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NSW Department of Planning & Environment
Major Projects Assessment – Hume Coal Project

Attention: Mr. Clay Preshaw

Opinion relating to geochemical impact to the environment by underground placement of washery rejects at the proposed Hume Coal mine, Southern Highlands, NSW

1. Introduction

I have been requested by Coal Free Southern Highlands Inc to provide my opinion relating to geochemical impacts to the environment consequent of the proposal by Hume Coal Pty Ltd to return coal washery rejects to mined-out voids within the proposed coal mine in Southern Highlands of New South Wales.

In preparing my opinion I have referred to the report by Geosyntec Consultants (December 2016), "Hume Coal Project Hydrogeochemical Assessment" (**Geosyntec Report**).

To provide my opinion, I requested a copy of the report by RGS Environmental Pty Ltd (31 March 2016) "Hume Coal Project, Geochemical Assessment of Coal and Mining Waste Materials (Ref. 111232 report R001_A)" (**RSG Report**), which the Geosyntec Report has belied on, but provision of this report was denied by Hume Coal. My inability to critically review the RSG Report has limited the scope and conclusions of my opinion.

Annexure A of my opinion provides my comments relating to questions and responses concerning the impact of groundwater quality from mining operations that are contained on Hume Coal's website (humecoal.com.au). It appears the questions and answers were intended to inform the general public, but in my opinion the responses give rise to uncertainties and are misleading.

2. Comments relating to the Geosyntec Report

Sealing of mined-out voids

The Geosyntec Report described the proposal to place coal washery rejects into mined-out voids, as follows "Once sufficient mine void space is available, mine reject material will be pumped directly from the CPP [coal processing plant] into the underground mined-out voids for final emplacement, avoiding the requirement for long-term surface storage or disposal of reject material. The reject material will be pumped into completed mine panels, which will be sealed with bulkheads and allowed to backfill with natural groundwater".

I understand the mined-out voids would be "sealed" by a bulkhead from the floor to the roof and that the floor and roof, themselves, would not be sealed.

The Geosyntec Report did not refer to evidence that the filled voids would remain sealed in the long-term.

Fracturing of Hawkesbury Sandstone

I understand that the method proposed for mining has been claimed to not give rise to significant caving of overlying Hawkesbury Sandstone so as not to result in significant change to the surface topography. However, because fracturing and caving, even if confined to relatively small areas above the mined-out voids, is of critical importance to the flow of groundwater into and out of the mined-out voids. In my opinion the Geosyntec Report should have addressed this matter.

In my opinion, release of stresses in the basal Hawkesbury Sandstone above mined-out voids would cause at least some caving and increased fracturing, which would result in an increase in the volume of groundwater migrating into the filled mined-out voids and into mine workings and subsequent contamination of groundwater, some which is expected to discharge into local surface water bodies.

The Geosyntec Report did not refer to the impact fracturing of basal Hawkesbury Sandstone would to the volume of groundwater that may enter and subsequently migrate from the mined-out voids.

Leaching tests

The Geosyntec Report relied on results of kinetic leach column (**KLC**) tests documented in the RGS Report to assess the impact of "…changes to groundwater quality resulting from groundwater flow through washery rejects backfilled in the mined-out voids and transport of derived solutes downgradient from the backfilled workings".

Given the potential for long-term contamination of groundwater from washery rejects in the mined-out voids and the potential impact to groundwater that discharges to local surface water bodies, together with the high level of concern expressed by local residents, it is my opinion that the Geosyntec Report should have critically assessed the reliability of the KLC results reported by RGS and should have expressed an opinion of the reliability of the tests to predict leaching characteristics in the long-term.

Although KLC tests and other leaching tests have been widely used to assess leaching characteristics of many waste types, the United States Environment Protection Authority (**USEPA)** concluded that commonly used leaching tests do not reliably estimate the leaching characteristics of many wastes in the long-term because these tests are unable to predict leaching behaviour over the wide range of potential disposal scenarios that are subject to diverse chemical and hydraulic conditions, which may change over time.

In 2014, the USEPA published "Leaching Test Relationships, Laboratory-to-Field Comparisons and Recommendations for Leaching Evaluation using the Leaching Environmental Assessment Framework (**LEAF**)", which recommended the LEAF testing procedure be employed to more reliably assess the leaching characteristics of waste materials in the long-term. The LEAF process uses a combination of up to four test methods and interpretation protocols to provide an integrated approach for evaluating leaching behaviour of materials using a tiered approach that considers pH, liquid-to-solid ratio (L/S) and waste from properties across a range of plausible field conditions and allows more reliable assessment of long-term leaching to be made.

In 2015 the Western Australia Department Environment Regulation endorsed use of the LEAF procedure in the "Background paper on the use of leaching tests for assessing the disposal and re-use of waste-derived materials" because "The main limitation of the procedures that are currently used is that they only provide representative leaching data for the two or three pH values under which the tests are carried out, and therefore may not provide information on the long-term leaching behavior of the material being tested under a range of conditions" and "Additionally, the tests are biased for acidic conditions which may give conservative values of leaching potential for chemical constituents present as cations in solution, but which also may greatly underestimate the concentrations of anionic substances under neutral to alkaline pH conditions".

Section 6.2.1 of the Geosyntec Report stated "The geochemical testing results (specifically, KLC testing) reported by RGS (2016) using representative samples of reject material and groundwater for leaching", but no confirmation was provided that the samples subjected to leach testing were representative of the large volume of coal that would ultimately produce washery rejects, which could have significantly different characteristics from batch-to-batch.

Section 6.2.2 "Assessment Methodology and Assumptions" of the Geosyntec Report stated that two leaching columns were used, one containing fine reject material and the other containing fine reject material mixed with limestone. The reject materials were leached with groundwater obtained from the WWS [Wongawilli Coal Seam] from which leachate was obtained for chemical analysis on a monthly basis for a period of six months.

Table 6.1 of the Geosyntec Report presented results of leach tests for only two samples, KLC 22 and KLC 24, and did not state whether the two samples of the washery rejects tested were the only samples tested or whether they were the two samples that presented the most favourable results. In any event, inspection of Table 6.1 indicated sample KLC 22 after leaching limestone amended washery reject still reported maximum concentrations of metals that exceeded the trigger values for protection of 95 % of freshwater aquatic species listed in the Water Quality Guidelines by aluminium (exceeded the trigger value by a factor of 2.5), cadmium (exceeded the trigger value by a factor of 65), copper (exceeded the trigger value by a factor of 2), manganese (exceeded the trigger value by a factor of 2), nickel (exceeded the trigger value by a factor of 23) and zinc (exceeded the trigger value by a factor of 78).

In my opinion, in the absence of the Geosyntec Report not assessing the reliability of the KLC tests to predict the long-term impacts to groundwater quality, significant uncertainty remains whether the washery rejects placed in the mined-out voids can be contained so as nit to contaminate groundwater.

Recommended groundwater monitoring program

Section 7.4 of the Geosyntec Report recommended that "…the baseline groundwater monitoring program should continue during the operation of the mine, and for sufficient time during the post-closure period to confirm the efficacy of the limestone amendment in mitigating acid and metals mobilisation from the emplaced reject material" and that the full monitoring network continues to be used and sampling be conducted on a quarterly basis.

The analytical suite is adequate, but the Geosyntec Report did not set out the methodologies and quality control procedures to be employed in collection, measurement of physical parameters on-site and chemical analyses of groundwater samples in assessing whether mining and emplacement of washery rejects has impacted the quality of groundwater.

In my opinion, the large number of bores that will be sampled and the large amount of physical and chemical data that will be generated are required to assessed by a rigorous method, such use of specific statistical procedure/s or use of control charts to reliably distinguish impact by mining operations from natural variations in groundwater parameters.

In my opinion, the Geosyntec Report should have set out the method/s and procedures, including quality control procedures, that will be employed to identify changes in the quality of groundwater and surface water so that impacts by mining can be confidently identified at the earliest opportunity.

Summary opinion relating to the Geosyntec Report

Overall, I expected the Geosyntec Report to have addressed all relevant issues relating to potential contamination of groundwater by washery rejects being placed into mined-out voids. However, the Geosyntec Report contained significant omissions that give rise to uncertainties relating to:

- Whether the KLC method was suitable for assessing the long-term to predict leaching characteristics of washery rejects in the long-term.

- Whether the number of washery rejects used for the leach tests by RGS were representative of the large volume of washery rejects that were proposed to be emplaced in the mined-out voids over the life of the mine.

  It seems improbable that KLC testing of only the two samples of washery rejects, which were referred to in the Geosyntec Report, were subject to KLC tests, but the Geosyntec Report did not address this matter.

- Whether the results of the chemical analyses of leachate from the washery rejects used for the KLC tests were reliable.

  Because the proposed mining and waste storage project poses significant potential environmental and social risks, it was expected that the Geosyntec Report would have assessed the reliability of the results reported by RGS in terms of the quality control parameters of precision, accuracy, representativeness, completeness and comparability and whether duplicate water samples were analysed for quality control purposes by the primary laboratory and whether triplicate water samples were analysed in a second commercial laboratory accredited by NATA, as is required for all reliable groundwater assessment programs.

  In addition, the Geosyntec Report did not address the use of more reliable leach tests, such as the LEAF process, which would have provided more representative results relating to the long-term leaching characteristics under a range of conditions.

- Whether the sealing of the filled mining voids could be accomplished by installation of bulkheads that would remain sealed in the long-term and, if leakage occurred, the impact that this would have on groundwater quality and to local water bodies in the long-term.

- Whether the effectiveness of the limestone amendment of the washery rejects was sufficient to maintain elevated pH conditions within the filled voids in the long-term or whether the limestone would become "spent" and result in lower pH conditions in the filled voids, which are favourable to mobilisation of many metals.

It is my experience that selection of a reliable method to control leaching of potential contaminants from waste materials exposed to groundwater in the long-term requires consideration of:

- The rate of flow of groundwater through the materials;
- The range of pH expected in groundwater within the waste materials;
- The reduction/oxidation conditions expected in the waste materials;
- The potential for new bacterial colonies to be established in response to change in groundwater characteristics and their impact to leaching of waste materials;
- The concentrations and variability of sulphur sources, particularly pyrite and any other sulfide minerals; and
- The quantity and physical conditions of amendments to control pH (e.g. as proposed, the addition of limestone).

3. Summary opinion

A number of uncertainties of critical significance with respect to impact to groundwater and potentially to surface water bodies into which groundwater discharges have been identified in relation to placement of washery rejects into mined-out voids.

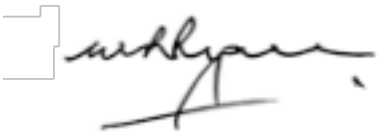
The uncertainties are required to be addressed before the mining plan can be finalised. In particular, I recommend that the following issues be addressed by an independent assessment of the following:

- Results of LEAF tests carried out on a range of washery rejects that are representative of rejects produced over the life of the mine and on rejects that have been amended by addition of a range of concentrations of fine-grained limestone;
- The extent of caving and fracturing that would occur in Hawkesbury Sandstone overlying the mined-out voids and the extent of fracturing that would occur in unmined coal adjacent to the mined-out voids;
- The integrity of the bulkheads in the long-term to prevent migration of contaminated water from the placed washery rejects;
- A revised hydrogeological model addressing contamination of groundwater and surface water by washery rejects be prepared in consideration of the results of the above; and
- A revised groundwater and surface water monitoring program if warranted by the results of the above.

My opinion has been based on review of the Geosyntec Report. If other reports are made available relating to impact to groundwater quality by washery rejects, I would be pleased to review the reports and to update my opinion.

If required, I would be pleased to provide a more detailed opinion following guidance provided by NSW Environment Protection Authority for review of reports by environmental consultants.

Yours faithfully



Bill Ryall
Director

Annexure A

Relevant extracts from Hume Coal's website

Hume Coal's website posed a number of questions and provided responses relating *inter alia* to impact of groundwater quality, as set out below.

Question 1

"What monitoring will be done?"

"Hume Coal has a comprehensive monitoring network for both surface and groundwater systems that has been in place for more than three years. We will continue to monitor this network into the future. Should approval to mine be granted, part of this approval would involve very strict environmental monitoring conditions that will require groundwater sampling and laboratory analysis on a regular basis. Frequency of monitoring will vary across surface and groundwater systems, with water levels requiring 6 or 12 hourly monitoring, while groundwater quality monitoring may be monthly or quarterly. The laboratories undertaking this work will be NATA Accredited (National Association of Testing Authorities Accreditation) and will undertake all work to ISO standards. Results from this sampling will be reported to the State Government and checked against all relevant water quality parameters, and agreed trigger levels".

Question 2

"*Will the underground emplacement of the reject material impact groundwater quality?"*

"The rock and stone returned back underground is essentially the parts of the coal seam and associated rock that we have to mine, but we don't want or need. It will be put back where it originated from in the coal seam, typically within hours or days of being mined. The material being emplaced is the natural rock and stone that was originally there. The process is carefully monitored to ensure that the material being placed back underground remains neutral and benign in the long term. This may include adding a natural substance like limestone to make sure the material stays neutral. We have done many short term and long term geochemical tests to ensure that the material being placed underground is benign and will remain so into the future".

Question 3

"What happens to the groundwater once coal is extracted?"

"After the coal is extracted, the unused portion of rock and stone material (commonly referred to as 'reject material') is replaced underground. Mining will occur in panels, and once a panel is mined it will be sealed up, and will gradually fill with water. After the panel is completely filled with water, the groundwater levels immediately above and adjacent to this area will immediately begin to recover to pre-mining levels. This recovery will be relatively fast compared to other mining systems and projects".

Question 4

"Will the region's water be impacted by the proposed project?"

"Hume Coal has designed a mine plan that will have no long-term negative impact on water resources. Water within the surface and groundwater resources of the Southern Highlands will remain available and the groundwater system will remain undamaged for future generations. The project will use water within sustainable limits under licence during mining from both surface and groundwater. There will be no impact on town water supplies".

Comments relating to Hume Coal's responses

Comments relating to Hume Coal's response to Question 1

With respect to Hume Coal's position as set out on their website, it is clear that extensive monitoring of groundwater quality is proposed to be undertaken prior to mining operations and "into the future", but the timeframe and extent of monitoring was addressed in section 7.4 "Recommended Monitoring Program", which "…recommended that the baseline groundwater monitoring program should continue during the operation of the mine, and for sufficient time during the post-closure period to confirm the efficacy of the limestone amendment in mitigating acid and metals mobilisation from the emplaced reject material".

However, neither the Hume Coal website nor the Geosyntec Report addressed the process that would be employed to identify whether significant impact to groundwater quality has occurred and the actions that would be taken if contamination of groundwater was identified by the monitoring program to pose an unacceptable risk to the environment or to human health. In my opinion, this issue raises another uncertainty that is required to be addressed prior to finalisation of the mining plan.

Comments relating to Hume Coal's response to Question 2

Hume Coal's position relating to washery rejects that will be used to fill mining voids stated the rejects will comprise "The rock and stone returned back underground is essentially the parts of the coal seam and associated rock that we have to mine, but we don't want or need" and that "The material being emplaced is the natural rock and stone that was originally there that are present in the coal seams prior to mining".

In my opinion, Hume Coals' description of the washery rejects is misleading because the washery rejects almost certainly will not comprise principally "natural rock and stone" in the natural condition these materials were in prior to mining. The washery rejects will comprise fine-grained coal and fine-grained crushed rock, the latter of which comprise alumino-silicate minerals (e.g. clays), other silica minerals, iron sulfides (e.g. pyrite) and iron/manganese oxides and carbonates (e.g. siderite), together with some coarser-grained rock fragments.

The fine-grained nature of the crushed coal and rock gives rise to very large surface areas of the reject materials, which in some reduction/oxidation and pH conditions provide increased solubility of metals and metalloids, and in some conditions provide decreased solubility of metals and metalloids, which are captured by strong surface forces. These effects were not addressed in the Geosyntec Report.

In my opinion, well in advance of commencement of mining, it is of critical importance to have a good understanding of the physical, mineralogical and chemical characteristics of the washery rejects that are proposed to be placed into the mined-out voids and of the leaching characteristics in the long-term.

In my opinion, there is the requirement for testing of a large number of samples representative of the likely range of washery rejects using methods that gives confidence that unacceptable concentrations of contaminants will not be leached from reject materials in the mined-out voids in the long-term.

In addition, the effectiveness of the fine-grained limestone that was proposed to be added to the washery rejects was stated in the Geosyntec Report to have been tested using column leaching each month over a 6 month period. The Geosyntec Report did not comment on the concentration or physical characteristics of the limestone amendment. In addition, the limited time of testing does not provide confidence that the limestone amendment would be effective in the long-term.

Comments relating to Hume Coal's response to Question 3

With respect to Hume Coal's position "After the panel is completely filled with water, the groundwater levels immediately above and adjacent to this area will immediately begin to recover to pre-mining levels. This recovery will be relatively fast compared to other mining systems and projects".

In my opinion, no justification has been provided that groundwater will "recover to pre-mining levels" and that the recovery will be "relatively fast" because mining-induced fracturing will result in increased permeability within basal Hawkesbury Sandstone and within unmined sections of the coal seams that will provide new, higher permeability pathways for migration of groundwater.

Comments relating to Hume Coal's response to Question 4

With respect to Hume Coal's position that "Hume Coal has designed a mine plan that will have no long-term negative impact on water resources. Water within the surface and groundwater resources of the Southern Highlands will remain available and the groundwater system will remain undamaged for future generations", in my opinion, there are uncertainties that the quality of groundwater will not be impacted adversely in the long-term because reliable predictions of long-term impact to groundwater cannot be arrived at in consideration of the results of leaching tests addressed in the Geosyntec Report, which did not consider the following potential long-term impacts:

- The reliability of the results of leaching tests;
- Changes in characteristics of leachate from washery rejects if the composition of the rejects changes;
- The effectiveness of sealing the washery rejects;
- The effect of fracturing of basal Hawkesbury Sandstone and unmined coal measures, which would give rise to large volumes of groundwater being contaminated by contact with the washery rejects; and
- The impact the quality groundwater has to the environment, both within the basal Hawkesbury Sandstone and the coal measures, and to human health and the environment within surface water bodies into which groundwater discharges.