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To: JATAM/KEDAI JATAM, Jl. Tebet Barat Dalam X E No.18, RT.12/RW.5, Tebet Barat, Kecamatan . Tebet, Jakarta Selatan – DKI Jakarta 12810 Indonesia.

Re: Dairi Prima Minerals (DPM) Mine site risks and Tailings disposal safety. Review of Dairi 2022 EIA Addendum.

Dear JATAM

I have previously reviewed plans for a proposed tailings storage facility (TSF) at the Dairi (DPM) lead-zinc mine in Sumatra, Indonesia, now starting construction, and made reports (Meehan (May 2021), and Meehan (2019)) on safety issues of the proposed TSF. My reports highlighted some of the hazards to which such a facility will be exposed, especially those due to the extreme earthquake activity and high rainfall in the Sumatra project area.

Now I have reviewed Dairi's (DPM) most recent 2022 Addendum to the Environmental Impact Statement (EIS) and present my findings here on that addendum.

As will be discussed here DPM's new EIA Addendum is still incomplete because it does not include important data necessary to evaluate the safety of the TSF proposed in it. Hence it is not possible to for me or any other party adhering to current international safety standards (Morgenstern 2016, ANCOLD 2012, 2022) to make final conclusions at this time (June 2023) as to safety of the TSF aside from preliminary comments such as I offer here.

The new EIA Addendum states that over the past twenty years several sites have been examined for the TSF, and a 1.2 million tons site, currerntly estimated a 1.67 million tons, next to and above the Sopokomil Village, was chosen in preference to an earlier selected site or sites (Middleton 2003) closer to the mine works. Whether the proposed size of the TSF is adequate is a matter of debate with Emerman (2023) presenting a researched estimate of 2.5 million tons, 50% more than the DPM estimate. My analysis and findings here are valid for all of the proposed sizes.

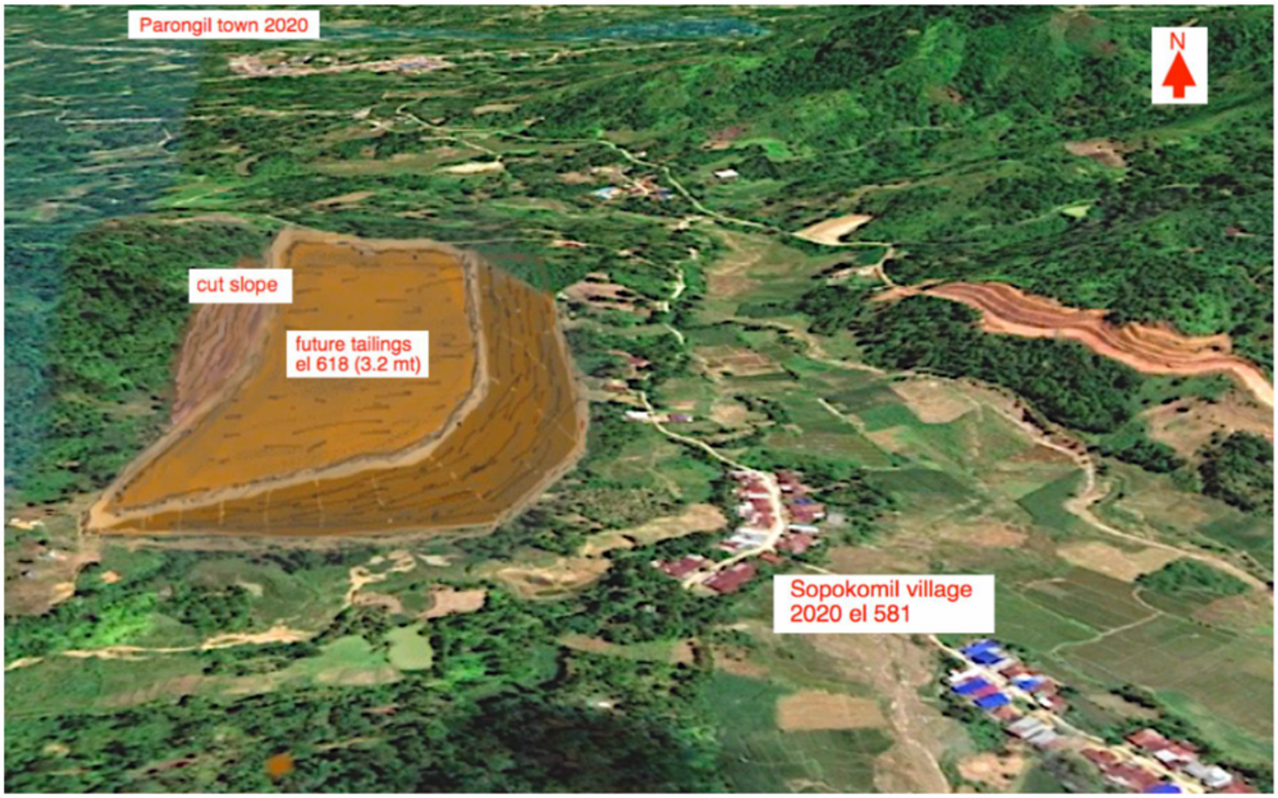


Figure 1. Planned configuration of TSF, 3.2 million tons at elevation 618. TSF configuration (brown color) from EIA Addendum fig 2.22 sketched onto Google Earth image by the author. Breach of the tailings dam above the Sopokomil village is likely in a strong earthquake because the ground between and beneath the village and the TSF and the dam foundation is unstable volcanic ash soils subject to liquefaction.

I am an engineer with fifty years experience in design, construction, and seismic safety engineering for dams. In my previously reviews of the DPM EIA and addenda I found the EIA consideration of tailings dam (TSF) safety lacks supporting geotechnical data which DPM holds but has not released. With my support, BAKUMSU requested, through the Ministry of Environment and Forestry, this essential DPM geotechnical data possessed by DPM. The data was not provided. It must be made available to allow independent third-party analysis of DPM's plans. The non-disclosure of data reinforces my opinion that foundation conditions at the proposed site are unsafe or inadequately understood. The 2022 EIA Addendum says as much:

3.1.5.4.3. Geological structure around the TSF site
Information on the geological structure that developed at the TSF location and its surroundings is very difficult to obtain, both through surface data and from data from geotechnical drilling, the high level of weathering on the surface and also as an area of alluvial sedimentation is the main factor in the difficulty of obtaining an overview of the structure in this TSF area….--EIA 2022

I agree that the geology of the TSF area is poorly understood. What has been missing in the multiple efforts to find an area suitable for TSF is a competent geological characterization of the area which requires some specialized knowledge of the deposition and morphology of volcanic ash deposits and their engineering implications.

In 2019 I reviewed (Meehan, 2019) publicly available geological data for the area around the mine site, consulted with geologists with knowledge of Sumatra geology, and did my own terrain study of the distribution of volcanic ash, concluding that the various proposed DPM tailings dam sites are all located on unstable volcanic ash foundations, (unlikely to be alluvium) bordered by highlands of older rock scarred by hundreds of active debris flows. All of this within one of the most seismically active and rainiest areas of the world. I then considered the options for alternative TSF sites but could find none because all of the land in this part of Sumatra is underlain by unstable volcanic ash deposits. In my 2021 report Appendix A I set forth results of my research on the extent and character of the volcanic ash. I could not find any engineering design that promised safety for a TSF built on such a foundation. I provided this assessment to BAKUMSU, concluding that the TSF could not be safely built in the vicinity of the mine - because the volcanic ash beneath the site was unstable. BAKUMSU filed my report to the Indonesian Ministry of Environment and Forestry.

In 2020 I subsequently reviewed a new EIA Addendum from DPM. This update admitted that the site presented the seismic safety problems that I had identified but provided little further information on tailings dam stability. The proposed TSF dam axis was moved closer to the side of the flood plain in an apparent attempt to find better foundation but new borings showed no improvement at this site which remains the site favored by DPM. Addendum provided no supporting data or analysis of the consequences of a tailings dam failure which is not only possible, but likely. There was no plausible planned abatement of public risks from the proposed dam.

Now I have reviewed another 2022 EIA Addendum, one which I understand is the current basis for the Indonesian Ministry of Forestry and Environment to provide Environmental

Approval to DPM. Again I note there is still no supporting data or analysis of the consequences of a tailings dam failure.

One significant difference, however, is that in the latest EIA Addendum, DPM now accepts the seismic hazard at the TSF site including "earthquake-prone, liquefied soil"

2.6.3
PT DPM recognizes that this TSF is potentially hazardous and needs to be stored safely during and after mining. For that reason, this TSF facility has been designed to the highest standard to anticipate all risks that could occur such as in the event of seepage, leakage or collapse of the retaining embankment by considering all the problems that exist at the site, such as high rainfall, earthquake-prone, liquefied soil. (liquefaction) and shallow groundwater. To support the study, PT DPM conducted geotechnical drilling of 28 drill points .... (EIA 2022 translation)

Meanwhile for this 2022 EIA Addendum, DPM, having now come to an admission of the serious seismic safety problems at the site, hired a world-class Indonesian seismologist named Danny Natawidjaja. DPM says that Natawidjaja produced a report saying ground motions with an intensity of 0.5g (.489g) are credible and must be applied at the proposed Tailings Storage Facility site. Though a copy of the Natawidjaja's report has not been made public, **I believe this 0.5g figure is intended to be applicable to bedrock 50 or more meters deep beneath the proposed dam, not to the dam foundation where the most acute and critical problems are likely to develop. Hence the Bishop method stability analysis the DPM advances (but does not document) to argue for stability is incorrect by a large margin.**

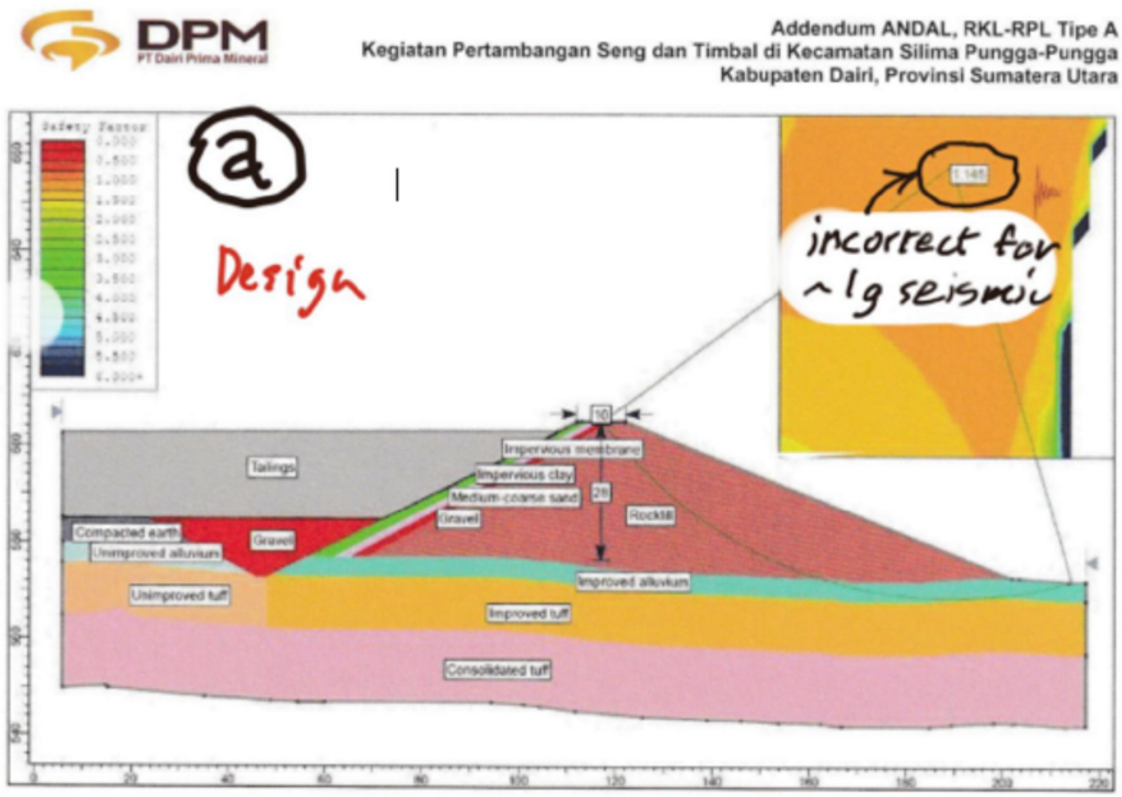
It is probable that Prof Natawidjaja, as a seismologist rather than an engineer, has not considered the local soil conditions at the DPM site above bedrock. Normally that knowledge is considered to be within the realm of responsibility and expertise of the project engineer, not the consulting seismologist.

DPM has progressively shifted the proposed location of the TSF after performing various field investigations that revealed unstable foundation support for the facility. DPM has never claimed that the condition of the volcanic ash is well suited for earthquake stability, commenting in various documents that it is "soft" and subject to "settlement" and useful only for unimportant facilities such as road fills. Their latest effort to move the TSF closer to the side of the Sopokomil Valley to avoid unstable ash was tested by borings which revealed again deep deposits of ash. These unstable soils not only intensify the earthquake response of the TSF but create a high risk of foundation liquefaction which would result in complete failure of the dam.

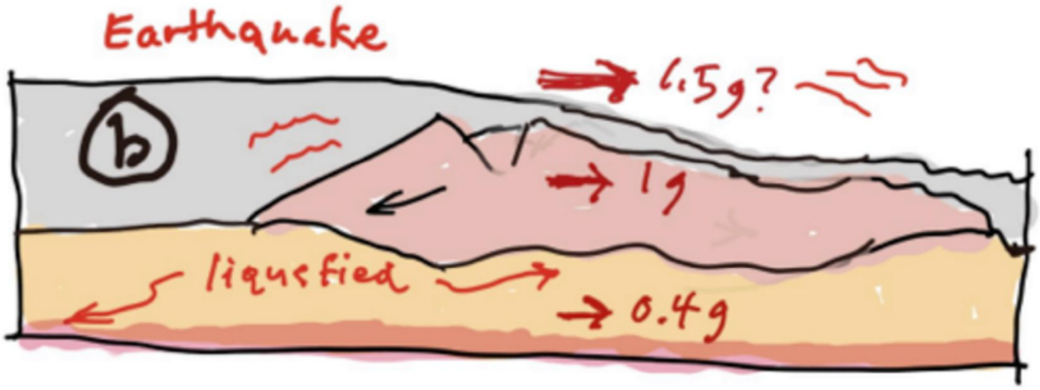
The few engineering notes in the 2022 EIA Addendum on the unstable ash soil foundation conditions to 50+ meters even at their currently preferred site are vague, do not meet engineering standards, and quite concerning from a stability standpoint:

a) 0-3.00m, consisting of residual soi/, composed of flaky clay, yellowish brown which is plastic;
b) 3.00 - 12.00 m, consisting of weathered tuff of moderate sand size, grayish white, sparse to moderate grain density, crystalline tuff composition.
c) 12.00- 15.90 m, consisting of weathered crystalline tuff, grayish-white, containing chunks, soft, easily decomposed by water.
d) 15.90 - 52.80 m, consisting of moderately weathered crystalline tuff, grayish-white, containing lumps, soft and rather difficult to decompose by water. --EIA 2022

Notwithstanding DPM claims of their having completed many explorations no further information on the character of the tuff has been provided. As we have previously set forth, it is certain that much of the tuff will be loose and uncemented. Such tuffs in other places in the world are known for their seismic instability (see Choi 2007, Meehan 2021). Volcanic ash consists of very fine glassy fragments resulting in a porous watery soil easily collapsed by seismic disturbance. My report (Meehan, 2021) contains a lengthy review of this.



Gambar 2.47 Gambar Perhitungan Nilai FoS Disesuaikan Dengan Kondisi Akhir TSF



These soft loose volcanic ash beds 50 or more meters deep would be present above the bedrock and below the dam embankment. They would change the character of seismic ground motion specified by Prof Natawidjaja as waves of energy move upwards from bedrock into the dam. The dam would see longer periods of seismic excitation and higher, more dangerous G forces. In many other sites with similar non-bedrock foundations, ground motions 0.5g at bedrock level (see b, above) would generate ground motions of close to 1g at the dam level. Ground motion could be amplified to exceed even 1g. This amplification phenomenon has been known and accepted by engineers since the late 1950s when it was introduced by my former Professor Ambraseys at University of London, Imperial College (Ambraseys 1958). Its recognition and evaluation is a central requirement in today's strict safety standards such as in ANCOLD.

This amplification in the material overlaying the bedrock would invalidate the undocumented seismic stability analysis provided by DPM in EIA Figure 2.47. That figure concludes that the “factor of safety” (which must be more than 1.0), will be 1.03 apparently for Prof Natawidjaja's "maximum credible" earthquake of .489g. However, if site amplification is taken into consideration, the “factor of safety” for DPM’s proposed TSF would be below 1.0, down to even 0.7 (meaning the dam would be considered highly unsafe). Even lower factors of safety would occur if the dam and tailings quantities were higher than that specified in the EIA. Emerman(2023) has conducted a study of surface storage requirements for the TSF and concluded that the EIA significantly underestimates the volume and height of the required TSF. If this proves to be the case, even lower margins of safety will result.

In addition to lowering the factor of safety, failure to consider amplification also results in an incorrect failure configuration such as the one shown on EIA figure 2.47, part A. Amplified ground motion or loss of foundation bearing capacity due to liquefaction would instead flatten the failure surface in a way that causes sinking of the dam as suggested in the sketch, part B herewith.

In addition to this, other of Natawidjaja’s published work (Natawidjaja 2007) indicates that the DPM TSF would be in an area of “seismic gap” – an area where a large earthquake may be imminent or overdue. This would indicate that an event of at least 0.4g at bedrock will very likely occur in the coming years. Even such an event creating motion of 0.4g at bedrock (so-called Operating basis Earthquake, ANCOLD 2012) would create motion of near 0.6 to 1g at dam level (Ambraseys and Sarma, 1967). With such ground motions at dam level the factor of safety would drop below the required 1.0, to 0.8 or less, and would lead to large deformations in the dam-foundation interface (Newmark, 1965). This would disrupt the dam safety drains, lining, and embankment. These failures would be largely irreparable. Non-repairable failure would violate ANCOLD standards. It would also cause drastic and complete liquefaction of the supporting ash soils, leading to sinking or downstream sliding of the entire dam (with catastrophic impact).

I note here that this potentiality was also likely recognised by Professor David Williams, recognized expert much involved with the ANCOLD standards which DPM claim to adhere to. In his capacity as advisor to the Compliance Advisor Ombudsman in 2022[2], I understand he advised the proposed DPM tailings storage facility was in “extreme” risk category.

This instability I have described now appears to be accepted as fact by DPM. They indicate as a corrective measure they are going to "improve" the weak ash soils in the foundation.

This, however, is a massive and extremely expensive undertaking. My analysis is that it may never actually be carried out.

DPM now claims, without any stated basis, (figure 2.47, extract attached) that unstable ash soil does not extend to depths greater than 16 meters. It may extend deeper, but even 16 m depth, over an area of roughly 100 x 500 m represents 800,000 cubic meters (more than a million tons) of soft volcanic soil that would need to be “improved”. This is more than the volume of the retaining rock fill dam. Removal, replacement, compaction or other form of stabilization of this amount of soil would be in an enormous task and unlikely to be implemented because it would make the project economically infeasible. There is not even any suggestion as to whether this ash *can* be improved by normal recompactive efforts, addition of chemicals, etc. In fact, the EIA Addendum elsewhere indicates that the ash is not suitable for important construction except for road fill because it is "soft volcanic eruption".

If instead the foundation “improvement” is to be accomplished by installation of rock drains as hinted in the EIA Addendum, it is possible to grasp the size of that project by looking at recommendations for rock drain stabilization of coastal sites in Indonesia where the foundation conditions are similar (but probably better than) those that exist at the proposed DPM TSF site. The referenced Anbazhagan 2011 paper shows the difficulty of such a project as understood by Indonesian engineers and supported by Indonesia's Directorate General of Water Resources, Ministry of Public Works. The Ministry report presents, as a best generic approach for stabilizing coastal sites, rock drain spacing in the range of 1 to 3 m apart.

If rock drain spacing in the range of 1 to 3 m was applied to the DPM TSF site, there would be the need to install many thousands of rock drains. It is difficult to believe that DPM could have in mind a foundation and improvement project of this magnitude. It would not be economically feasible. Here it should also be noted that the Toba Tuff volcanic ash at the proposed DPM TSF site would also be more difficult than the coastal sites.

Moreover, if the DPM project is subjected to a design study, as called for by ANCOLD 2012 (Appendix A), the conclusion almost certainly will be that amplified movement of the rock dam, on even the most extensively improved foundation, would still be large enough to destroy underground safety features such as drains and liners.

(Of note here is that DPM also claim to adhere to ANCOLD 2012, whereas this standard has been superseded by ANCOLD 2019, which developed after a string of tailings dams disasters around the world, resulting in the loss of hundreds of lives. ANCOLD 2019 contains more stringent design and transparency requirements, particularly in regard to liquefaction hazard. I pointed this out in my review of the 2021 EIA Addendum, but DPM has not referred to it in their 2022 EIA Addendum.)

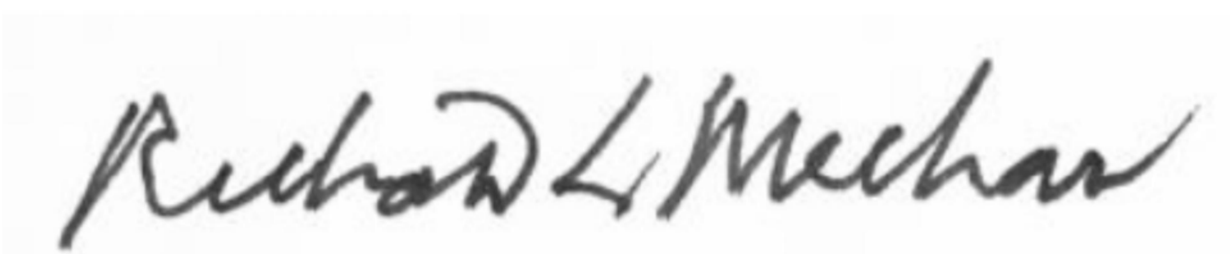
Both ANCOLD 2012 and ANCOLD 2019 standards call for extensive review by independent, third-party experts. It appears that DPM has not set forth any plan for such management of the project. At one point in the EIA DPM claims that the design of the TSF was done by outside consultants, the Knight Piesold firm. My understanding is that Knight Piesold did not design a TSF for the currently proposed site – they were not engaged with DPM after 2008.

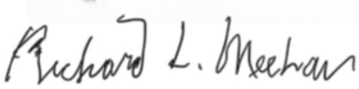
Review of plans by independent third-party experts will eventually necessitate making geological and engineering data from all investigations available.

With all three EIA Addenda there has been a withholding of data, including field test results (field penetration tests, water content, density, shear strength, and shear wave velocity) for the 50 m ash deposits and the overlying 5 m of alluvial soil. Without this data, and necessary laboratory tests as well, and without an extensive review by independent experts of international and independent stature, it cannot be said that ANCOLD standards have been or can be fulfilled. Environmental approval under these conditions can only be regarded as premature.

Thus, the regulators have been presented with an unverified proposal for a tailings storage facility in one of the most difficult and unstable areas of the world. The TSF and dam would be located just above human settlements with no restriction on their likely future expansion[3]. Tailings dam failures/collapses in other parts of the world including recent years have killed hundreds of people and severely polluted farmlands and riverine environments (Jefferies 2021). I see no data-backed findings in the 2022 EIA Addendum that indicate this can be avoided in the case of the DPM tailings storage facility.

In summary, I see that the ANCOLD standards that DPM claim to follow have not been correctly applied. I am confident that oversight of this project by any credible expert or agency will join me in my recommendation that Indonesian Ministry of Environment and Forestry responsibly reverse their Environmental Approval.





Richard L. Meehan
June 15, 2023

footnotes

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1. This safety factor of 1.03 contradicts elsewhere in the EIA Addendum where it is said to be 1.15.
2. https://www.cao-ombudsman.org/sites/default/files/downloads/CAO_Compliance_Appraisal%20Report_PSBC_Indonesia_July_2022_EN.pdf
3. Earlier DPM reports and communications state the mine would expend past the initial reserves.

References

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Biographical note: I was an engineering graduate student of N. Ambraseys at Imperial College in 1966 when he and his student Sarma were carrying out research and writing what became the seminal paper on the behavior of dams in earthquakes. In the 1970s I used these techniques to analyze the seismic behavior of many hydraulic fill dams in California. More advanced approaches to the problem have been developed in the decades since that time, but the A&S paper which can be found here below remains an excellent introduction to the subject for non-specialists. It shows amplification of seismic intensity of as much as 300% for conditions quite similar to those at the Dairi TSF.

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Richard Meehan qualifications

Richard Meehan holds engineering degrees from MIT and Imperial College, University of London, where he developed, under the direction of engineers Norbert Morgenstern and Nicholas Ambraseys, an interest in fluid flow in fractured rock systems and its applications in engineering seismology. In the mid-1960s he formed a California partnership with Douglas Hamilton and has continued to be active in their hundreds of joint consulting projects. In the 1970s he worked with engineer Tom Leps on many safety studies of old hydraulic fill dams in California. Over the past decades, he developed a specialty in safety problems of critical infrastructure facilities including dams, mining waste problems, and flood control levees. He was principal plaintiffs' expert consultant and witness on the California Paterno case, which redefined State responsibility for potentially hazardous public flood control facilities. He represented General Electric as an expert witness in safety hearings in its successful quest to relicense under the Atomic Energy Commission the Vallecitos nuclear reactor facility in Northern California, which had been determined to be exposed to a geologic faulting hazards; Meehan memorialized that controversy in a book, *The Atom and the Fault* (MIT press) published in 1982. He was an adjunct/consulting professor at Stanford University School of Engineering for twenty- five years.