180	9.00	10.00	16329	Sand_c	2.5	1.0	7.5	76.69	10.39	3.84	1.39	1.21	1.87	1.95	0.11	0.78	0.10
HSAC180	**0m**	**10m**			**5.8**	**1.7**	**13.0**	**78.6**	**8.7**	**4.8**	**1.6**	**0.9**	**1.1**	**1.7**	**0.3**	**1.1**	**0.1**

APPENDIX 2: Bulk Sample Preperation

NEW ZEALAND INSTITUTE FOR
Minerals to Materials Research
Te Kahuōpapa

To whom it may concern

In January 2021, the Westland Mineral Sands Co Limited, requested that NZIMMR process 100tonne bulk samples from the heavy mineral sand deposits at Nine Mile (south of Westport; HPN-210209-019) and Ruatapu (south of Hokitika; HPR-210210-020) to create a bulk heavy mineral concentrate (HMC) sample for each location.

The 100tonne bulk samples were delivered to the NZIMMR Research Facility at Spring Creek on the 9th & 10th February 2021.

For each sample, processing involved initially screening the material to remove oversize and foreign (plant) material as well as much of the clay fraction. The screened material was then processed through NZIMMR's 6.3 spiral to form HMC. The HMC was collected in bulk bags, each weighing approximately 1 tonne. A spike sample was collected from each of the bulk bags to form a composite subsample which would be representative of the bulk sample created for each location.

The composite sub-samples (HPN-210209-019 spiral con & NPR-210210-20 spiral con) were dried and split to obtain a variety of splits that were representative of the bulk HMC material. One split from each location was used to provide material for the radioactivity analysis undertaken by ESR. Based on other HMC samples, this material has a non-radioactive classification as the Bq/g values is expected to be less than 1. Note under New Zealand law material with a Bq/g value of greater than 10 is defined as radioactive.

The concentration processing undertaken to acquire this bulk HMC sample is very similar to the processing that would be expected to be used to create a wet HMC during mining operations, i.e. sizing and wet spiral concentration.

Kind Regards

Dr Shaun Hayton
NZIMMR

TEST REPORT

Test report number:	TR23-465	**Report date:**	25/07/2023
Client name:	Hardie Pacific	**Order number:**	WMS21_01
Client's address:	57 Leith Street, Dunediun 9016		
Samples submitted by:	Tom Ritchie	**Date received:**	29/06/2023
Samples analysed by:	Levi Bourke	**Analysis start date:**	29/06/2023
Customer supplied description:	Heavy mineral sands		
Sample received as:	12 Sand samples		
Analyses requested:	NORMs and any man-made gamma emitters if found present		
Analytical methods:	Gamma Spectrometry		

Concentration: If the measured value is above background at a level of confidence of 95%, then the concentration of the radionuclide is reported. The reported uncertainty is based on the combined standard uncertainty (u_c) multiplied by a coverage factor (k) = 2 (providing a level of confidence of 95%) as described by International Organization for Standardization, Guide to the expression of uncertainty in measurement, ISO, Geneva (1995).

Minimal Detectable Concentration: Reporting of a 'less than' result means that the measured value was consistent with a background measurement. The minimal detectable concentration with a level of confidence of 95% for both errors of the first and second kind is calculated according to ISO standard 11929 "Determination of the characteristic limits (decision threshold, detection limit and limits of confidence interval) for measurements of ionizing radiation – Fundamentals and application".

Traceability: Traceability to appropriate national or international standards is maintained. Details are available on request.

Quality Statement: The Environmental Laboratory has been accredited by International Accreditation New Zealand to ISO 17025. Test methods used in determining results for this report do not fall within the scope of accreditation, however.

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Results

Sample number		23-1405	
Client sample code		RS1-A / HSAC006_Sink	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	74	9.2
	Lead-214	80.2	9.8
	Thorium-234	74	13
Thorium-232 Decay Chain	Lead-212	225	28
	Radium-224	237	37
	Actinium-228	211	30
Uranium-235 Decay Chain	Thorium-227	< 5.1	N/A
	Uranium-235	5.0	1.8
Other Naturally Occurring Radionuclides	Potassium-40	305	40

Sample number		23-1406	
Client sample code		RS2-A / HSAC013_Sink	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	86	11
	Lead-214	97	12
	Thorium-234	84	14
Thorium-232 Decay Chain	Lead-212	264	33
	Radium-224	281	43
	Actinium-228	247	35
Uranium-235 Decay Chain	Thorium-227	< 5.1	N/A
	Uranium-235	4.2	1.7
Other Naturally Occurring Radionuclides	Potassium-40	152	21

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Sample number		23-1407	
Client sample code		RS3-A / HSAC053_Sink	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	58.9	7.4
	Lead-214	63.9	7.8
	Thorium-234	55.2	9.2
Thorium-232 Decay Chain	Lead-212	192	24
	Radium-224	195	28
	Actinium-228	186	27
Uranium-235 Decay Chain	Thorium-227	< 2.8	N/A
	Uranium-235	2.1	1.1
Other Naturally Occurring Radionuclides	Potassium-40	116	17

Sample number		23-1408	
Client sample code		RS4-A / HASAC082_Sink	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	75.5	9.4
	Lead-214	82	10
	Thorium-234	77	12
Thorium-232 Decay Chain	Lead-212	220	27
	Radium-224	244	35
	Actinium-228	208	30
Uranium-235 Decay Chain	Thorium-227	< 3.3	N/A
	Uranium-235	4.2	1.5
Other Naturally Occurring Radionuclides	Potassium-40	230	32

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Sample number		23-1409	
Client sample code		RS5-A / HSAC101_Sink	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	54.5	6.8
	Lead-214	60.8	7.4
	Thorium-234	52.2	9.4
Thorium-232 Decay Chain	Lead-212	163	20
	Radium-224	173	28
	Actinium-228	156	22
Uranium-235 Decay Chain	Thorium-227	< 4.3	N/A
	Uranium-235	3.7	1.4
Other Naturally Occurring Radionuclides	Potassium-40	117	16

Sample number		23-1410	
Client sample code		RS6-A / HSAC180_Sink	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	63.1	7.9
	Lead-214	69.8	8.6
	Thorium-234	62	11
Thorium-232 Decay Chain	Lead-212	170	21
	Radium-224	171	29
	Actinium-228	162	23
Uranium-235 Decay Chain	Thorium-227	< 4.8	N/A
	Uranium-235	2.5	1.3
Other Naturally Occurring Radionuclides	Potassium-40	172	23

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Sample number		23-1411	
Client sample code		RS1-B / HSAC006_Float	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	11.5	1.7
	Lead-214	11.1	1.5
	Thorium-234	11.7	3.3
Thorium-232 Decay Chain	Lead-212	17.4	2.3
	Radium-224	18.2	8.5
	Actinium-228	15.4	2.6
Uranium-235 Decay Chain	Thorium-227	< 2.8	N/A
	Uranium-235	< 0.61	N/A
Other Naturally Occurring Radionuclides	Potassium-40	203	27

Sample number		23-1412	
Client sample code		RS2-B / HSAC013_Float	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	9.0	1.4
	Lead-214	9.4	1.3
	Thorium-234	7.4	2.7
Thorium-232 Decay Chain	Lead-212	14	1.9
	Radium-224	11.4	6.5
	Actinium-228	13.7	2.4
Uranium-235 Decay Chain	Thorium-227	< 2.6	N/A
	Uranium-235	< 0.59	N/A
Other Naturally Occurring Radionuclides	Potassium-40	151	21

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Sample number		23-1413	
Client sample code		RS3-B / HSAC053_Float	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	9.0	1.4
	Lead-214	9.8	1.4
	Thorium-234	8.7	2.4
Thorium-232 Decay Chain	Lead-212	16.1	2.1
	Radium-224	16.5	5.1
	Actinium-228	14.3	2.7
Uranium-235 Decay Chain	Thorium-227	< 1.6	N/A
	Uranium-235	< 0.45	N/A
Other Naturally Occurring Radionuclides	Potassium-40	165	24

Sample number		23-1414	
Client sample code		RS4-B / HSAC082_Float	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	12.3	1.9
	Lead-214	12.0	1.7
	Thorium-234	13.1	3.1
Thorium-232 Decay Chain	Lead-212	18.7	2.4
	Radium-224	15.1	6.0
	Actinium-228	16.4	3.0
Uranium-235 Decay Chain	Thorium-227	< 1.8	N/A
	Uranium-235	< 0.55	N/A
Other Naturally Occurring Radionuclides	Potassium-40	214	30

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Sample number		23-1415	
Client sample code		RS5-B / HSAC101_Float	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	12.3	1.8
	Lead-214	14.4	1.9
	Thorium-234	14.2	3.8
Thorium-232 Decay Chain	Lead-212	20.8	2.7
	Radium-224	24.6	9.1
	Actinium-228	18.5	3.1
Uranium-235 Decay Chain	Thorium-227	< 3.1	N/A
	Uranium-235	< 0.63	N/A
Other Naturally Occurring Radionuclides	Potassium-40	258	35

Sample number		23-1416	
Client sample code		RS6-B / HSAC180_Float	
	Radionuclide	**Activity (Bq/kg)**	**Uncertainty (Bq/kg)**
Uranium-238 Decay Chain	Bismuth-214	15.4	2.2
	Lead-214	17.2	2.3
	Thorium-234	19.5	4.5
Thorium-232 Decay Chain	Lead-212	25.1	3.2
	Radium-224	19.4	7.2
	Actinium-228	22.8	3.7
Uranium-235 Decay Chain	Thorium-227	< 3.0	N/A
	Uranium-235	< 0.83	N/A
Other Naturally Occurring Radionuclides	Potassium-40	301	40

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Additional Information

Based on above results we estimate all three naturally occurring decay chains are present and in radioactive equilibrium.

Results relate only to the samples as received.

Validity of results is based on true and correct customer supplied description.

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Michael Lechermann, Key Technical Person

Date: 25/07/2023

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Report number:	2021-378
Report date:	2 June 2021

TEST REPORT

Client name:	NZIMMR	**Order number:**	N/A
Client's address:	100 MacKay Street, Greymouth 7805		
Samples submitted by:	N/A	**Date received:**	21/04/2021
Samples analysed by:	Levi Bourke	**Analysis start date:**	23/04/2021
Customer supplied description:	HPR-210210-020		
Sample received as:	Powder		
Analyses requested:	Naturally Occurring Radionuclides		
Analytical methods:	Gamma Spectrometry		

Concentration: If the measured value is above background at a level of confidence of 95%, then the concentration of the radionuclide is reported. The reported uncertainty is based on the combined standard uncertainty (u_c) multiplied by a coverage factor (k) = 2 (providing a level of confidence of 95%) as described by International Organization for Standardization, Guide to the expression of uncertainty in measurement, ISO, Geneva (1995).

Minimal Detectable Concentration: Reporting of a 'less than' result means that the measured value was consistent with a background measurement. The minimal detectable concentration with a level of confidence of 95% for both errors of the first and second kind is calculated according to ISO standard 11929 "Determination of the characteristic limits (decision threshold, detection limit and limits of confidence interval) for measurements of ionizing radiation – Fundamentals and application".

Traceability: Traceability to appropriate national or international standards is maintained. Details are available on request.

Quality Statement: The Environmental Laboratory has been accredited by International Accreditation New Zealand to ISO 17025. Test methods used in determining results for this report do not fall within the scope of accreditation, however.

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Results

U-238 Decay Chain

Sample number	Bi-214 (Bq/kg)	Pb-214 (Bq/kg)	Th-234 (Bq/kg)
2021-946	93 ± 11	102 ± 12	70 ± 20

Th-232 Decay Chain

Sample number	Pb-212 (Bq/kg)	Ra-224 (Bq/kg)	Ac-228 (Bq/kg)
2021-946	237 ± 29	250 ± 37	225 ± 32

U-235 Decay Chain

Sample number	Th-227 (Bq/kg)	U-235 (Bq/kg)
2021-946	< 4.4	4.2 ± 1.4

Other Naturally Occurring Radionuclides

Sample number	K-40 (Bq/kg)
2021-946	78 ± 11

Additional Information

Based on above results we estimate all three naturally occurring decay chains are present and in radioactive equilibrium.

Results relate only to the samples as received.

Validity of results is based on true and correct customer supplied description.

This report, or any copy of it, is only valid if it is complete. It shall not be reproduced except in full.

Michael Lechermann, Environmental Physicist

Date: 2 June 2021

APPENDIX 4:SGS Results

WESTLAND MINERAL SANDS CO LIMITED

120 Medway Road,
Hanmer Springs,
7334,
NEWZEALAND

Lab Ref	WP010066
Client Ref	
Project	WEEKLY_U_TH
Cost Code	GEOCHEM
Status	Final
Received	02/08/23
Reported	09/08/23
Date Start/End Analysis	9/8/2023 - 9/8/2023
Samples	12
First Sample	RS1-B / HSAC006_Float
Last Sample	RS6-A / HSAC180_Sink
Pages	3

Copy

Notes

Authorised by

Nick Lees
Operations Manager

On behalf of:

Lab Ref	WP010066
Client Ref	
Project	WEEKLY_U_TH
Reported	09/08/23
Status	Final
Page	Page 2 of 3

ANALYTICAL REPORT

Scheme	XRF75V	XRF75V
Units	PPM	PPM
Detection Limit	2.00	4.00
Upper Limit	4,000.00	10,000.00
	U	Th
RS1-B / HSAC006_Float	<2	<4
RS2-B / HSAC013_Float	<2	<4
RS3-B / HSAC053_Float	<2	<4
RS4-B / HSAC082_Float	<2	<4
RS5-B / HSAC101_Float	<2	<4
RS6-B / HSAC180_Float	<2	5
RS1-A / HSAC006_Sink	5	50
RS2-A / HSAC013_Sink	6	64
RS3-A / HSAC053_Sink	4	47
RS4-A / HSAC082_Sink	4	49
RS5-A / HSAC101_Sink	3	37
RS6-A / HSAC180_Sink	4	41

DESCRIPTION

XRF75V : Pressed Powder XRF