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1. Introduction

This report has been written in response to a request for expert advice from EDO NSW, acting on behalf of the Belubula Headwaters Protection Group, in relation to the proposed McPhillamys Gold Project. I have been asked to address the following issues in regards to any hydrological impacts arising as a result of the Project.

a) In your opinion, was the assessment of environmental impacts, as far as it relates to your areas of expertise, appropriate and sufficient?
b) What, if any, concerns do you have about the environmental impacts of the Project, bearing in mind the mitigation measures proposed?
c) Provide any further observations or opinions which you consider to be relevant.

The advice given here is confined to the areas relevant to the project where the writer has expertise. These are principally in the field of engineering and environmental hydrology, especially how soil and topographic properties determine water pathways and rates of flow in catchment soils and in landscapes. A brief statement of my qualifications and experience relevant to this advice is given at the end of this report.

In writing this report, I declare that I have read the Expert Witness Code of Conduct in Schedule 7 of the *Uniform Civil Procedure Rules 2005* and agree to be bound by it.

I have read and considered the following Project documents:

McPhillamys EIS Executive Summary;

Appendix D – TSF Definitive Feasibility Study;

Appendix F – TSF Risk Assessment;

Appendix J – Surface Water;

Appendix K – Groundwater;

Appendix R – Mine Preliminary Hazard Analysis; and

Appendix X – Water Pipeline.

I have also consulted, as necessary, with relevant publications of Australian National Committee on Large Dams (ANCOLD), the Dams Safety Committee of NSW, and the Department of Industry; these are listed in Section 1.3, Appendix D of the Project EIS.

2. General

Of particular concern in this project is the possibility of contaminating the upper catchment and watercourse of the Belubula River with toxic water from the Tailings Storage Facility (TSF). This may occur via seepage (most likely) or from TSF water that spills over the engineered embankment during rare storms. There is a third possibility, better described as catastrophic, where the TSF embankment itself fails.

Four recent instances of this occurring are at the nearby Cadia mine operated by Newcrest, at two BHP/Vale-owned tailings dams in Brazil, and at the Mount Polley mine in Canada. In each of these cases, seepage in one guise or another has been implicated.

This report gives comments on how the EIS considers (a) seepage and (b) TSF spillway overflow.

They relate to the short and long-term impacts on the river downstream from the project.

3. Seepage

Of all the background documents quoted in the EIS and its appendices, the most relevant is Tailings Management (DoI, 2016). This document, as well as the EIS, identifies seepage as the factor that determines whether leakage into the watercourse will occur.

Natural seepage at the project site occurs through the various soil horizons, the weathered rock, and through the basement rock strata. It is driven by gradients that are similar to the local topographic gradients. Almost all subsurface flow would be expected to occur at fairly shallow depth, in the top metre or two of the soil regolith, where hydraulic conductivities (Ks) are highest.

In order to comply with the EPA Guideline for Solid Waste Landfills, the EIS proposes to employ a clay lining over the entire storage floor area, with performance equivalent to a 1,000 mm blanket with Ks of 1.0E-09 m/s. The purpose of the lining is to reduce seepage through the base of the TSF storage area to a negligible amount. It is proposed that the lining be constructed using the in-situ surface soil after removing vegetation and root material larger than 25mm, then ripping, moisture conditioning and compacting the top 300mm of the soil regolith to achieve a maximum Ks of 3.0E-10 m/s, thus satisfying the EPA requirement.

In my opinion, it can not be assumed that such a fabricated clay liner will remain unbroken. It is likely to be multiply-pierced during or after construction, mechanically or by fauna, making it ineffective as a seepage barrier. Seepage analyses in the EIS should therefore be done using the scenario of no effective clay liner. This requires close examination of the hydraulic properties of the soil regolith, which becomes the significant determinant of seepage from the TSF.

The EIS (Appendix D) describes a broad program of in-situ measurements of Ks in the soil regolith at the TSF storage site using the Talsma-Hallam constant-head permeameter method. As I would expect, these give values for Ks that are spread over a thousand-fold range (Table 11, App D) and include six values (out of 30) of about 1.0E-05 m/s. However, the subsequent seepage calculations, eg Section 7 App D, use Ks values of 5.0E-08 m/s for the soil, and 1.0E-08 m/s for the saprock. Comparing the Ks values used for the seepage calculation with the values actually measured, they are obviously too low.

The calculated seepage quantities and velocities, using Darcy's Law, are therefore also too low, by a factor of up to one thousand. For example, Plate 31 states that in the saprock, *peak groundwater flow (takes) 20 years to travel 10 metres*; a more realistic estimate would be 1,000 to 10,000 metres. This flow would re-surface downstream into the bed and banks of the Belubula river well before travelling this distance. And it follows that because the groundwater flow velocity has been grossly under-estimated, the volume of seepage liquid that reaches the drainage system beneath the TSF embankment has also been under-estimated in the EIS by a factor of more than 100.

It may be that the high seepage rates described above may take several years to develop. But because the hydraulic gradient within the soil regolith will be permanently much greater than it was under natural conditions (ie, before the static water head increased from zero to about 40 metres), it is my opinion that preferred pathways for subsurface flow will develop with time, by micro-erosion in macropores, such that seepage rates will increase rather than diminish. It is not possible to predict how rapidly this will occur. It may be within the life of the mine and/or after mine closure. In any case, in my opinion and based on my experience with smaller flow-measuring weirs, it is very likely.

The consequences of time-increasing rates of seepage will be observable not only at the sump pond below the embankment wall, but also in the stream bed and banks further downstream. The mine operators, during and after the mine's life, should ensure that this contaminated water is also captured and appropriately treated. It is not clear from the EIS that this will be done, apart from immediately downstream from the embankment.

4. TSF Spillway Overflow

If a storm event occurs such that the TSF storage fills and overflows via the engineered spillway, then contaminated water will flow into the Belubula river. (The NSW Dams Safety Committee (DSC) requires that such an engineered spillway must be incorporated into the embankment.) But the EIS does not consider the frequency of such overflow events. In my opinion, this is a major omission in the EIS documents.

The EIS adopts the recommendations of the DSC in selecting hydrologic design parameters for the TSF emergency spillway, and the clean water interception storages around the TSF. The hydrologic analyses that underpin these designs are well established, and for this project, they have been used appropriately in the EIS.

However, it is my opinion that the criteria for TSF embankment design are not sufficient, because the plans do not provide for an emergency overflow dam which is kept empty during normal operations. Notwithstanding the risk assessment done for this Project (App F of EIS), the main concern of the DSC is to ensure the integrity of the embankment itself, ie, to ensure that it does not fail under the storm conditions that DSC says it should be designed for. In order to ensure that any embankment does not fail by overtopping and subsequent catastrophic embankment erosion, DSC requires that the TSF must incorporate a spillway that will safely pass the design flood. This has been done for this Project.

But the DSC has nothing to say about smaller storms that pose no threat to the safety of the TSF embankment, but which are large enough to fill the TSF such that some flows over the spillway occur. Although the toxicity of such overflows will be diluted by rainfall, the impact on water quality downstream will be potentially very serious and should be assessed, if not avoided altogether.

Methods do exist for simulating the time-behaviour of water in a storage such as this TSF, given a sequence of inputs and outputs using historic meteorologic data and operational water use patterns within the mine. These can be used to simulate the TSF storage behaviour, and provide some insight on whether and by how much the TSF will spill into the Belubula river.

The Victorian Government provides detailed guidelines for the management of Tailings. The aim of the Guidelines is "*to encourage the adoption of the best industry standards and practice in tailings management and to minimise the cost of the operations to current and future generations*". The Victorian guidelines require that a TSF spillway should lead to an emergency overflow dam, kept empty during normal operations, as described above. The Proponent has not included this fail-safe feature in the project. NSW guidelines may not specify an emergency overflow dam, but such a structure would improve environmental protection downstream.

Section 3.4.2 of App D, EIS, states that "*For the purpose of this report, three stages of development are proposed, but further sub-stages may be undertaken*".

The preferred location of the TSF, shown for example in Plate 11, App D, gives no room for downstream enlargement. It is difficult to see how an extra sub-stage can be added to the TSF embankment at the project site without major alterations to all the other water infrastructure. It may well be that re-consideration of a stepped TSF could solve this problem, and at the same time provide the emergency overflow dam described above.

5. Brief Curriculum Vitae

Qualifications: B.E. (Hons), M. Eng. Sci (NSW), Ph.D. (Iowa)

Professional and Research Experience:
I have 46 years experience in investigations and research in State and Commonwealth government agencies and universities, including 7 years in the USA. I was employed by CSIRO from 1970, and attained the most senior scientific position in that organisation, Chief Research Scientist. Since 1982, I led CSIRO's research program in forest hydrology. In 1991, I led the successful bid for the formation of the Cooperative Research Centre for Catchment Hydrology, and was appointed its founding Director.

My research led to practical procedures to predict how natural landscapes respond to changes in vegetation cover and land use. My theoretical and field work has shown how soil, terrain and vegetation affect water balance and water quality in landscapes. I developed methods for predicting a broad range of hydrologic effects that could result from a change in land use or disturbance.

Since retiring from CSIRO in 1995, I have been engaged in consultation for industry and government, with emphasis on solving water and land management problems caused by disturbance such as mining or vegetation disturbance. I have collaborated with Local, State and Federal government agencies and industry as a consultant, researcher, reviewer and “honest broker” in matters dealing with land and water management.

I have published over 140 refereed journal papers and book chapters, and edited four books. Since retirement from CSIRO, I have produced about 40 consultancy reports for various clients, and continued to contribute to the research literature.

Emmett M. O'Loughlin

23 October 2019.