

**Fingerboards Mineral Sands Project:
Provision of further Expert Advice to the Inquiry and Advisory Committee
K.H. Joyner Ph.D.**

Scope of Task



Following on from my previous appointment to review and provide advice on the Environment Effects Statement (EES) Appendix A011 Radiation Assessment Report, the IAC has requested that I review the radiation related aspects of a number of relevant technical documents received since December 2020. The documents I have reviewed are:

1. Document 41: Attachment 2 – DHHS Letter – DHHS review of Kalbar project
2. Document 72: Kalbar Expert Witness Statement – Darren Billingsley – Radiation
3. Document 125: Kalbar Supplementary Expert Witness Statement – Darren Billingsley – Radiation
4. Document 87: MFG Expert Witness Statement – Assoc Prof Gavin Mudd – Radiation
5. Document 89: MFG Expert Witness Statement – Assoc Prof Tilman Ruff – Health and Radiation
6. Document 234: Radiation and Human Health Expert Meeting Statement
7. Document 258: Bendigo District Environment Council (BDEC) - Comments on review of the Radiation Assessment A011

'I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Inquiry and Advisory Committee.'

My qualifications and experience are attached at the end of this report.



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Summary of Report

The submission from DHHS is clear and unambiguous - the department [DHHS] is satisfied the assessment methods have been implemented appropriately and the conclusions regarding radiation safety impacts based on these methods are valid. The department is also satisfied that the estimates of radiation doses to workers and to members of the public provided by Kalbar in the EES are accurate based on the information available prior to the commencement of mining operations. The radiation dose estimates made prior to mining need to be verified at the commencement of mining operations and periodically during mining operations.

The department states that should the project proceed Kalbar mining practices will be subject to the legislative requirements of the *Radiation Act 2005* (the Act) and the Radiation Regulations 2017 (the Regulations) governing worker protection, public protection, and environmental protection from radiation. Kalbar will need to obtain a management licence prior to commencing operations under the Act and will be required to submit a comprehensive Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP) that address aspects of on-site and off-site radiation exposures. Regulatory compliance will be ensured by the Department.

The DHHS advice goes onto to outline in detail how the department would ensure regulatory compliance if the project were to proceed.

From a radiation perspective it would appear there is little or no benefit from the use of centrifuges.

The radiation conclave statement is another key input which details remaining areas of disagreement between experts including:

1. Extent and timing of further background radiation assessment to be performed before the project were permitted to proceed.
2. Documentation including the RMP and the RWMP should be public and drafts available before the project were permitted to proceed.
3. Dust management is a particular concern.
4. All aspects of the proposed project should take account of the greater radiation risk for children, and women and girls.
5. The project should consider and plan for plausible impacts of global heating over its full life.
6. Consultative bodies established in relation to the mine should include representatives of local community and food growers' organisations.
7. The designation of the Fingerboards project as a 'nuclear action' under the Commonwealth Environment Protection & Biodiversity Conservation (EPBC) Act.
8. The BDEC also question the management of the heavy mineral concentrate (HMC) stockpiles and whether the mine can be considered as a closed system with respect to the handling and transport of the HMC.

Kalbar has a number of key documents which in my view can be used to converge on mutually acceptable outcomes. These documents include:

- Risk treatment plan template airborne dust_RevC - Kalbar update - 15 June 2021 (clean)
- Mitigation Register (EES, Attachment H) - Kalbar update - 15 June 2021 - rev1
- EES Chapter 6 Stakeholder consultation

Document 41: Attachment 2 – DHHS Letter – DHHS review of Kalbar project

1. The advice from the DHHS¹ (the department) is clear and unambiguous:
 - i. The Kalbar Operations Pty Ltd (Kalbar) Fingerboards mineral sands orebodies contain trace amounts of naturally occurring radioactive materials.
 - ii. The department's assessment is that the methods used by Kalbar to estimate the radiation related impacts of the project is well established and appropriate for the task. Furthermore, the department's assessment is that the methods have been implemented appropriately and the conclusions regarding radiation safety impacts based on these methods are valid.
 - iii. The department is satisfied that the estimates of radiation doses to workers and to members of the public provided by Kalbar in the EES are accurate based on the information available prior to the commencement of mining operations. The radiation dose estimates made prior to mining need to be verified at the commencement of mining operations and periodically during mining operations.
 - iv. Potential radiation exposure of members of the public is estimated to be 37 microSieverts² and significantly less than the public radiation dose limit of 1000 microSieverts (1 milliSievert) prescribed in the Regulations. Radiation monitoring will be required throughout the life of the mining project.
 - v. In the event that the project proceeds, Kalbar mining practices will have to comply with the legislative requirements governing worker protection, public protection, and environmental protection from radiation. The legislative requirements are the Radiation Act 2005 (the Act) and the Radiation Regulations 2017 (the Regulations). The Act and Regulations are administered by the Department of Health and Human Services (the department). A management licence will need to be obtained by Kalbar prior to commencing operations.
 - vi. When applying for the necessary Management licence under the Act, Kalbar will be required to submit a comprehensive Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP) that address aspects of on-site and off-site radiation exposures. The radiation exposures will consider atmospheric transport of radionuclides, groundwater transport of radionuclides, surface water transport of radionuclides, and gamma radiation exposure. The RMP and RWMP will need to demonstrate how Kalbar can satisfy the requirements of the Act and Regulations.
 - vii. The Australian Radiation Protection and Nuclear Safety Agency's Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing would be applied as a condition of a Management licence issued to Kalbar. This Code provides for radiation protection in mining and mineral processing industries and for protection of human health and the environment from the effects of radioactive waste from mining and mineral processing. The RMP and RWMP would be periodically reviewed by the department in conjunction with inspection of mining, mineral processing and waste management operations.
2. The advice goes onto to outline in detail how the department would ensure regulatory compliance if the project were to proceed. This would include:
 - Pre-mining Background Characterisation

¹ Note DHHS and DHS are used interchangeably throughout this document by the various people quoted.

² Appendix A011 Radiation Assessment Report Table 19: Estimated annual radiation doses for a Critical Group individual – March 2020.

- Periodic Document Review
 - Inspections of Mineral Sand Mines
 - Verification of Code Requirements
 - Inter-Agency Cooperation
3. It is clear that should the project proceed Kalbar mining practices will be subject to the legislative requirements of the *Radiation Act 2005* (the Act) and the Radiation Regulations 2017 (the Regulations) governing worker protection, public protection, and environmental protection from radiation. Kalbar will need to obtain a management licence prior to commencing operations under the Act and will be required to submit a comprehensive Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP) that address aspects of on-site and off-site radiation exposures. Regulatory compliance will be ensured by the Department.

Document 72: Kalbar Expert Witness Statement – Darren Billingsley – Radiation

4. The Radiation Assessment Report (RAR)³ forms the basis of Mr Billingsley Expert Witness Statement. Mr Billingsley has responded to the peer review⁴ of the RAR and to submissions on the EES relating to radiation and radioactivity.
5. The peer review was predominantly in agreement with the RAR and concluded among other items that:
 - i. The methodologies and numerical values used for estimates/calculations of the exposures to the public are appropriate.
 - ii. With regard the exposure to airborne dust inhalation during operations – using conservative assumptions the maximum annual effective dose to a Critical Group member of the public, as a result of dust inhalation is estimated as 29 μSv .
 - iii. in relation to exposure to radon/thoron gas I agree that the dose to a member of the public from this pathway is negligible.
 - iv. In relation to exposure via ingestion (crops); the prospective annual doses shown in Tables 17 and 18 of the Report represent conservative upper bounds.
 - v. In relation to exposure via consumption of drinking water I am in agreement with the conclusion that the consumption of drinking water would be an inconsequential exposure pathway relative to other pathways assessed.
6. The peer review raised issues with:
 - i. The management of tailings which Mr Billingsley clarified - *‘Tailings will be stored in the TSF before being returned to the mine void. The process water dams will not be used to store tailings.’*
 - ii. Use of updated regulatory codes which Mr Billingsley clarified – *‘Applicable Codes will be referenced in future documents including the RMP and RWMP, still to be drafted. The updated Codes of Practice do not impact on the assessments and conclusions of the RAR.’*
 - iii. Ingestion by livestock which Mr Billingsley clarified – *‘Whilst this exposure pathway is considered to present a negligible risk, it can be modelled using commercially available software. Data on local farming practices can be used as inputs where it is applicable. I [DB] recommend that an assessment of this exposure pathway be undertaken for incorporation into the Radiation Environment Plan. The REP requires approval from the Victorian DHHS prior to issue of a Management Licence.’*
Mr Billingsley has completed a preliminary numerical assessment⁵ of the ingestion by livestock using RESRAD⁶ software and indeed it has shown to present a

³ Appendix A011 Radiation Assessment Report April 2020

⁴ Doc #9 7/12/20 Inquiry and Advisory Committee - Expert Advice - Ken Joyner - Review of Radiation Assessment Report

⁵ Documents 464 Kalbar - Memo from Darren Billingsley regarding RESRAD files (Fourth RFI Response to Q6).

465 Kalbar - Attachment to Memo - Fingerboards Livestock BASELINE Preliminary. 466 Kalbar - Attachment to Memo - Fingerboards Livestock OPERATIONS Preliminary.

⁶ The RESRAD family of codes is developed at Argonne National Laboratory to analyse potential human and biota radiation exposures from the environmental contamination of RESidual RADioactive materials. The codes use pathway analysis to evaluate radiation exposure and associated risks, and to derive clean-up criteria or authorized limits for radionuclide concentrations in the contaminated source medium. The RESRAD family of codes is widely used by regulatory agencies, the risk assessment community, and universities in more than 100 countries around the world. <https://resrad.evs.anl.gov/>

negligible risk. This preliminary assessment should be updated and incorporated into the REP.

- iv. Analysis of radionuclides in environmental dust should be included in the environmental monitoring program. Mr Billingsley agreed and stated, *'it will be important to fully characterise TSP environmental airborne dust once operations commence, including identification of the radionuclide content.'*
7. Mr Billingsley then reviews and responds to comments from Regulatory Agencies (EPA and East Gippsland Shire Council) and then parties other than regulators, including members of the public. It is pertinent to consider one particular comment from the East Gippsland Shire Council⁷ as this comment is also made by Associate Professors Mudd and Ruff in their expert witness statements and oral evidence.

'It is noted that the ICRP have recently published new dose factors for naturally occurring radionuclides. The factors are for inhalation and ingestion of radionuclides, and also for the inhalation of the decay products of radon. The factors apply to occupational exposures only at this stage. Dose factors generally need to be approved by the local authority and adopted in local legislation. It is understood that the new factors are yet to be adopted in Victoria. It is suggested that the potential doses be re-assessed using the latest dose factors. This will provide a "best practice" assessment of doses. Note that this is not expected to significantly change the final assessed dose, however it is appropriate to consider the new dose factors.' [Emphasis added].

Mr Billingsley responded: *'Estimates of potential occupational doses are an important component of the RMP still to be drafted. The RMP will require approval from the Victorian Department of Health and Human Services (DHHS) prior to a Management Licence being issued to Kalbar.'*

It is agreed that the latest ICRP dose conversion factors (DCF) should be used to calculate potential occupational doses. These factors would be used in-lieu of the expectation they will be adopted in Victoria in due course. It should be noted that all dose calculation methodologies, including DCF, must be approved by the DHHS.

8. Mr Billingsley then goes onto discuss the Radiation Management Plan stating that Kalbar will be required to submit a Radiation Management Plan and a Radioactive Waste Management Plan. Both documents will stipulate ongoing monitoring requirements and controls that will be required for the Project. A Radiation Environment Plan will also be required. A Future Work Plan (RAR, Section 13) outlines further work to be conducted by Kalbar prior to commissioning. These requirements still apply. Mr Billingsley then elaborates some additional recommendation made in response to some of the suggestions put forward in the submissions. These additional recommendations apply to Ground Water; Surface Water; Long-lived Radionuclides; Air Sampling; In-pit Radon; Crops and Grazing Cattle.
9. During his oral evidence Mr Billingsley provided a power point presentation⁸ in which he used an updated Table 19 from A011 which contained a figure of 38 microSieverts (as opposed to the original 37 microSieverts) resulting from the inclusion of exposure pathways of consumption of beef and milk from livestock grazing in the mining area.

⁷ Submission 716B East Gippsland Shire Council Page 91

⁸ Document 305 Kalbar - Darren Billingsley Presentation – Radiation 12/05/2021

Radiological Impact – Member of the Public

Exposure pathway	Annual Dose Adult male Year 20 (μSv)
Airborne dust inhalation, 60 $\mu\text{g}/\text{m}^3$, ore material, 1 μm AMAD, occupancy at residence 8760 hours, 100% outdoors, breathing rate 0.93 m^3/h	29
Radon and thoron inhalation dose as a result of Project	negligible
Consumption of leafy vegetables grown solely in 'Margin to Flats'. Ore deposition at 0.2 $\text{g}/\text{m}^2/\text{month}$, distributed evenly through top 2 cm of soil and displaced to root depth.	5.8
Ingestion of ore as a result of dust deposition, 50 mg/day , 10% ore fraction.	1.2
Drinking water originating from Waterglen WTP which sources water from the Mitchell River.	negligible
Following a truck loaded with HMC, 5 metre separation distance, 1 hr/year	negligible
Waiting at rail crossing when HMC shipment passing, 2-metre separation, 1 hr/year	1.2
Consumption of beef, solely from livestock grazing in the mining area	0.4
Consumption of milk, solely from dairy cows grazing in mining area	0.3
Total:	38 μSv

10. Mr Billingsley concluded his oral evidence with two slides detailing a):

What is still required:

- Finer grid gamma radiation survey of mining areas, and areas of exposed ore at the surface.
- Additional groundwater and surface water samples to identify Ra-226/228 concentrations.
- Air sampling for Total Suspended Particulates (TSP)
- Radionuclide content in local crops.
- Commitment to assess impact on livestock for human consumption.
- Preparation of all necessary Management Licence documents including RMP, RWMP and the REP.

11. And b):

In Summary:

- Substantial baseline data has been collected to date.
- The Fingerboards Project/Kalbar will need to comply with the requirements of the *Victorian Radiation Act 2005*.
- Estimated doses to workers and members of the public are well below regulatory dose limits, even with conservative assumptions applied.
- Impact on non-human species living in natural habitats concluded the radiological impact is insignificant.
- Whilst additional baseline data is warranted to supplement existing data, any results will not modify the outcomes of the impact assessment conducted.

Document 125: Kalbar Supplementary Expert Witness Statement – Darren Billingsley – Radiation

12. This supplementary expert witness statement relates to a review of Technical Note TN01 Implementation of centrifuges for water recovery and tailings management^{9,10}.
13. It is claimed by Kalbar that the technical note indicates that there would be clear advantages for the Project if centrifuges are included:
- Centrifuges would provide certainty about water recovery from the fine tailings that is independent of climatic and soil conditions.
 - There is no need to construct the temporary tailings storage facility (TSF) or the in-pit fines TSFs if centrifuges are used, as they create a dry cake from fine tailings.
 - Centrifuges allow the continuous backfilling of the mined voids without the need to rip and remove in-pit fine TSFs before the commencement of rehabilitation operations, which means that the disturbed mining area is smaller, and rehabilitation can occur sooner after the completion of mining in any particular area.
 - The continuous mining and backfilling operation significantly reduces overburden haul distance, which in turn reduces noise and dust generation.
 - Any risk of seepage from fine tailings is removed as this material is fully dewatered to a state that will only retain capillary moisture that cannot seep to the environment.
14. Mr Billingsley concluded:
- If the changes were adopted, I believe it would have no impact on my radiation assessment report (RAR), or the contents of the witness statement I have already provided in relation to the Project on 29/1/2021. All dose estimates and impacts discussed in the RAR and my witness statement have been based on conservative worst-case input parameters, irrespective of the finer detail of the processing stream, and tailings disposal process as outlined in the Technical Note.
15. The EPA also considered the issue of the centrifuges¹¹ and with respect to air quality stated:
- EPA considers that the proposed inclusion of centrifuges to the fine tailings circuit and associated activities such as hauling of fine tailings to the mine and deposition of the tailings into the mine void is unlikely to change the risk to beneficial uses of air quality, compared to the TSF process.
- EPA considers that the introduction of the proposed centrifuges to the fine tailings circuit may contribute to mitigating some dust generation activities on the site (such as reducing overburden haulage and accelerating rehabilitation). However, there is also a risk of increased dust generation due to the increased daytime mining and haulage activity as the centrifuge cake will be transported during the day – whereas the exhibited EES indicated there was no haulage associated with tailings

⁹ Document #43 Technical Note TN01 Implementation of centrifuges for water recovery and tailings management, Kalbar Resources, 18/1/2021

¹⁰ Document #43A Kalbar – Corrected Technical Note 01 (TN 001)- Implementation of centrifuges for water recovery and tailings management. Note the map showing the indicative locations of the centrifuges in TN 001 (Tabled Document 43) is incorrect. TN 001 (Tabled Document 43a) has been revised to include an updated map. All revisions are shown as a ‘track change’

¹¹ Submission_514_-_EPA_Victoria_Supplementary_submission_-_Centrifuges_Redacted

management. The result is that overall emissions from the exhibited EES and the centrifuge proposal are relatively similar.

16. From a radiation perspective it would appear there is little or no benefit from the use of centrifuges.

Document 87: MFG Expert Witness Statement – Assoc. Prof Gavin Mudd – Radiation

17. Assoc. Prof Gavin Mudd (hereafter Prof Mudd) provided a summary and key issues as follows:
- i. Based on the available data from the Fingerboards EES, the region is not significantly elevated in environmental radiation, although further work is clearly required to confirm this over the full proposed project area. This is important in helping to determine potential rehabilitation criteria (if the project proceeds).
 - ii. Considerable further work is required to ascertain the levels of radionuclides naturally present in crops and vegetables as well as in surface water and groundwater.
 - iii. Almost all of data and information which would be required for statutory radiation licences and approvals remains left for ‘future work’, limiting the ability to assess the standards and procedures for the proposed Fingerboards project.
 - iv. Export of the heavy mineral concentrate raises concerns about relevant uranium and thorium safeguards given the potential to extract these nuclear source materials. This issue, a matter of national environmental significance, is poorly addressed and in reality, effectively dismissed/ignored in the Fingerboards EES.
 - v. The targets for rehabilitation sound reasonable but lack detailed quantitative or qualitative criteria to facilitate monitoring and assessment.
 - vi. There is a complete lack of specific and detailed financial costings for project rehabilitation.
 - vii. The lack of time allowed for maintaining, monitoring and then assessing the rehabilitation of former mining areas is of major concern – will this take 5 years or considerably longer, and how will this be funded by the proponent?
18. At this point I must declare that I do not have the expertise nor experience to comment specifically on points (iv) – (vii) above of Prof Mudd’s summary of his expert witness statement.
19. Based on the Expert Witness Statement and the oral evidence of Prof Mudd I have listed the key issues that I noted related to radiation that I believe are the basis for the concern expressed by Prof Mudd.
- i. The work presented in SGS (2020)¹² includes 156 measurements of gamma radiation levels and the measurements identified in the future work plan for the EES notes the need for further gamma radiation measurements, including a finer resolution survey. Prof Mudd maintains this should have been completed and presented through the EES process.
 - ii. There is a failure to cross-reference or compare against available aerial radiometric mapping and there is no legend or scale for the radiometric results, leaving the map as a relative scale only with light blue being low and red being high. The map suggests that an area of mineral sands mineralisation appears as a red anomaly west of Glenaladale, although this needs to be assessed in detail with respect to geology and mineralisation – something which the EES fails to do.
 - iii. The work presented in SGS (2020) includes 10 soils tested for radionuclide content. This is a very small number of tests for such a large project area. Given the

¹² Note the reference SGS (2020) used by Prof Mudd is the same document authored by Mr Billingsley RAR (2020).

- variability shown (varying by a factor of almost one hundred), a much larger number of soil samples should have been collected for testing – especially considering rehabilitation criteria and the suitability of different soils and materials for proposed rehabilitation designs.
- iv. The Future Work Plan, notes the need for further assessment of radionuclides in soils, considering “locations relative to the Project area, crop type, cultivation methods, fertilizer use, and gamma survey field measurements”. Prof Mudd believes this work should have already been completed and presented through the EES process.
 - v. For radionuclides in crops Prof Mudd comments this section is very short and rather terse – plus the values given in Table 4 are calculated only and not directly measured. The transfer factors are not given, nor a basic explanation of the calculations undertaken to derive the values in Table 4. Although it is asserted that the transfer factors are appropriate for the region, there is no direct evidence presented to support this – such as previous scientific studies nor direct sample analyses of crops from the Glenaladale region.
 - vi. Section 13, the ‘Future Work Plan’, notes the need to assess radionuclides in vegetables in Lindenow – yet I believe this work should have already been completed and presented through the EES process.
 - vii. The ‘Future Work Plan’, notes the need to conduct detailed radon surveys, especially to understand baseline levels and factors affecting variability. Prof Mudd believes this work should have already been completed and presented through the EES process.
 - viii. Prof Mudd agrees that the tailings would not be classified as radioactive waste as per the Australian (and related IAEA) code. The production of the HMC, however, is a designated radioactive material, meaning that a formal Radioactive Waste Management Plan will be required to meet Australian and Victorian regulations – yet this plan is still to be developed and only very generic issues noted in the SGS.
 - ix. Prof Mudd notes that the section on Post-Mining Criteria for Site Remediation and Rehabilitation (Chapter 11 of the Fingerboards EES) that in general the commitments made in Table 11.2 are generally good but often lack quantitative criteria, making implementation and assessment more difficult. Prof Mudd goes onto give specific comments on (1) surface water and groundwater quality reflect original (pre-mining) baseline chemistry (Table 11.2, page 11-10) – yet there remains insufficient data upon which to define and quantify baseline chemistry and (2) rehabilitation to ensure that radiation dose at surface and radon levels in atmosphere is less than or equal to baseline levels found within the project area. Prof Mudd maintains there is insufficient data to properly define and quantify baseline radiological conditions.
 - x. There appears to be no recognition of the length of time required to actively monitor and maintain the site to ensure that the numerous rehabilitation targets and associated criteria are achieved. That is, will monitoring and site maintenance occur for 5 years after the cessation of
 - xi. In response to a question - is there anything any further that you wish to say in relation to the radiation, the risk of radiation impacts of this project? Prof Mudd responded that the main issues *‘really come down to how well things are managed. Prof Mudd goes onto state ‘certainly dust is going to be the main issue’.*
 - xii. Prof Mudd also commented that *‘I think it comes down to making sure that there are stringent requirements, you know a good level of monitoring to make sure*

there's data to underpin success on that so .. it does require that very very careful management.'

- xiii. In cross examination Prof Mudd was asked on numerous occasions about the regulatory oversight to be provided by DHS and he stated, *'no that's not a document I've read sorry'*.
 - xiv. In re-examination Prof Mudd stated that he had not seen versions of the radiation management plan or the radioactive waste management plan and went onto explain that one of the problems he always encountered *'these types of processes between an agency like DHS and the company is they're not public'* and I think *'those sorts of uh documents and plans and so on I think should be out in the public realm', 'from my point of view I like these things to be public I think that's a transparency and accountability certainly important part of the way I would see these projects operating'*.
 - xv. Also, in re-examination Prof Mudd was asked *'would you expect the radiation management plan and the radioactive waste management plan to be public documents that are available to members of the community or not?'* Prof Mudd responded: *'I would hope they are I think historically I've found that these documents are not made public but I think I would certainly hope they are I think that's important transparency to to help validate the claims that are being made about management and low risk or things like that so that way um you know the evidence is there and so we can have confidence or or otherwise in these documents I think it's an important part of the process and for the committee's purposes in assessing the environmental effects of this project'*.
20. I have confirmed with DHS that the RMP, RWMP and REP documents are treated as commercial in confidence and are not released by DHS.
21. At this point it is worthwhile reiterating the advice from DHS:
- i. When applying for the necessary Management licence under the Act, Kalbar will be required to submit a comprehensive Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP) that address aspects of on-site and off-site radiation exposures. The radiation exposures will consider atmospheric transport of radionuclides, groundwater transport of radionuclides, surface water transport of radionuclides, and gamma radiation exposure. The RMP and RWMP will need to demonstrate how Kalbar can satisfy the requirements of the Act and Regulations.
 - ii. The Australian Radiation Protection and Nuclear Safety Agency's Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing would be applied as a condition of a Management licence issued to Kalbar. This Code provides for radiation protection in mining and mineral processing industries and for protection of human health and the environment from the effects of radioactive waste from mining and mineral processing. The RMP and RWMP would be periodically reviewed by the department in conjunction with inspection of mining, mineral processing and waste management operations.
22. It is also worthy of note that Kalbar has:

- i. An extensive Dust Management Plan¹³ which details with Compliance standards, Acceptance criteria, Controls to address hazard, Residual risk assessment, Monitoring and Reporting.
- ii. An extensive Mitigation Register¹⁴ dealing with identified risks.
- iii. An extensive Stakeholder Consultation Plan¹⁵ which could be used to address the issues of transparency and accountability raised by Prof Mudd.

¹³ Kalbar - Risk treatment plan template airborne dust_RevC - Kalbar update - 15 June 2021 (clean)

¹⁴ Kalbar - Mitigation Register (EES, Attachment H) - Kalbar update - 15 June 2021 - rev1

¹⁵ EES Chapter 6 Stakeholder consultation

Document 89: MFG Expert Witness Statement – Assoc Prof Tilman Ruff – Health and Radiation

23. Prof Tilman Ruff (hereafter Prof Ruff) has provided a review of health related research upon which he concludes new evidence shows that radiation risks to health are greater than previously thought and are not adequately reflected in regulatory limits. Health risk exists below the maximum permissible doses for the public and for workers. Radiation health risks are 4 - 5 times greater for children than adults and 40% greater for women and girls than for men and boys at all ages. Young adults are more susceptible than older adults.
24. It is certainly not my intention to marginalize or trivialize this expert evidence but in my view this review of health related research should be debated with ARPANSA and the State and Territory Regulatory Agencies responsible for setting limits for human exposure to ionizing radiation. For the Fingerboards project under consideration the current regulatory limits and regulatory oversight from DHS are appropriate.
25. Prof Ruff also has provided a large amount of commentary on possible implications for international nuclear safeguards and the *Victorian Nuclear Activities (Prohibitions) Act 1983*. As I have stated previously (para 18) I do not have the expertise or experience to make an informed comment.
26. I will comment on each of the remaining conclusions of Prof Ruff:
 - i. All aspects of project management should aim for radiation exposures for workers and the public which are as low as practicable and well below regulatory limits and set action levels that would trigger prompt evaluation and response, with involvement of DHHS. I would recommend that the latter levels (including all exposure pathways) be set at around 1-2 mSv per year for workers and 0.1 - 0.2 mSv/yr for the public.

Comment: The ALARA Principle is the fundamental guiding principle in radiation protection, and it is important to note the full text of the Radiation Protection Principle in Section 7 of the *Victorian Radiation Act 2005* which stipulates that persons and the environment should be protected from unnecessary exposure to radiation through the processes of justification, limitation and optimisation where—

- (a) justification involves assessing whether the benefits of a radiation practice or the use of a radiation source outweigh the detriment;
- (b) limitation involves setting radiation dose limits, or imposing other measures, so that the health risks to any person or the risk to the environment exposed to radiation are below levels considered unacceptable;
- (c) optimisation—
 - (i) in relation to the conduct of a radiation practice, or the use of a radiation source, that may expose a person or the environment to ionising radiation, means keeping—
 - (A) the magnitude of individual doses of, or the number of people that may be exposed to, ionising radiation; or
 - (B) if the magnitude of individual doses, or the number of people that may be exposed, is uncertain, the likelihood of incurring exposures of ionising radiation — as low as reasonably achievable taking into account economic, social and environmental factors.

With regards the recommendation for action levels to be set at around 1-2 mSv per year for workers and 0.1 - 0.2 mSv/yr for the public. Action levels may well be included in the RMP, RWMP and REP documents but the levels will no doubt be determined through consultation between DHS and Kalbar. It should be noted that the estimated dose for the public is already below the 0.2 mSv/yr at 0.038 mSv/yr.

- ii. A major project which will run over more than two decades must consider the implications of global heating and factor them into its mine management.

Comment: As mentioned previously Kalbar has an extensive mitigation register which should specifically address extreme weather conditions.

- iii. To minimise the public health and environmental impacts of both routine and accidental releases of HMC during handling and transport, every effort should be made to minimise multiple handling and especially dust generating loading of HMC onto and off trucks, and onto ships from wharves, and open storage of HMC at the mine or on wharves or anywhere else. Every effort should also be made to minimise the number and distance of truck movements required to transport the HMC, and preferably to eliminate them altogether. The ideal would be for the HMC to be loaded via as closed a system as possible (e.g. a closed conveyor or pipe) directly into train-borne containers at or immediately adjacent to the mine site, containers which are then sealed and transported by rail to be shipped offshore.

Comment: The handling of the HMC will require active management and stringent controls and again these will no doubt be determined through consultation between DHS and Kalbar.

I have previously underscored the point that process controls for ensuring the total concentrations of uranium and thorium contents of HMC remain below 10 Bq/g limit to ensure exemption with the need to comply with shipping, documentation and placarding requirements.

Again, I note the extensive Dust Management Plan which details with Compliance standards, Acceptance criteria, Controls to address hazard, Residual risk assessment, Monitoring and Reporting.

- iv. As recommended by Dr Joyner and DHHS, all possible exposure pathways of workers and the public should be assessed and monitored, including through farm work and other types of prevalent local employment or other activities, and sampling of all agricultural products downwind and downstream of the planned mine, including not only vegetables and grain, but fish, and animal products in the form of both meat and dairy products. If any Aboriginal people harvest bush foods in areas potentially affected by the project, associated exposures should also be assessed.

Comment: Mr Billingsley has completed this work at least for meat and dairy products and shown that these exposure pathways pose a negligible risk. Monitoring of downstream water will be implemented, and this could be used as a surrogate for determining any impact on aquatic life. Prof Mudd and Prof Ruff have both drawn attention for the need for strict protocols for when determining the impact on crops to minimize the variability of such monitoring. I agree that any bush food harvested by Aboriginal people in areas potentially affected by the project should be assessed.

- v. All mine personnel should wear appropriate personal radiation dosimeters at all times on site.

Comment: Such personal monitoring is routine and would be included in RMP, RWMP and REP documents and enforced by DHS.

- vi. All environmental and health relevant monitoring data during every phase of the mine's operation and rehabilitation should promptly be made publicly available.

Comment: I have no in principle objection to such a recommendation and it could form part of the Kalbar Stakeholder Consultation.

- vii. All consultative bodies established in relation to the mine should include representatives of community organisations.

Comment: I have no in principle objection to such a recommendation and it could form part of the Kalbar Stakeholder Consultation.

Document 234: Radiation and Human Health Expert Meeting Statement

27. In reviewing this document, I am including the power point presentations of Mr Billingsley (Table Document 305) and Prof Ruff (Table Document 445). The most expedient way to proceed with the review of Radiation and Human Health Expert Meeting Statement is to comment on those areas where the experts disagree.

- i. The 'Future Work Plan', notes the need for further gamma radiation measurements, including a finer resolution survey.

Prof Mudd believes this work should have already been completed and presented through the EES process.

Mr Billingsley disagrees stating the finer grid survey is not part of the EES process. Conventionally it is required prior to soil disturbance and pre-mining including the mining areas, processing, stockpiling, etc. for remediation criteria purposes. A management licence will not be issued without this data being collected. The existing survey is intended to provide an indication only of approximate levels for comparison with the natural levels, and to assist undertaking the impact assessment. Mr Billingsley does acknowledge that a finer grid survey will assist in identifying other area of outcropping in the project area if they exist.

Comment: Both the peer review and DHS were agreement that the methods used by Kalbar to estimate the radiation related impacts of the project is well established and appropriate for the task. Furthermore, the department's assessment is that the methods have been implemented appropriately and the conclusions regarding radiation safety impacts based on these methods are valid.

- ii. SGS (2020) also fails to cross-reference or compare against available aerial radiometric mapping, either from Geoscience Australia or the Geological Survey of Victoria ('GSV').

Mr Billingsley and Prof Mudd agree that the aerial radiometric mapping reinforces the importance of completing a finer grid survey. Closer scrutiny of the aerial data may assist in developing a survey plan. Both agree that the aerial survey averages gamma readings over a very large area whereas a finer grid survey is local point data which is more useful in terms of mine planning, radiation management and site rehabilitation.

Comment: This represents more agreement than disagreement and that aerial radiometric mapping will be included should the project proceed.

- iii. With respect to radionuclides in crops Prof Mudd maintains the values given in Table 4 are calculated only and not directly measured. The transfer factors are not given, nor a basic explanation of the calculations undertaken to derive the values in Table 4. Although it is asserted that the transfer factors are appropriate for the region, there is no direct evidence presented to support this – such as previous scientific studies nor direct sample analyses of crops from the Glenaladale region. Mr Billingsley disagrees that it is an ineffective means of impact assessment. There are extremely large errors with lab assessment of foliage due to geometry variations from sample to sample. To identify impacts from operations thus would be difficult, based on dust concentrations expected. A theoretical approach has been taken using factors from IAEA2010, Table 17. 'Mean' transfer factors used.

‘temperate’ environment assumed as only other option is ‘tropical’. However importantly, identical factors have been used for the baseline, and the project impact. It is this dose difference (RAR, Table 18) that is of importance – not the factors themselves.

Prof Mudd responds he is familiar with the literature, acknowledge the huge variation, that’s why I’m cautious. Ultimate test is testing the vegetable foliage itself.

Comment: For the radionuclide content within vegetation grown in the district component of the pre-mining background radiation level, DHS is of the view that the assessment Kalbar has provided in the Report employs an international best practice estimate using an agreed methodology developed by the International Atomic Energy Agency.

I also agree with the use of temperate mean transfer factors for the impact assessment but should actual measurements of the vegetable foliage be performed then there should be a rigorous and unambiguous test protocol agreed to minimize the variability that can be anticipated from the measurements.

- iv. The ‘Future Work Plan’, notes the need to assess radionuclides in vegetables in Lindenow – Prof Mudd believes this work should have already been completed and presented through the EES process.

Mr Billingsley despite reservations of the ability to assess impact in the future, I acknowledge analysis of radionuclides in crops is important based on concerns in the community. It is a recommendation in my Witness Statement (8.8, page 15).

The timing of these measurements is to be discussed.

Comment: Noting that the timing of such measurements is yet to be discussed there is agreement to proceed with the measurement of radionuclides in vegetables in Lindenow. Again, it is important that actual measurements of the vegetable foliage should be performed with a rigorous and unambiguous test protocol agreed beforehand to minimize the variability that can be anticipated from the measurements.

- v. The designation of the Fingerboards project as a ‘nuclear action’ under the Commonwealth Environment Protection & Biodiversity Conservation (EPBC) Act.

Comment: As I have stated previously this is outside my area of expertise and experience and I am unable to comment.

- vi. Prof Ruff - Radiation exposures for workers and the public should be kept much lower than regulatory limits. Action levels that trigger prompt evaluation and response.

All in agreement that trigger levels will appear in the radiation plan, needs to be real time, multifaceted, include workers and offsite residents, have clear levels that would trigger review, investigation, additional measures, and should be low.

Comment: I have commented at length on the ALARA principle and the Radiation Protection Principle in Section 7 of the Victorian Radiation Act 2005 at para 26 (i).

- vii. Prof Ruff - All aspects of the proposed project should take account of the greater radiation risk for children, and women and girls and currently no mention. Prof Ruff - young children should be included. At least some basic identification of where and how children might be exposed to the mine and HMC transport pathways through the various ways (inhalation, road traffic, dust ingestion etc.) would be prudent to identify. A geographic map could help to identify locations where children spend lots of time apart from homes- e.g. kindergarten, childcare, schools, playgrounds, sports facilities.
- Mr Billingsley responded that there was partial agreement with statement and acknowledged that [young children] are not included in EIS for radiation. The EIS doses calculated (37 $\mu\text{Sv}/\text{annum}$ total) do not warrant special targeting of assessment of doses to individual groups. Estimated dose assumptions were explained. Dose was calculated for an infant, but not included in report. Based on lower inhalation dose and higher ingested dose, estimated total dose is 39 $\mu\text{Sv}/\text{y}$.

Comment: I have commented at length on the ALARA principle and the Radiation Protection Principle in Section 7 of the Victorian Radiation Act 2005 at para 26 (i).

- viii. Prof Ruff - All aspects of project management should aim for radiation exposures for workers and the public which are as low as practicable and well below regulatory limits, and set action levels that would trigger prompt evaluation and response, with involvement of DHS. I would recommend that the latter levels (including all exposure pathways) be set at around 1-2 mSv per year for workers and 0.1 - 0.2 mSv/yr for the public.
- There was agreement following discussion.
- Mr Billingsley commented that action Levels will be set in the RMP for approval by the DHS. Rather than annual doses, investigation and DHS reportable levels will be based on discrete sample results (dust, Radon, quarterly TLD) exceeding a specific value. And will ensure annual doses are minimised before they even occur. Need to be careful setting fixed annual dose thresholds too low.
- Mr Neil Wain (DHS) confirmed that action levels would be difficult to regulate against. The Act does not have offences for exceeding trigger levels and don't have power to create an offence for exceedance of a constraint in a licence condition, but we can require the company to undertake activities like investigations and report back on results. If we feel there is a risk a limit will be exceeded, we can issue a notice or suspend licence to suspend activities.
- All in agreement that trigger levels will appear in the radiation plan, needs to be real time, multifaceted, include workers and offsite residents, have clear levels that would trigger review, investigation, additional measures, and should be low.
- Mr Billingsley made the comment expected doses were comparable or less than limits proposed by Prof Ruff anyway.

A number of the remaining concerns raised by Prof Ruff are responded to in paras 26 iv, v, vi and vii.

- ix. Prof Ruff referred to a new recommendation discussed at radiation expert meeting concerning the current ICRP dose coefficients (ICRP 137, 2017) to be applied to radiation dose assessment, monitoring and management for the proposed project. Mr Billingsley had already responded to this in his expert witness statement 'Estimates of potential occupational doses are an important component of the RMP

still to be drafted. The RMP will require approval from the Victorian Department of Health and Human Services (DHHS) prior to a Management Licence being issued to Kalbar.

It is agreed that the latest ICRP dose conversion factors (DCF) should be used to calculate potential occupational doses. These factors would be used in-lieu of the expectation they will be adopted in Victoria in due course. It should be noted that all dose calculation methodologies, including DCF, must be approved by the DHHS.

Document 258: Bendigo District Environment Council (BDEC) - Comments on review of the Radiation Assessment A011

28. BDEC make a number of points:

- Their review has found that SGS have dramatically under-estimated the radiation loading to which mine workers will likely be exposed.
- SGS has failed to identify the two most significant sources of radiation likely to be present on the Fingerboards project. These sources are the stockpile of HMC at the loading dock and a further temporary stockpile of HMC described as waiting contractual arrangements. These stockpiles of HMC are scaled by the proponent as up to 50,000 tonnes (Reference - Project Description A006. Chapter 3.5.2) and 500,000 tonnes (Reference - Draft Work Plan) respectively.
- The radiation loading to mine workers, or members of the public on the mine site, from the HMC stockpiles will then be far greater than the evaluations provided by SGS, that is likely to be in the order of up to several hundred mSv. This level would greatly exceed the accepted legal loadings at a worksite in Victoria, that is 20mSv for mine workers and one mSv for members of the public respectively.

i. **Comment:** The department's [DHHS] assessment is that the methods used by Kalbar to estimate the radiation related impacts of the project is well established and appropriate for the task. Furthermore, the department's assessment is that the methods have been implemented appropriately and the conclusions regarding radiation safety impacts based on these methods are valid.

- It also follows that as these exposed stockpiles of HMC are capable of generating massive dust loads during adverse weather conditions that the exposure to humans or other receptors beyond the mine boundary has not been correctly evaluated by SGS and is now problematic. HMC when dry has little resistance to wind erosion, consisting of fine (< 200 micron), medium density particles which are not bound and normally poorly consolidated.

ii. **Comment:** Kalbar has an extensive Dust Management Plan which details with Compliance standards, Acceptance criteria, Controls to address hazard, Residual risk assessment, Monitoring and Reporting.

- The radiation assessment conclave report listed as pre-hearing document 234 describes the agreed position of the conclave members, being that HMC is the most significant consideration in establishing the safety of workers on the Fingerboards site. Page / item 15 states -

‘ The ideal would be for the HMC to be loaded via as closed a system as possible (e.g. a closed conveyor or pipe) directly in to train-borne containers at or immediately adjacent the mine site, containers are then sealed and transported by rail.’

‘All agreed in principle’.

The proponent would have understood that a closed system, as described, is not possible within their mine model. SGS were present at the conclave meeting held on the 14th of April.

It is reasonable to consider that the peer review members of the conclave, due to the mechanisms of a peer review as established by the IAC, are unlikely to have viewed the draft Work Plan so would not have identified the HMC stockpiles or considered them as potential sources of significant radiation.

- iii. **Comment:** There is clearly a disagreement about the mine being a closed system or not. This would be an issue for DHHS to investigate to ensure the RMP and REP documents accurately reflect the situation.
- SGS have provided a radiation loading evaluation for workers engaged with bulk handling of HMC at the Port of Melbourne. Bulk handling of HMC at the Port of Melbourne would not be a permitted activity. These omissions or failures by SGS demonstrate that they have failed to gain an understanding of the mine model.
- iv. **Comment:** Section 9.1.7 of the RAR 2020 states *‘Irrespective of the shipment method to be utilised, Kalbar propose to, in conjunction with the selected port authorities, undertake a risk assessment and implement controls as required (refer to the Future Work Plan in Section 13). The Kalbar RMP radiation monitoring programme will include assessment of wharf facilities for an initial 12-month period.’*
- The proponent in a further pre-hearing document, number 243 dated the 16th of April, has changed the draft Work Plan by withdrawing the description of HMC stockpiles and providing a replacement description of HMC stored in silos. It is assumed the addition of these silos is intended to provide radiation shielding to the stored HMC. These silos add more than 30% to the capital cost of the project and should now be considered as the fourth iteration of the mine model prior to the panel hearing. It is likely that the use of silos is impractical.
 - The silos would present a totally unacceptable risk to workers entering these enclosed spaces to remove blockages to the flow of HMC as they could be exposed to dangerous accumulations of radon gas.
- v. **Comment:** DHHS have commented ‘When applying for the necessary Management licence under the Act, Kalbar will be required to submit a comprehensive Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP) that address aspects of on-site and off-site radiation exposures. The radiation exposures will consider atmospheric transport of radionuclides, groundwater transport of radionuclides, surface water transport of radionuclides, and gamma radiation exposure. The RMP and RWMP will need to demonstrate how Kalbar can satisfy the requirements of the Act and Regulations.’

Qualifications and Experience

My name is **Kenneth Henry Joyner**, [REDACTED]
Victoria.

My formal qualifications are:

- B.Sc. Hons (La Trobe) 1970: H1.
- Ph.D. (La Trobe) 1975: “Phase Height Measurements on the Ionosphere”.

My Professional Affiliations are:

- Fellow of the Australian Radiation Protection Society.
- Member of the Bioelectromagnetics Society (USA).
- Senior Member of the Institute of Electrical & Electronics Engineers (IEEE)
- Member of the IEEE Standards Association
- Member of Institute of Engineers Australia (Certified Practising Engineer)
- I was a member of the Radiation Advisory Committee for 17 years retiring in 2020.

The Radiation Advisory Committee is established under the Radiation Act 2005 and the committee's function is to consider, advise and report to the Minister for Health or the Secretary of the department on any matters relating to the administration of the Act and Radiation Regulations 2017.

My major area of expertise relates to non-ionizing or electromagnetic radiation but in the 45 years since graduating I have delivered university undergraduate courses in nuclear physics, been involved in the identification and disposal of radioactive sources, conducted in-building radon measurements and through my 17-year tenure on the Radiation Advisory Committee I have been involved in

- The promotion of radiation safety procedures and practices.
- Recommendation of the criteria for the licensing of persons and the qualifications, training or experience required for licensing.
- Recommendation of which radiation sources should be prescribed as prescribed radiation sources.
- Recommendation of the nature, extent and frequency of tests to be conducted on radiation apparatus and sealed radioactive sources.
- Codes of practice, standards or guidelines with respect to particular radiation sources, radiation practices or uses.

Specifically for electromagnetic radiation I have been directly involved in the justification, limitation and optimisation of human exposure which mirrors the principle of protection in the Victorian Radiation Act 2005 that persons and the environment should be protected from unnecessary exposure to radiation through the processes of justification, limitation and optimisation.