IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of an application for resource consents by **TIGA MINERALS AND METALS LTD**
AND	
IN THE MATTER	of a submission by the **COAST ROAD RESILIENCE GROUP INC**

Statement of evidence of Dr John Phillip Bradley

For COAST ROAD RESILIENCE GROUP INC

Topic: Radioactivity of West Coast heavy mineral concentrates

Dated: January 23, 2024

Coast Road Resilience Group Inc
Email: coastroadrg@gmail.com

INTRODUCTION

1. My full name is John Phillip Bradley. I have a BsC and MSc from the University of Canterbury (1976, 1978), and a PhD from Arizona State University (1982). I have held positions in the private sector, US government, and academia, including Director of the Institute Geophysics and Planetary Physics, Lawrence Livermore National Security (2002-2013), and Professor, Hawaii Institute of Geophysics and Planetology, University of Hawaii (2014-2022). I currently hold honorary appointments as Affiliate Faculty (University of Hawaii) and Senior Affiliate Scientist, at Lawrence Berkeley National Laboratory. I have authored approximately 335 publications in the scientific literature.

2. I have the following relevant experience:

   2.1 Early career employment in beach sand mining (Dillingham Mining Co) in northern NSW, Australia. My duties included field work (core sampling of beach sand deposits) and laboratory separations of heavy mineral concentrate (HMC).

   2.2 A Masters thesis (University of Canterbury) describing the HMC's *aka* "black sands" that I collected from rivers and beaches along the West Coast of the South Island, from Barn Bay in the South to Cape Foulwind in the North. I was also provided heavy mineral concentrates by the Kanieri gold dredging operation on the lower Taramakau river. Both detrital (transported) and authigenic (precipitated *in situ* from ground water) radioactive minerals were identified in the Kanieri dredge concentrates, including a high abundance of the rare earth element-rich mineral monazite exhibiting surprisingly high radioactivity. Initial steps were taken by the dredge company to extract and store the monazite for sale. However, a DSIR advisor cautioned that attempts to recover monazite could trigger regulatory oversight, potentially imperiling continuation of the Kanieri dredging operation.

   2.3 Peer-reviewed publications on West Coast heavy mineral sands published in the Journal of the Royal Society of New Zealand (Bradley et al., 1979, 2002).

   2.4 A background in nuclear forensics, including analysis of laboratory synthesis experiments, isotopically-enriched nuclear materials, and interdicted materials. These activities have encompassed both academic peer-reviewed research (Abrajano et al., 1990a & b; Bates et al., 2002), and research conducted while holding a Federal "Q" clearance.

3. I have been asked by the Coast Road Resilience Group Inc to provide expert evidence in relation to the occurrence of radioactive minerals in West Coast beach sands.

4. In preparing this statement of evidence, I have reviewed the following documents that concern radioactive minerals at Barrytown: (1) TiGa Resource Consent Application and documents therein; (2) Addendum 5-2 entitled *"Peer review of radiological assessment conducted by IHC Mining titled, "Radioactivity of BJV material tested project 2019"* attached to TIGA S42A Officers Report, the Environment Court of New Zealand, Te Kōti Taiao o Aotearoa Practice Note 2023; (3) Statement of Evidence and attached correspondence by M. R. Ryan dated January 19, 2023; (4) publications in the peer-reviewed literature concerning West Coast beach sands and heavy mineral concentrates in general and Barrytown in particular, spanning the period *circa* 1950 to 2022.

5. In the past, I have provided written and in-person expert technical and scientific testimony in the US, UK and Europe. I am cognizant of the responsibilities and codes of conduct in such a role. My qualifications are summarized above. I confirm that the issues addressed in this brief of evidence are within my area of expertise.

6. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

7. I acknowledge that in July 2023 I submitted a letter in relation to the TIGA Minerals and Metals Ltd application to the Hon. David Parker, Minister for the Environment.

8. I am not a paid consultant in this matter, nor do I seek to be.

SCOPE OF EVIDENCE

9. The following sections and references therein describe the occurrence and properties of natural radioactive minerals found in beach sand deposits found along the West Coast of the South Island, New Zealand, and the potential radiological implications of mining beach sand minerals at Barrytown.

SUMMARY

10. The beach sands at Barrytown, like beach sands and river sediments elsewhere along the West Coast, contain radioactive minerals. Regardless of their abundance in the Barrytown placer deposit, they will become enriched along with ilmenite and other heavy minerals in the concentrate produced and then transported from Barrytown. Therefore, a pre-emptive independently overseen sampling and analysis program, in conjunction with on-site radiation monitoring, should precede consent to mine, process and export the Barrytown beach sands.

EVIDENCE

11. A large body of scientific literature spanning decades, including publications eminent by New Zealand geoscientists, C. O. Hutton (1910-1971) and C . J. Wilkins (1917-2002), establish that West Coast beach sands, including those at Barrytown, contain monazite and other radioactive minerals, e.g. the thorium silicate mineral "Huttonite" (Hutton, 1950; Overstreet, 1967; Wells and Haverkamp, 2020; Tay et al., 2021. The most abundant radioactive mineral is monazite, a rare earth metal phosphate that also contains uranium and thorium. Ilmenite, garnet, zircon and gold, but not monazite, at Barrytown are the minerals to be concentrated and exported for sale. The reported abundances of monazite and other radioactive minerals are estimated to be below current regulatory requirements. However, two documents (Att. T and Att. U) attached to the Consent Application, that appear to form the basis of the estimate, present what can best be a described as frivolous assessment of the abundance of radioactive minerals at Barrytown. It appears that only two samples were analysed, one of which is described as 'high grade" with 55% "heavy mineral" content. If true, two samples with undescribed heavy mineral content hardly constitute an informed assessment of the abundance of radioactive minerals at Barrytown.

12. Based on my own experience, heavy mineral assemblages in beach sand deposits vary spatially in heavy mineral content, such that a sample enriched in ilmenite may be recovered at one location and another enriched in monazite from another location. I found that the radioactivity levels in West Coast "black-sand" (HMC) samples I collected to be substantially higher than the levels currently being reported at Barrytown. I used a Geiger counter, the standard device for detecting and measuring ionizing radiation. The Applicants initially used x-ray fluorescence (XRF), a method for detecting and measuring element abundances, but not radioactivity. Lechermann and Ardouin (2023) explain why limiting testing of the Barrytown HMC to XRF measurements may not yield an accurate measurement of radioactivity: **They conclude, as I do, that there is not enough information to be satisfied that the results of only two samples are accurate enough, or that enough sampling and assessment have been done, to draw the conclusion the radiological risks at Barrytown are minimal and not of regulatory concern: They recommend additional sampling be carried out using an analytical technique that actually measures radiation.**

13. A subsequent Report describes actual radiation measurements on a larger sample (Ryan, 2023), and the Applicant is to be commended for this supplementary effort. Unfortunately, the Ryan Report raises at least as many questions as it answers. First,

it acknowledges (Paragraph 32) that radioactivity variation in the Barrytown mine is to be expected, and I concur. I found an almost order of magnitude variation in just two West Coast HMC samples from the same location, both above regulatory limits (Footnote[1]). According to the subsequent Ryan Report, a total of 111 samples from 35 drill holes were blended into a single 500 gram sample for the radionuclide testing, effectively preventing detection of the expected variation in radioactivity levels among individual samples. Applicant's proposed solution to the uncertainty surrounding radiation levels at Barrytown is to conduct once quarterly testing of HMC samples. With a projected throughput of ~250,000 tonnes/year of HMC (Consent Application, Att. S), such a testing regime would likely be statistically insignificant and irrelevant.

14. Because radionuclides contaminate solids, air *and* water, all three must be sampled to arrive at a credible conclusion about radioactivity. According to the Ryan Report, HMC, tailings and slimes but not atmosphere were measured for radioactivity using gamma ray spectrometry (GRS). Radium detection is reported but not Radon (a colourless, odourless gas) even though the weighted average of the detected parent isotopes ^{214}Bi and ^{214}Pb also establishes the presence of Radon. Radon is the most insidious radionuclide in the environment because it is the largest source of ingested background radiation, a significant cause of cancers, and Radon detectors are increasingly recommended for homes and buildings worldwide. Radon was detected all samples including the slimes, consistent with the known solubility and mobility of Radon and other radionuclides in water and colloidal suspension (e.g. Bates et al., 1992).

15. The Ryan Report fails to address the ultimate fate of the radioactive materials mined at Barrytown. As shown in the Report, radioactivity will preferentially follow the HMC and it will become even further amplified in one or more of the beneficiated mineral separates produced, either at the secondary processing plant contemplated by the Applicant or elsewhere by others. In the latter case, some might argue that radioactivity is not the Applicant's problem, but ultimate responsibility should belong to the entity that originally disturbed, concentrated and exported radioactive materials from Barrytown.

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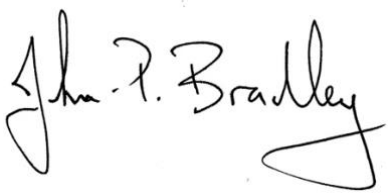
[1] With the caveat that HMC recovered elsewhere on the West Coast cannot be assumed to be representative of HMC at Barrytown, measurements of the radioactivity of two Kanieri dredge HMC samples yielded 1962 and 9318 total counts/minute respectively, **underscoring the high variability in radionuclide abundances in HMC from the same locality** (Bradley et al., 1979). These count rates would translate into accumulated doses at least 100 times the maximum allowable radiation dose of 1 mSv above background levels over 12 months (Att. P, Proposed Conditions of Consent Revised).

16. Monazite is the most abundant radioactive solid mineral at Barrytown. Recognizing its economic potential, **Wells and Haverkamp (2020) caution, as I do, that mining monazite may create health and regulatory concerns.** As described above (paragraph 14) ingestion of radioactive matter by inhalation of solid particulates is a particular epidemiological concern (Appendix A). A recent Westport News story entitled *"Westport gets sandblasted",* by stockpiled dockside HMC reported to contain both ilmenite and "rare earth elements", i.e. monazite elsewhere (Appendix B), underscores the need for due diligence with respect to the production, transport, additional processing, and storage of HMC.

CONCLUSION

17. The beach sand placer deposit at Barrytown contains radioactive minerals, the most abundant of which is monazite, and they will be preferentially sequestered in the heavy mineral concentrate (HMC) produced and transported from Barrytown. This HMC will exhibit radioactivity significantly above ambient background levels. Therefore, a more extensive program of radioactivity measurements of air, sand and water, overseen by an independent regulatory agency, should precede beach sand mining and HMC export from Barrytown.

John P. Bradley, PhD



January 20, 2024.

LITERATURE CITED

Abrajano, T.A., Bates, J.K., Bradley, J.P., "Analytical Electron Microscopy of Leached Nuclear Waste Glasses," *Ceramic Trans.* **9**, 211-228 (1990).

Abrajano, T.A., Bates, J.K., Woodland, A.B., Bradley, J.P., and Bourcier, W.L., "Secondary Phase Formation During Nuclear Waste Glass Dissolution." *Clays and Clay Minerals* **38**, 537-548 (1990).

Bates, J. K., Bradley, J. P., Teetsov, A. S., Bradley, C. R., Tenbrink, M. B., "Colloid formation during waste form reaction: implications for nuclear waste disposal." *Science* **256**, 649-651 (1992).

Bradley, J. P., Chu, P. M. and Wilkins, C. J (2002) Transport and distribution of magnetite and ilmenite on Westland beaches of New Zealand; with comment on the accumulation of other high-density minerals. *J. Royal Soc. NZ* **32**, 169-181 (2002).

Bradley, J.P., Wilkins, C.J., Oldershaw, W., Smale, D. "A Study of Detrital Heavy Minerals in the Taramakau Catchment." *J. Royal Soc. NZ* **9**, 223-251 (1979).

Hutton, C.O. 1950: Studies of heavy detrital minerals. *Geological Society of America bulletin* **61**: 635-671.

Lechermann, M. and Ardouin, C. (2023) Peer review of radiological assessment conducted by IHC Mining titled, "Radioactivity of BJV material tested project 2019. *In* TIGA S.42A Officers Report, Addendum 3.5 (6 pp).

Overstreet, W. C. (1967) The geological occurrence of monazite. *USGS Prof. Pap.* **530** (318pp.)

Ryan, M. R. (2023) Statement of Evidence of Mitchell Robert Ryan. Submission by Anderson Lloyd, January 19, 2923.

Tay, S.L., Scott, J. M., Palmer, M. C., Reid, M. R. and Stirling, C. H. (2021) Occurrence, geochemistry and provenance of REE-bearing minerals in marine placers on the West Coast of the South Island, New Zealand. *N. Z. J. Geolog. Geophys,* 64, 89-106.

Wells, C. H. and Haverkamp, R. G. (2020) Characterization of the Heavy Mineral Suite in a

Holocene Beach Placer, Barrytown, New Zealand. *Minerals* **10**, 86-101.

NBL Program Office
U. S. Department of Energy

SAFETY DATA SHEET
MONAZITE SAND ORE MATERIALS

SECTION 1: CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

NBL Program Office
U. S. Department of Energy,
1 Science.gov Way,
Oak Ridge, TN 37830
1-240-780-6842

Emergency Phone Numbers: 1-240-780-6842

Chemical Name: Monazite Sand/Powdered Monazite Sand

Other Identifiers: CRM 7-A, 82Th1448

Use and Restriction: This material is prepared for use as a standard or in inter-laboratory comparison programs at analytic laboratories, which routinely handle uranium. New Brunswick Laboratory (NBL) expects that recipients of this material are in compliance with 29 CFR 1910.1200(h) which requires employers to provide employees with effective information and training on hazardous chemicals in their work area.

SECTION 2: HAZARDS IDENTIFICATION

Classifications/Hazards:

OSHA HAZARDS: Highly toxic by inhalation. Highly toxic by ingestion.

TARGET ORGANS: Kidney, liver, lungs, brain.

GHS Classification:

Acute toxicity, Oral (Category 3)
Acute toxicity, Inhalation (Category 3)
Acute toxicity, Dermal (Category 3)
Target organ toxicity repeated (Category 2)
Carcinogenicity (Category 1B)

Specific target organ toxicity – repeated exposure (Category 2)

GHS Label elements, including precautionary statements

Pictogram:

Signal Word: Danger

Hazard statements(s)

Fatal if swallowed or inhaled
May cause cancer
May cause damage to organs through prolonged or repeated exposure
Causes skin irritation

Precautionary statements (s)

Obtain special instructions before use
Do not handle until all safety precautions have been read and understood
Do not breath dust/fume/gas/mist/vapors/spray
Wash skin thoroughly after handling
Do not eat, drink, smoke when using this product

Other hazards
Radioactive

NFPA Rating (SCALE 0-4)

Health Hazard:	3
Fire:	2
Reactivity:	1

CERLA Rating (SCALE 0-3)

Health:	3
Fire:	2
Reactivity:	1
Persistence:	3

Appendix B

Westport gets sandblasted

Ellen Curnow

Sand mined near Cape Foulwind and stockpiled on the Westport wharf blew through town yesterday.

Sand-filled gutters on Palmerston Street this morning. Photos: Ellen Curnow

This morning, the gutters outside the Cosmopolitan Hotel and down Palmerston Street past Reynolds Shoes and PRs Café were clogged with sand.

West Coast Bulk Logistics (WCBL) Buller port operations manager Jared Rogers told The News sand piles were left exposed over the New Year public holidays. It should have been covered.

Workers were today covering the sand piles, Mr Rogers said.

"I'll need to go and find out why the piles been left open over the long weekend."

Mr Rogers said he planned to install sprinklers within the next week, "so that, if there is a point that we need to access the pile and open it up, we'll have the ability to completely wet it first so there's no flying sand".

Mr Rogers was away from Westport over the long weekend, but he would return tomorrow morning, assess the mess and make a plan to clean it up. If necessary, the company would pay for Palmerston Street to be swept.

"We can do whatever it takes to come and sort it out."

The WCBL hiccup was disappointing, Mr Rogers said. The company didn't want to disrupt local businesses with its port operations.

"We're working hard to work with the community and portray a good image within the community."

He planned to contact affected businesses directly to apologise.

When WCBL's sister company Westland Mineral Sands gained its mining consent from the Buller District Council and West Coast Regional Council, a dust management plan was one of the conditions. Mr Rogers said WCBL was stepping up its management plans because the West Coast was facing a windy summer.

MetService meteorologist Alwyn Bakker said yesterday was a noticeably windy day for Westport, "but not spectacularly so".

The gust speeds peaked at about 60km/h around 4pm, with mean speeds of about 40km/h.

The wind was considerably stronger on December 31, with a maximum gust of 80km/h recorded, and a max mean speed of about 55km/h.

"It wasn't quite the windiest day in 2023, but it was close. The 30th of May got a gust of 81km/h which just pips it at the post."

The main difference was yesterday's wind was predominantly west/southwest, whereas on New Year's Eve it was northerly.

Heavy mineral sand stockpiled on Westport's wharf blew through town in yesterday's strong winds. Photo: Ellen Curnow