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Memorandum

20 January 2023

To: Andrew Wannan

From: James Tuff

Subject: McPhillamys Gold Project - Tailings storage facility salinity modelling

Dear Andrew,

This memorandum presents the results of geochemical modelling that was conducted to predict levels of salinity in the tailings storage facility (TSF) proposed as part of the McPhillamys Gold Project over a ten-year period of simulated tailings deposition (2022 to 2032). The methods and results are described below.

1 Model methods

Modelling was based on the site-wide water balance developed in GoldSim and provided by Regis Resources Limited (Regis). Water quality predictions were calculated in the hydrochemical software, PHREEQC ('PH-REdox-EQuilibria-(in)C')[1], which is recognised as an industry-standard tool for predictive water quality. The water balance inputs and outputs to the TSF were assigned water quality values from previous campaigns of laboratory testing and geochemical reporting[2]; these were mixed in PHREEQC based on their relative proportions from the water balance to predict the TSF water quality.

1.1 Water quality inputs

Conceptually and based on the water balance, the TSF was modelled as a reservoir with the following inputs and outputs:

- Inputs:
  - Runoff water into the TSF.
  - Direct rainfall on the TSF.
  - Tailings water introduced when tailings is deposited (tailings 'bleed' water).

1 https://www.usgs.gov/software/phreeqc-version-3

2 SRK (2019). McPhillamys Gold Project: Geochemical Characterisation. Report prepared for Regis Resources Limited

- Outputs:
  - Tailings pond evaporation.
  - Tailings beach evaporation.
  - TSF pumping (wholesale removal of the tailings water for use around site).

This is shown schematically in Figure 1.

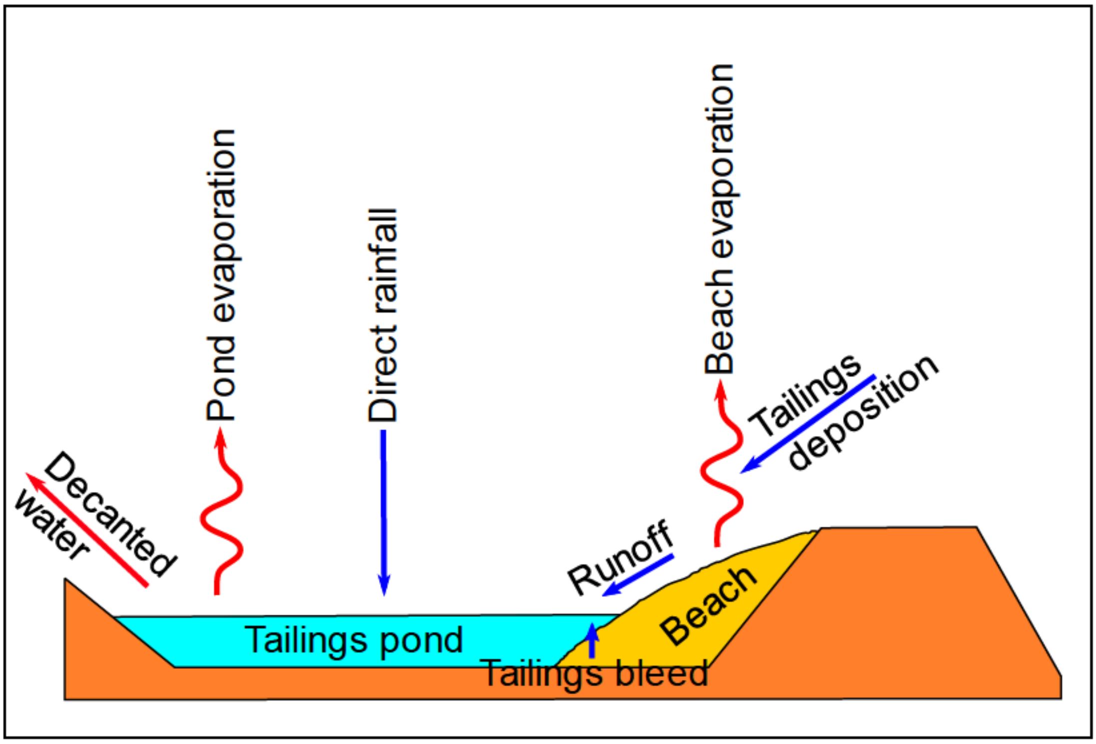

Figure 1 Schematic of the TSF inputs and outputs

Of the above inputs and outputs, water quality representing direct rainfall and evaporation was modelled as the addition/removal of clean (pure) water. Water qualities representing runoff, tailings bleed, and TSF pumping water were selected as follows:

i Runoff water quality

Runoff water quality was modelled from leachate test results on three samples representing the potential weathered states of the tailings (oxidised, transitional, and fresh). These samples were chosen to represent the runoff water quality because they demonstrated an adequate range in composition that may be expected as fresh tailings is deposited and subsequently weathers, thus providing the model with an inherent range of weathered-state conditions. All three tailings samples were identified as potentially acid forming (PAF), with sulfur concentrations ranging from ~ 1.7 to ~ 5.3 % and electrical conductivities between ~ 230 and 1070 µS/cm[3].

[3] SRK (2019). McPhillamys Gold Project: Geochemical Characterisation. Report prepared for Regis Resources Limited

ii Tailings bleed water quality

The tailings samples were supplied to SRK as slurries; in each case the tailings supernatant/tailings liquor was analysed by SRK for water quality. The modelled tailings bleed water quality inputs were derived from the oxide, transition, and fresh tailings liquors, as representatives of the water quality associated with tailings deposition.

iii TSF pumping water quality

As wholesale removal of TSF water, the pumped water quality was modelled as the resultant water quality following each step-wise addition and removal of water based on the water balance. As a result, this water quality varied at each modelled calculation step.

iv Summary of input water quality

Table 1 shows the water quality input concentrations used in the PHREEQC modelling.

Table 1 PHREEQC model water quality inputs

PHREEQC SOLUTION #		1			2	3			4	5	6+
Description		Runoff[1]			Direct Rainfall	Tailings[1] bleed			Pond evaporation	Beach evaporation	TSF pumped water
Parameter	Units	Oxide	Transition	Fresh		Oxide	Transition	Fresh			
pH	—	6.8	7.7	7.5	6.5	6.8	7.7	7.5	6.5	6.5	Water quality calculated at each model step – ie the 'resultant water quality', which is then removed as directed by the water balance
EC	µS/cm	45	91	565	—	45	91	565	—	—	
SO_4	mg/L	7	23	235	—	258	396	628	—	—	
Cl	mg/L	2	3	16	—	446	436	609	—	—	
F	mg/L	0.3	0.1	0.1	—	0.3	0.1	0.1	—	—	
Ag	mg/L	0.001	0.001	0.001	—	0.07	0.06	0.07	—	—	
Al	mg/L	0.23	0.49	0.01	—	4.9	7.1	2	—	—	
As	mg/L	0.011	0.01	0.001	—	0.072	0.089	0.61	—	—	
B	mg/L	0.05	0.05	0.05	—	0.05	0.05	0.05	—	—	
Ba	mg/L	0.002	0.001	0.025	—	0.006	0.005	0.011	—	—	
Be	mg/L	0.001	0.001	0.001	—	0.001	0.001	0.001	—	—	
Ca	mg/L	3	13	99	—	2	5	12	—	—	
Cd	mg/L	0.0001	0.0001	0.0002	—	0.05	0.023	0.021	—	—	
Co	mg/L	0.001	0.001	0.002	—	0.05	0.06	0.004	—	—	
Cr	mg/L	0.001	0.001	0.001	—	0.005	0.001	0.001	—	—	
Cu	mg/L	0.001	0.001	0.001	—	76.6	59.9	57.2	—	—	

Table 1 PHREEQC model water quality inputs

PHREEQC SOLUTION #		1			2	3			4	5	6+
Description		**Runoff[1]**			**Direct Rainfall**	**Tailings[1] bleed**			**Pond evaporation**	**Beach evaporation**	**TSF pumped water**
Parameter	**Units**	**Oxide**	**Transition**	**Fresh**		**Oxide**	**Transition**	**Fresh**			
Fe	mg/L	0.06	0.05	0.05	—	0.5	1	4	—	—	
Hg	mg/L	0.0001	0.0001	0.0001	—	0.0001	0.0001	0.0001	—	—	
K	mg/L	1	1	1	—	5	17	14	—	—	
Mg	mg/L	1	1	7	—	1	1	1	—	—	
Mn	mg/L	0.001	0.009	2.2	—	0.009	0.006	0.009	—	—	
Mo	mg/L	0.001	0.001	0.001	—	0.017	0.017	0.022	—	—	
Na	mg/L	3	1	1	—	365	436	440	—	—	
Ni	mg/L	0.001	0.001	0.001	—	0.23	0.16	0.2	—	—	
Pb	mg/L	0.001	0.001	0.001	—	0.016	0.011	0.003	—	—	
Sb	mg/L	0.001	0.002	0.002	—	0.02	0.03	0.1	—	—	
Se	mg/L	0.01	0.01	0.01	—	0.04	0.04	0.1	—	—	
Sn	mg/L	0.001	0.001	0.001	—	0.001	0.001	0.001	—	—	
Sr	mg/L	0.002	0.018	0.63	—	0.07	0.08	0.24	—	—	
Tl	mg/L	0.001	0.001	0.001	—	0.001	0.001	0.001	—	—	
U	mg/L	0.001	0.001	0.001	—	0.001	0.001	0.001	—	—	
V	mg/L	0.01	0.01	0.01	—	0.04	0.04	0.02	—	—	

Table 1 PHREEQC model water quality inputs

PHREEQC SOLUTION #		1			2	3			4	5	6+
Description		**Runoff[1]**			**Direct Rainfall**	**Tailings[1] bleed**			**Pond evaporation**	**Beach evaporation**	**TSF pumped water**
Parameter	**Units**	**Oxide**	**Transition**	**Fresh**		**Oxide**	**Transition**	**Fresh**			
Zn	mg/L	0.005	0.005	0.005	—	4.5	7.3	11.4	—	—	

1. Water quality from SRK (2019). McPhillamys Gold Project: Geochemical Characterisation. Report prepared for Regis Resources Limited

1.2 PHREEQC modelling

The water quality model was developed in the hydrochemical software, PHREEQC, using the Minteq.v4 database, which contains thermodynamic data for over 1,500 potential dissolved species and ~ 800 potential precipitates[4] . The primary model commands used were:

- Water quality inputs as defined by the SOLUTION code block.
- The MIX code block was used to calculate the exchange between the inputs and outputs defined in the GoldSim water balance model.
- Precipitates and gas species in equilibrium with each solution were defined using the EQUILIBRIUM_PHASES code block.

Each model step calculated the water quality resulting from mixing the inputs to and outputs from the initial TSF water quality. This resultant water quality was then used as the 'initial' water quality for the next model step and mixed with the inputs and outputs at this step based on the volumes predicted in the water balance model. The resultant mixes charted the development of the pit water quality over the simulation runs.

The assigned water qualities are shown in Table 1; each water quality was defined in the SOLUTION code block in PHREEQC.

Alkalinity was calculated based on the prevailing water compositions, pH and partial pressure of CO_2, as defined by the equilibria within the PHREEQC databases. Equilibrium with atmospheric O_2 and CO_2 was maintained with dissolved gas concentrations based on Henry's Law:

$$C_i = {}^{P_i}/_{H_i}$$

where the concentration (*C)* of dissolved species *i* in the solution (O_2 and CO_2 in the model) is equal to the partial pressure (*P)* of species *i* in equilibrium in the atmosphere above the solution divided by the Henry's constant (*H*) for that species in water. With *C* in moles per litre (mol/L) and *P* in atmospheres (atm), the constants are 770 Latm/mol for O_2 and 29 Latm/mol for CO_2[5].

Chloride analyses were used to check the ionic balance. Variations in the partial pressure of CO_2 and chloride charge balance were used to test model sensitivity and simulate the effect of equilibrium and redox conditions (ie a well-mixed, aerated TSF versus a poorly mixed, anoxic TSF) on the resultant predicted water quality.

[4] Parkhurst, D.L., and Appelo, C.A.J. (2013). Description of input and examples for PHREEQC version 3 – A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. U.S. Geological Survey Techniques and Methods, book 6, A43, 497p

[5] Sander, R. (2015). Compilation of Henry's law constants (version 4.0) for water as solvent. Atmospheric Chemistry and Physics, 15, 4399-4981

2 Water quality results

2.1 Scenarios

Initial modelling was conducted based on the geochemistry of tailings samples described by SRK as potential representatives of tailings feeds. A further set of modelling scenarios was then conducted to account for the use of higher salinity process water in the tailings stream (ie water from the pipeline development). As reported in the Submissions Report (EMM 2020), the quality of water to be sourced and pumped to the mine site from Centennial's Angus Place, Springvale Coal Services and Mount Piper Power Station currently ranges from around 600 mg/L TDS to 7,000 mg/L, with a likely average of approximately 3,500 mg/L. Scenarios were therefore run using both the expected average and maximum TDS.

Section 1.2.2 details the TSF water quality modelling results of the initial ('base case') modelling on the SRK tailings samples; Section 1.2.3 describes the additional higher TDS process water model results.

2.2 Base case models

Figure 2 shows the simulated salinity, represented as total dissolved solids (TDS), for the model scenarios investigating the effects of oxidised, transitional, and fresh tailings on the TSF water quality. As Figure 2 shows, TDS increases during the initial period of tailings deposition but then plateaus as the TSF varies around its operating volume (Figure 3). As expected, the fresh tailings provide the highest salinity input, whereas the oxidised tailings input the lowest load to the TSF. All scenarios show that the TSF is expected to have relatively low salinity, with levels similar to freshwater (≤ 1,000 mg/L TDS), or slightly brackish water (≥ 1,000 mg/L TDS). Note that the drop in values shown in Figure 2 in 2029 corresponds to a large, modelled influx of rainfall (ie a large input of clean water) which dilutes the system somewhat.

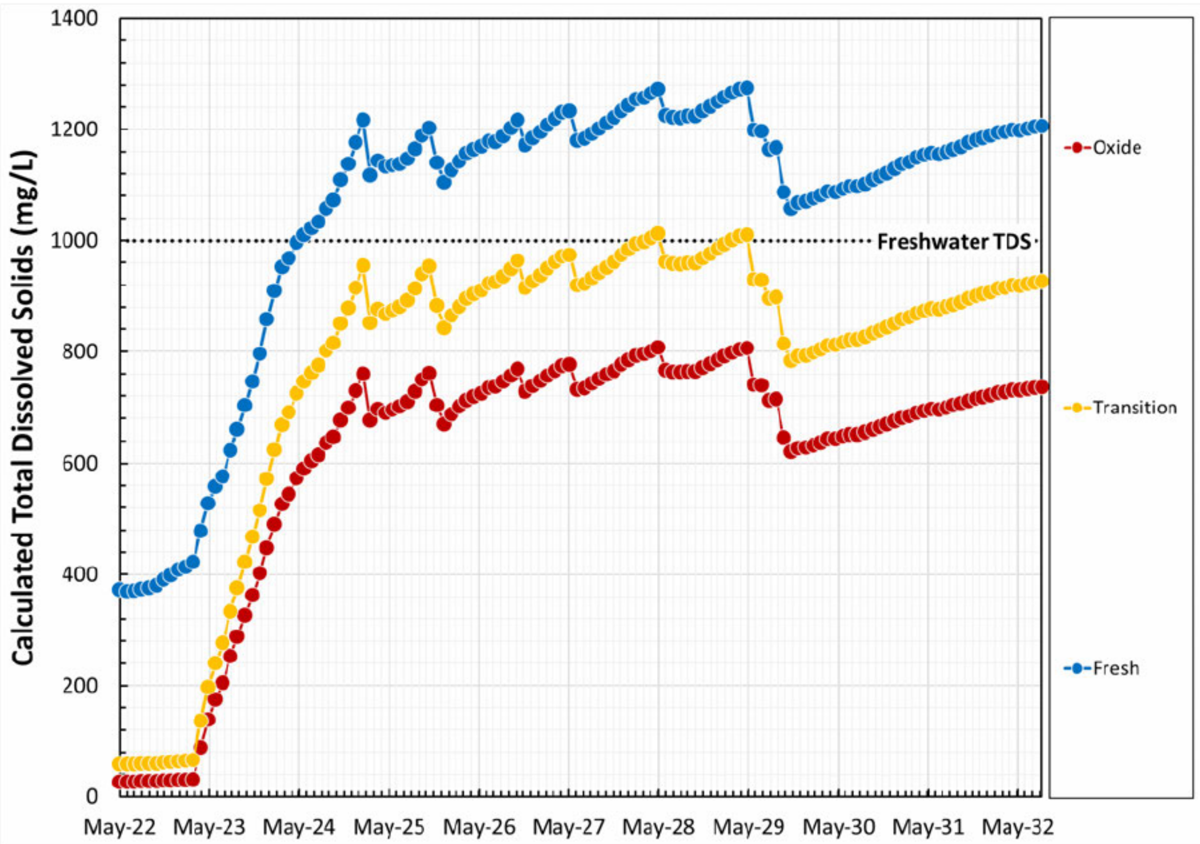

Figure 2 Predicted TDS in the modelled tailings scenarios

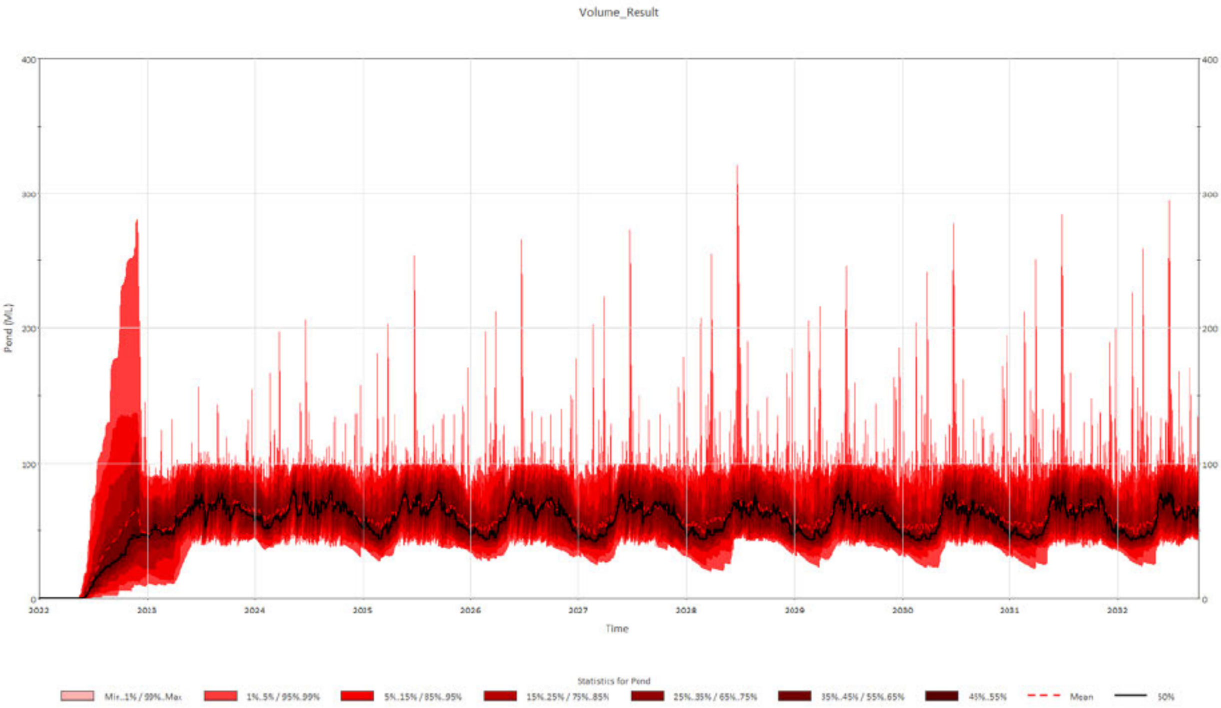

Figure 3 GoldSim water balance predicted TSF volumes

Model sensitivity analysis was conducted by varying the charge balance (on chloride) and the partial pressure of CO_2, to simulate the effects of well-mixed and aerated tailings versus poorly mixed anoxic tailings on the resultant TSF water quality. Figure 4 shows that variations in the prevailing conditions are predicted to have marginal effects on the salinity of the TSF. Note that the original, well mixed, aerated tailings deposition model (oxide) plots directly beneath the 'Oxide sensitivity model' results in Figure 4.

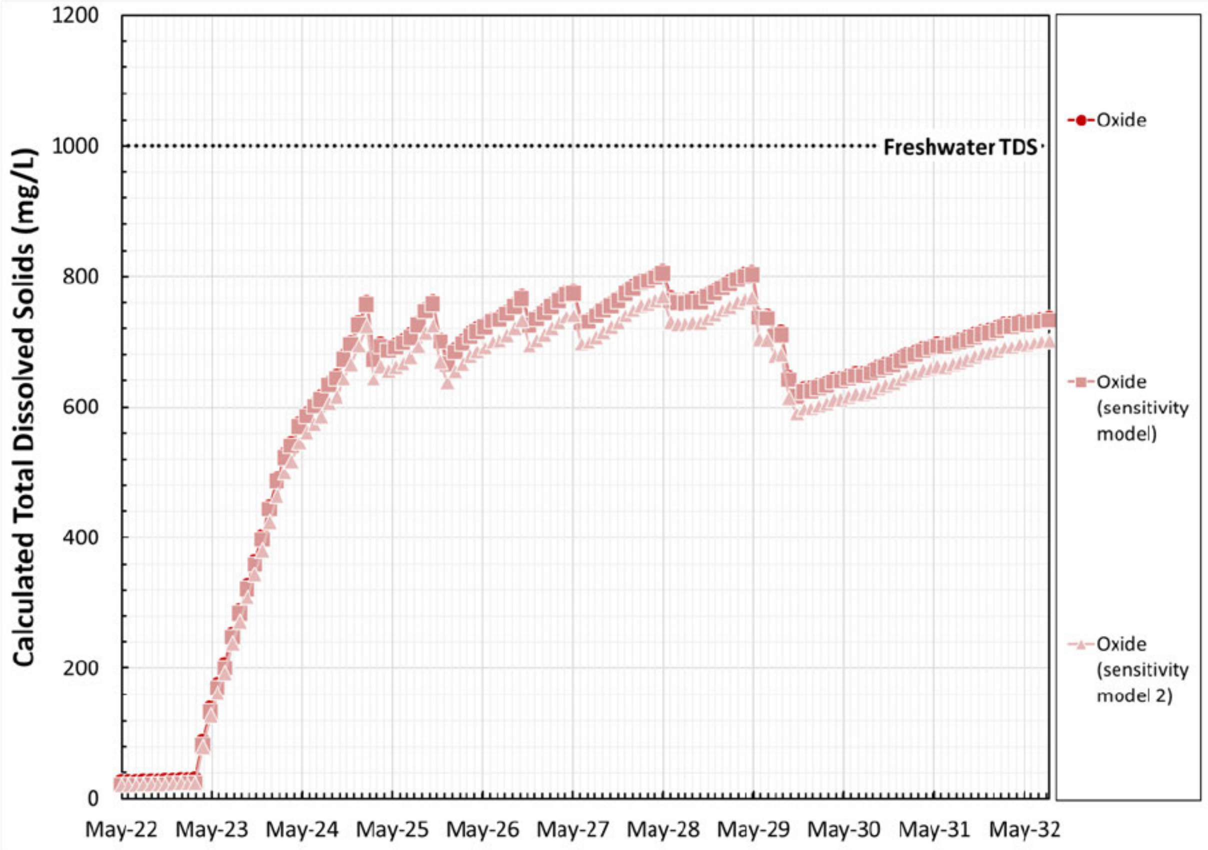

Figure 4 **Predicted TDS simulating poorly mixed, aerated tailings deposition ('Oxide sensitivity model') and poorly mixed, anoxic tailings deposition ('Oxide sensitivity model 2').**

Although the tailings leachate water quality reported neutral to slightly alkaline pH values (6.8 for the oxidised tailings, 7.7 for the transitional tailings, and 7.5 for the fresh tailings; Table 1), acid-base accounting on these samples predicted that they would be PAF[6]. Potential acid generation in tailings was examined in a further model scenario simulating PAF fresh tailings at low pH (~2), with results shown in Figure 5. The simulations predict that introduction of PAF tailings (or actively acid generating tailings) is likely to increase the overall salinity of the TSF; however, values are predicted to remain slightly brackish, rather than fully saline (≥ 10,000 mg/L TDS).

[6] SRK (2019). McPhillamys Gold Project: Geochemical Characterisation. Report prepared for Regis Resources Limited

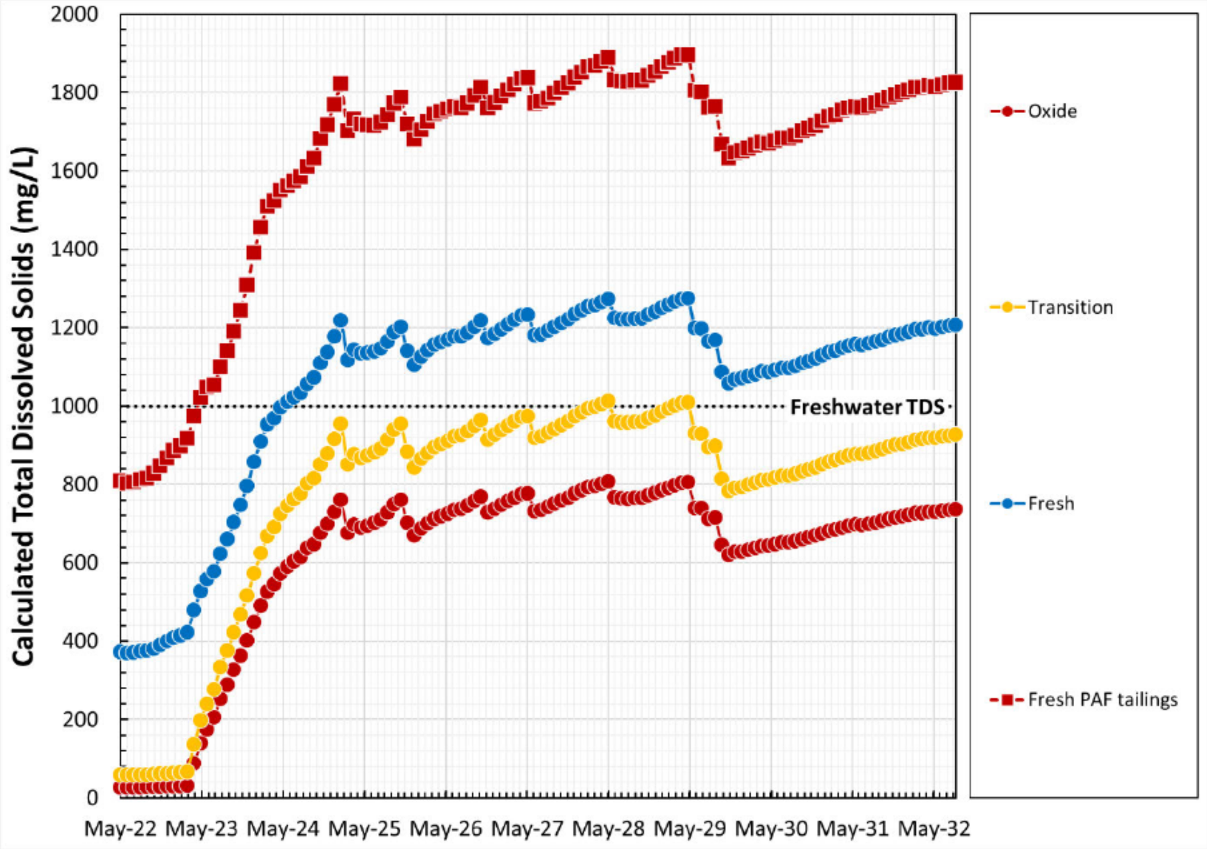

Figure 5 **Predicted TDS comparing simulated PAF tailings deposition with the original oxidised, transitional, and fresh tailings deposition scenarios**

2.3 Models accounting for salinity in process water

EMM have been advised on the potential use of higher salinity process water (with an average TDS of 3,500 mg/L and an upper limit of 7,000 mg/L) in the tailings stream and additional models were conducted to assess its effect on the resultant TSF water quality.

Table 2 shows the model water quality inputs adjusted for the average and upper limit TDS values of the process stream. These adjusted values were applied to the tailings bleed input water quality. Only major ions were adjusted, since these represent 95% of the total solids in the tailings bleed water quality. As in the initial models, alkalinity was calculated based on the CO_2 balance outlined in Section 1.1.2. Model scenarios were conducted on the transitional tailings composition for comparison to the initial base case scenarios. Further scenarios were also conducted on the fresh tailings composition and the fresh PAF tailings composition (both adjusted according to the TDS of the process water) to stress the model and to provide 'worst case' or 'what if?' scenarios.

Table 2 Major ion concentrations and pH used in additional models

Tailings	Transition	Fresh	Transition	Fresh	Fresh PAF
Parameter	TDS adjusted to 3,500 mg/L		TDS adjusted to 7,000 mg/L		
pH	7.7	7.5	7.7	7.5	2
SO_4 (mg/L)	1065	1232	2131	2464	2464
Cl (mg/L)	1173	1195	2346	2390	2390
Ca (mg/L	13	24	27	47	47
K (mg/L	46	27	91	55	55
Mg (mg/L)	2.69	1.96	5.38	3.92	3.92
Na (mg/L)	1173	863	2346	1726	1726

The results of four additional scenarios are shown in Figure 6 (note the logarithmic scale on this figure). These scenarios were as follows:

- Transitional tailings bleed water quality adjusted to process water with 3,500 mg/L TDS ('average salinity process water').
- Transitional tailings bleed water quality adjusted to process water with 7,000 mg/L TDS ('upper limit salinity process water').
- Fresh tailings bleed water quality adjusted to upper limit salinity process water (TDS = 7,000 mg/L).
- Fresh PAF tailings bleed water quality adjusted to upper limit salinity process water (TDS = 7,000 mg/L).

As expected, addition of higher salinity process water results in higher resultant TDS in the TSF, with the upper limit of process water salinity contributing to the highest values (Figure 6). The maximum value of TDS reported from the additional model scenarios was ~ 4,500 mg/L. Interestingly, the fresh tailings and fresh PAF tailings scenarios, which were conducted to provide the 'worst case', reported similar TDS values to the transitional tailings scenario with 7,000 mg/L TDS process water. In the modelling presented here, this 'upper limit' in TDS is caused by two effects:

- Total solid loads are moderated by dilution from direct rainfall events; and/or
- The total solid load in the TSF is solubility limited, with precipitation moderating the concentrations in the TSF water.

The model results show that a number of minerals are at or close to saturation in the TSF in these high salinity scenarios. These include sulfates such as gypsum ($CaSO_4{:}2H_2O$), anhydrite ($CaSO_4$), and jarosite ($KFe_3(SO_4)_2(OH)_6$), salt/halite (NaCl), and a number of iron oxides and oxy-hydroxides (eg goethite, FeOOH). As such, TDS may be moderated by mineral precipitation.

Although the additional model scenarios indicate that the TSF is likely to experience an increase in salinity, the water quality is predicted to remain brackish (< 10,000 mg/L TDS) at < 4,500 mg/L TDS. This is noted to be greater than most baseline groundwater monitoring data (< 2,000 mg/L), although it is within the range of groundwater reported from the Anson Formation, which was noted at < 5,200 mg/L TDS[7].

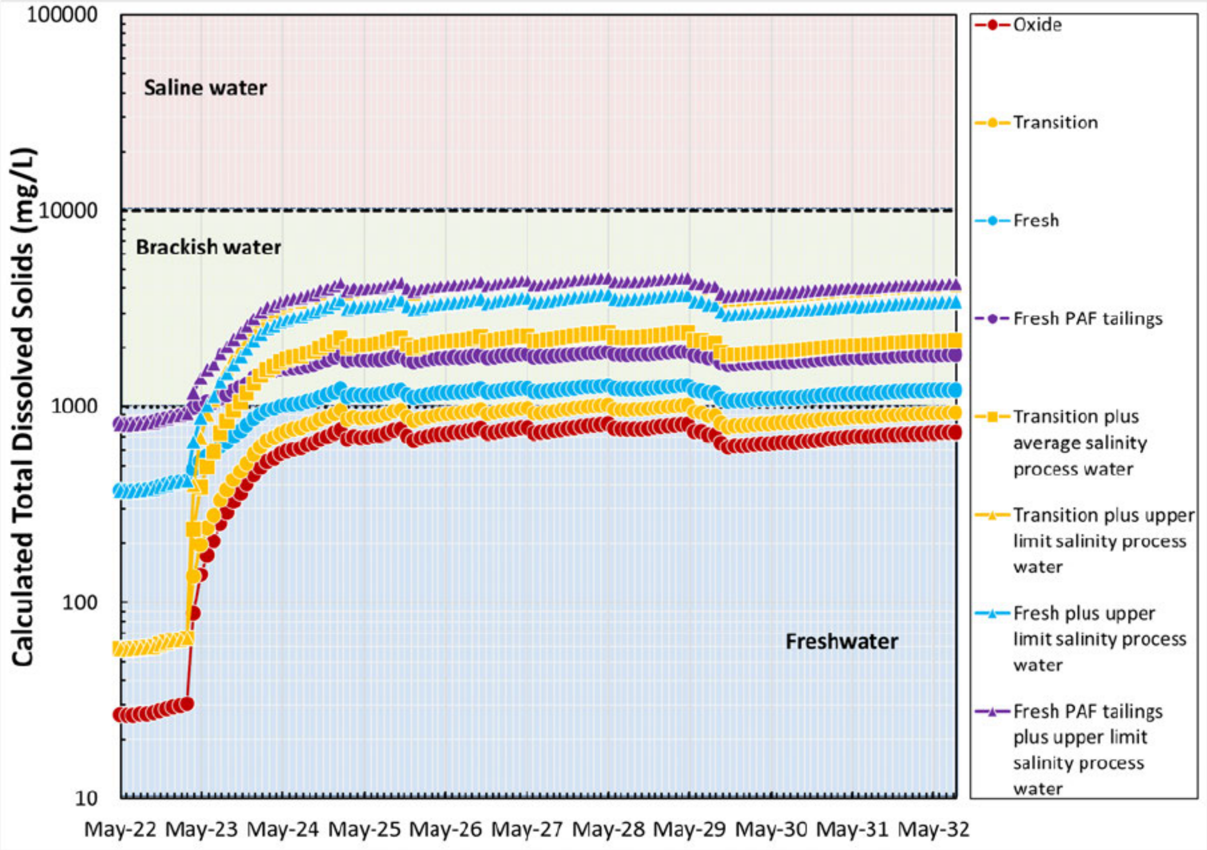

Figure 6 Predicted TDS comparing the initial model results with the additional higher TDS process water scenarios

3 Model assumptions and limitations

The PHREEQC geochemical model is a simplification of a real system, so it is subject to limitations. Limitations result from the simplification of the conceptual model upon which the geochemical model is based, the inaccuracies of measurement data, and the incomplete knowledge of the input parameters (data gaps). The water quality sources used in the model may be revised as additional information is acquired. The geochemical model is intended to provide an indication of potential changes in geochemistry following mixing and is not intended to provide real system answers.

7 EMM (2020). McPhillamys Gold Project Amendment Report – Groundwater Assessment Addendum (Amendment Report Appendix H).

4 Summary

Water quality modelling, based on the site conceptual model and TSF water balance, was conducted on a range of scenarios to assess the effect of input salinity on the resultant TSF water quality. Initial models looked at the effect of deposition of oxidised (weathered), transitional, and fresh tailings on the salinity of the TSF (represented by TDS). The models predicted that the fresh tailings, which is unweathered and contains the highest potential load, resulted in slightly brackish TSF water (~ 1,200 – 1,300 mg/L TDS). Deposition of fresh PAF tailings was predicted to increase the TSF salinity to ~ 1,800 mg/L TDS.

To simulate the use of higher salinity process water in the tailings stream, additional model scenarios were conducted to account for the higher dissolved solid load. As expected, these models showed an increase in TSF salinity that depended primarily on the TDS of the process water: addition of process water with a TDS of 7,000 mg/L resulted in the highest resultant TSF water quality values of ~ 4,500 mg/L. This predicted water quality nevertheless remains brackish, rather than saline (> 10,000 mg/L TDS).

Further model scenarios were conducted in an attempt to 'stress' the model and provide the 'worst case'. Resultant TSF TDS values remained at the upper limit of TDS (~4,500 mg/L) predicted in the more standard models. In the model scenarios presented here, this upper limit is the result of (i) dilution from direct rainfall onto the TSF pond, and/or (ii) solubility limits where sulfates and other minerals precipitate thus moderating TSF TDS.

Yours sincerely

James Tuff
Associate Geochemist
[redacted]