BEFORE THE OTAGO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER OF	Discharge Permit, Water Permit and Landuse Consent Application RM20.024
	Oceana Gold Limited

STATEMENT OF EVIDENCE OF JAMES MITCHELL BLYTH

ON BEHALF OF OTAGO REGIONAL COUNCIL

14 July 2020

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INTRODUCTION

1 My full name is James Mitchell Blyth

2 I am a Director and Water Resource Scientist at Taylor Collaborations Limited ('Collaborations'), an applied science consulting firm.

3 I hold a Master of Science (MSc) Degree with first class honours from the University of Waikato.

4 I am a Certified Environmental Practitioner (CEnvP) under the Environmental Institute of Australia and New Zealand (EIANZ).

5 I have 10 years of work experience, at roles within regional councils, industry (mining) and consulting. This experience covers a range of water sciences, including water quality, water resources, hydrology, hydraulics and wetlands. In particular, throughout my career I have had numerous involvement in water balance and catchment hydrological and water quality models.

6 For ~4 years I was employed as a Mine Water Consultant in Australia, and developed and applied specific hydrological and environmental skills relating to:

- Mine water modelling – in a range of software, including hydraulics (HEC-RAS, HEC-HMS and XPSWMM) and hydrology/water quality (GoldSim, eWater Source and various others software).

- I was one of the lead GoldSim modellers in Australia for water balances and water quality models over this period in the global mining consulting firm SRK Consulting. This involved working on projects around the world, including running employee and client GoldSim training courses in South Africa, Laos, Sydney and Brisbane, while at the same time contributing to technical projects in Thailand, Laos, Canada, Australia and Indonesia.

7 Since returning to New Zealand in 2014, I have continued to be actively involved in water balance and water quality modelling using both GoldSim and eWater Source software, and over the 2018/19 period was the technical lead for New Zealand for catchment water quality modelling at Jacobs New Zealand Limited, my previous employer.

BACKGROUND AND SCOPE

8 In February 2020 I was engaged by Aquanet Consulting Limited on behalf of Otago Regional Council (ORC) to provide a technical review of the resource consent applications by Oceana Gold (NZ) Ltd ('the applicant'/'Oceana'), specifically relating to the suitability of the modelling methodology applied in the Assessment of Environmental Effects on the Deepdell North Stage III Project.

9 An initial review was conducted in February 2020, and a technical memorandum was produced for Aquanet Consulting Limited ('Aquanet') and ORC, that assessed:

- the use of GoldSim to undertake water balance and water quality modelling of the mine site, and how this has been used to support the applicants consent application. Water quality current and future state was considered throughout the review, but not commented on (as this was being assessed by Aquanet).

- The documents provided by the applicant that were reviewed include the **Assessment of Environmental Effects – Deepdell North Stage III Project** and **Appendix E – Water Quality Effects Assessment**.

10 The February 2020 technical memorandum included a description of the additional information needed to address my questions and concerns relating to the applicants GoldSim modelling, including queries on input data, water quality modelling approaches and model calibration. This was provided so further information could be requested by ORC under S.92 (1) of the RMA (referred as the '**S.92 Request'** from here in).

11 In April 2020, the applicant provided a response to the **S.92 Request** for more information, which will be referred to as '**S.92 Response'**. My questions from the February 2020 memorandum were specifically addressed in the document **Appendix E - GHD Response to ORC RFI** (prepared 24 March 2020) as part of the **S.92 Response.**

12 On the 16 April 2020, I provided a final assessment of the **Appendix E - GHD Response to ORC RFI** to Aquanet and ORC, as an addition to the February 2020 technical memorandum. This April memorandum included:

- A critical review of the updated information and suitability of the modelling provided by the applicant in response to ORC's S.92 RFI, specifically on two topics:

    i. Model hydrological calibration

    ii. Water quality modelling

13 This evidence documents the information previously provided to Aquanet and ORC in the February and April 2020 technical memorandums and my opinion on model suitability.

14 I have not been to the site, nor have I undertaken any additional monitoring or field investigations. My review relies on the data and information provided by the applicant and their advisors.

15 I have read the submissions by āti Huirapa Rūnaka ki Puketeraki and Te Rūnanga o Ōtākou, The Department of Conservation and Macraes Community Incorporated, they do not provide technical information relating to specifically to the GoldSim modelling applied in the application, and as such will not be commented on this evidence.

CODE OF CONDUCT

16 I have read and agree to comply with the Code of Conduct for Expert Witnesses produced by the Environment Court and have prepared my evidence in accordance with those rules. My qualifications as an expert are set out above.

17 I confirm that the issues addressed in this brief of evidence are within my area of expertise.

18 I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

OVERVIEW OF GOLDSIM MODELLING ASSESSMENT

19 The applicants GoldSim model is a coupled water balance and water quality model representing the site and its various infrastructure. The water quality model is a simple mass balance model to estimate concentrations of contaminants or nutrients in various water bodies.

20 The model has been built to represent current mining state while also assessing the impact of future mine development (i.e. Deepdell North Stage III Project) on hydrology and water quality, to test how this development may impact on the applicants ability to meet existing resource consent limits in downstream locations during operation and post closure.

21 The model was run for a 40-year timeframe on a daily timestep, in a Monte Carlo simulation. 100 iterations were run (meaning the 40 year simulation was run 100 times), providing a range of probabilistic outcomes for flow and water quality. The historical rainfall record used in the modelling was however only 28 years, subsequently meaning the full rainfall record is likely repeated in every iteration, in varying sequences. A longer-term synthetic record would have provided even greater climatic variability, however 28 years of rainfall data is suitable to provide a range of hydrological flows and subsequently water quality load variations for the assessment.

SUITABILITY OF HYDROLOGIAL MODELLING

22 The applicant provided an assessment of the hydrological models calibration performance (for 6.5 years) as a deviation from the observed data (percentage error). A more standardised method of assessing model performance is comparison to the Nash Sutcliffe Efficiency (NSE) and Percent Bias (PBIAS), detailed in Moriasi *et al.* 2007, was requested as part of the **S.92 Request**. My assessment of the associated **S.92 Response**, found:

- Model performance was considered unsatisfactory for the NSE metric and PBIAS (%) for the entire calibration period, however when the data were filtered for flows below <1000 L/s and low flows <100 L/s, calibration improved generally from good to very good, respectively. Flows <1000 L/s represent ~98% of the recorded flow data.
- High flows result in additional dilution to any loads discharged from the mine, and subsequently would have lower concentrations. Therefore, the accurate simulation of high flows in the context of the mines potential impact on water quality is of less importance than at low to moderate flows when ecological toxicity effects are likely to be more prevalent.
- The suitable calibration at low to moderate flows suggest this hydrological model would be appropriate to simulate flow and can be linked to a water quality model to estimate loads and concentrations. In addition, the modelled low to moderate flows were underpredicted when compared to observed flows, providing for a more conservative estimate of water quality impacts (as there would be less dilution and subsequently, higher simulated concentrations).

23 As part of the **S.92 Request**, I also requested information on the calibration and accuracy of the flows within the mine site. The affected mine area represents a small part of the overall catchment area (~2% as indicated in **Appendix E – Water Quality Effects Assessment**) that contributes flow within the calibrated hydrological model, but could potentially contribute higher loads of nutrients and contaminants than other landuses in the catchment. Subsequently, understanding the flow dynamics within the mine site is important to accurately estimate nutrient and contaminant loads.

24 The **S.92 Response** identified there was no hydrological data from within the mine site to calibrate the model to localised flows, such as diversion drains or sediment pond water levels. The applicant has used the rational method with runoff coefficients (varying depending on landuse type and disturbance) to predict mine site flows, which is typical in many mine water balances. I consider this approach to be acceptable, however have some suggested recommendations (see the **RECOMMENDATIONS** section at the end of this evidence).

SUITABILITY OF WATER QUALITY MODELLING

25 The water quality model applies a truncated normal distribution, centered around the mean observed concentration for each water quality parameter (i.e. sulphate, nitrate-N) for the appropriate landform (i.e. waste rock dump, impacted land).

- This is coupled with flow generated from the water balance model to predict a load, and subsequently a downstream concentration. This means on every day of a simulation, a water quality concentration is randomly selected from the truncated normal distribution and applied in the modelled flow for that landform, to generate a load, ultimately ending up downstream (i.e. the Shag River). A truncated distribution is acceptable if it covers an appropriate range of the observed water quality data.

26 Within the **S.92 Response,** the applicant provided figures of the observed monitoring data, mean concentration and upper/lower bounds for the normal distribution applied at various sites for sulphate only. No other modelled water quality parameters have been presented (i.e. nitrate-nitrogen, arsenic, lead) and subsequently, I could not assess these water quality parameters. The modelled sulphate distributions provided in the **S.92 Response** are considered to be suitable to represent the range of observed concentrations to date.

- However, concentrations at some locations are increasing (Figure 1) and may exceed the upper threshold applied in modelling, in the future. The lower flows simulated in the model (see evidence line 22) could provide conservative estimates of concentrations, however this is on the basis that the simulated seepage and runoff volumes from the waste rock stack would be accurate and contributing the appropriate load.

27 Assuming the truncated normal distribution method applied on other water quality parameters captures the observed data, as per the sulphate examples in the **S.92 Response**, this would be considered acceptable, however any sites that show an increasing trend in concentrations should be monitored (see Figure 1 below). As mentioned in evidence line 26, no model input data was provided by the applicant for these other parameters and I have therefore not assessed their suitability.

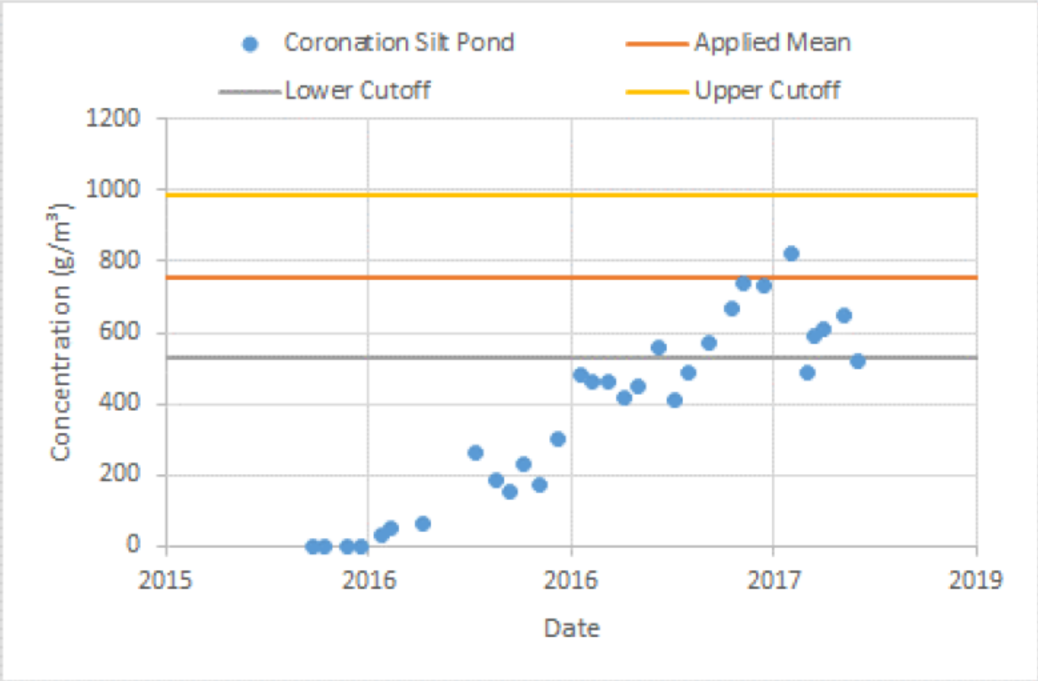

Figure 1. Example of the observed water quality sulphate concentrations (blue dots) for the Coronation Silt Pond used in water quality modelling, where the upper, lower and mean modelled parameters have been indicated (provided by the applicant in the **S.92 Response** as Figure 3-4, **Appendix E - GHD Response to ORC RFI**).

28 The current upper threshold for sulphate in Figure 1 has been applied in the model and exceeds the highest recorded observed concentration by ~20%, providing margin for the water quality modelling. See **RECOMMENDATIONS** section at the end of this evidence for consideration of additional monitoring.

29 As part of the **S.92 Request**, I asked for more information on the water quality model calibration, including nutrient loads from other landuses in the catchment and accuracy of the model for the current state (before mine development scenarios were considered). The **S.92 Response** identified that:

- No specific land use mapping was undertaken to model nutrient loads off other landuses within the catchment. Instead, a 'natural' background water quality concentration was applied in the model for each of the parameters (i.e. sulphate and nitrate-nitrogen). This natural background concentration was based off observed monitoring data at site DC01, and sense checked from data at DC07.

30 While the applicant applied the mean (from observed data) for the 'natural' background concentrations, the dataset used for this assessment was sparse for the sulphate and nitrate-nitrogen records presented in the **S.92 Response**.

- In my opinion (in the absence of large datasets) applying the mean concentration from upstream sites (DC01) for water quality parameters such as sulphate or other metals (i.e. arsenic) would be acceptable, as it is likely the natural load of these contaminants would be small with minimal input from other upstream primarily rural landuses (as indicated by the applicant in **Appendix E - GHD Response to ORC RFI**).

- In regards to nitrate-nitrogen concentrations, a background value (greater than the mean concentration) of 0.05 g/m^3 was applied in the model. This was from a very limited dataset of only four data points prior to 2015, and may not represent the full range of river concentrations, which can fluctuate significantly over a year depending on upstream farming practices and seasonal hydrological changes. The 'natural' background nitrate-nitrogen load could be higher and subsequently, any modelled impacts of the mine (contributing to a nitrate-nitrogen load) may underestimate the cumulative effects in the receiving environment (i.e. the Shag River).

31 The **S.92 Response** presents the water quality model calibration from 2015-2018 for sulphate and nitrate nitrogen at DC08 and Shag River at Loop Road. This compares modelled concentrations against observed water quality data and showed the baseline model is suitably calibrated for scenario assessments of the waste rock stack development and would be considered conservative when simulating sulphate concentrations. Limited monitoring data for nitrate-nitrogen data (see Figure 2) reduces the confidence in the models baseline calibration for this contaminant, despite the model showing it is conservative in simulating nitrate-nitrogen concentrations. Only 12 sample concentrations are presented over a 3 year period for DC08 and 7 samples at Loop Road.

32 No other water quality parameters used in the model have been presented (for calibration purposes) and therefore I have not assessed these.

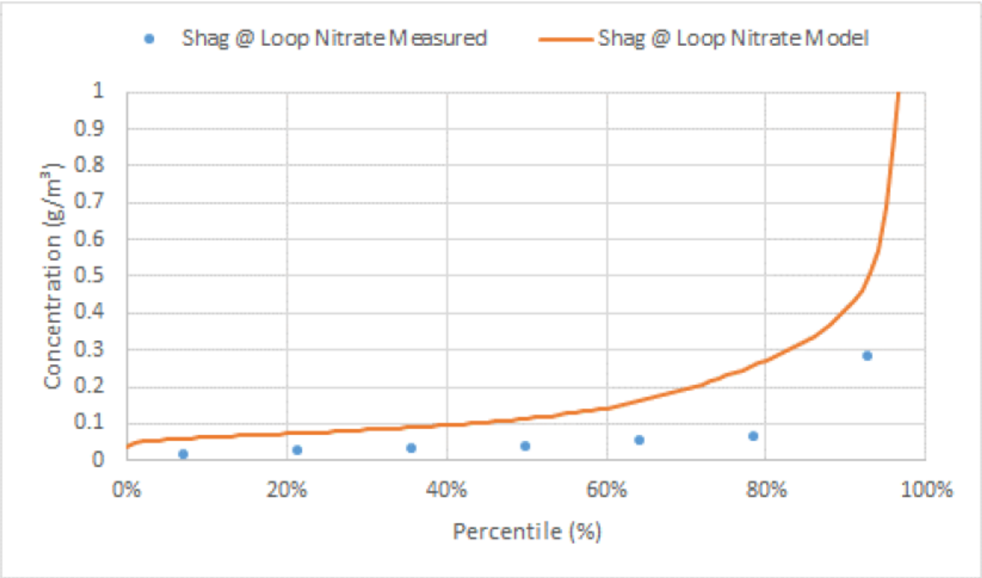

Figure 2. Comparison of measured and modelled nitrate-nitrogen concentrations at Shag River at Loop Road from 2015 to 2018 (this is reproduced from Figure 3-14 in the **S.92 Response, Appendix E - GHD Response to ORC RFI**).

RECOMMENDATIONS

33 Additional monitoring of flows or water levels could be conducted within the mine site at appropriate mining locations/infrastructure (such as sediment ponds or collection drains), should this consent application be granted. This is on the basis that in the future, the site water balance and quality model could be recalibrated or modelling assumptions relating to seepage and runoff validated. A significant divergence from model assumptions (such as a greater seepage or runoff volume) could mean the model under-predicts receiving environment water quality impacts.

34 Ongoing water quality monitoring within the mine site is recommended at existing sites used to provide water quality inputs within the GoldSim model, and additionally at locations downstream of planned developments (such as waste rock stack seepage or any spoil piles), should the consent be granted. In my opinion, an additional 3–5 years of observed data would help validate the models input assumptions.

35 Further monthly/bi-monthly monitoring of the nitrate-nitrogen concentrations is recommended at DC01 and/or DC08 to validate the natural background nitrate-nitrogen concentrations and the fixed value of 0.05 g/m^3 applied in modelling.

SUMMARY

36 The GoldSim model used to simulate the effects of future mine development is suitably calibrated for flow and water quality, based on the data available and presented by the applicants.

37 Further monitoring and collection of hydrological and water quality data will help validate the models input assumptions while also providing additional information to improve the model's performance in the future.

REFERENCES

Moriasi, D. N., Arnold, J. G., Van Liew, M. W., Bingner, R. L., Harmel, R. D. and Veith, T. L. (2007). Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations. Transactions of the ASABE 50 (3), 885–900