Date: 10/02/2020

To: Elyse Neville
Senior Consents Planner
Otago Regional Council

Oceana Gold Deepdell North Stage III project – Initial review

Dear Elyse,

At your request I have read the relevant sections of the report "*Oceana Gold (NZ) Ltd - Deepdell North Stage III Project: Assessment of Environmental Effects*" ('the report'), including Chapters 1, 2, 3,5 and 7 and Appendices E, O and S. In this memorandum I provide a review of the methodology and conclusions of the Aquatic Ecology Effects Assessment (Appendix O of the report) and the Water Quality Effects Assessment (Appendix E of the report), outline the additional information required to finalise my assessment and present recommendations on the proposed consent conditions (Appendix S of the report).

1 Background

Oceana Gold (NZ) Ltd ('the applicant'/'Oceana') are applying for a resource consents that will enable them to:

- Mine from the edge of an already back filled pit (the Deepdell North Pit) to create the Deepdell North Stage III Pit;
- Create the Deepdell East Waste Rock Stack by using waste rock from the Deepdell North Stage III Pit to backfill the existing Deepdell South Pit and build up the relatively flat and developed pastureland to the north; and
- Upon completion of mining divert surface flows from the Deepdell East Waste Rock Stack into the Deepdell North Stage III Pit to create a lake (Deepdell North Stage III Pit Lake).

Oceana's proposal has the potential to adversely affect the water quality and ecology of the nearby surface water bodies through the discharge of contaminants from site dewatering and the Deepdell East Waste Rock Stack, and stream reclamation. Accordingly: the report includes:

- An assessment of the effects of contaminants discharged from the Deepdell East Waste Rock Stack on the water quality of the receiving environments; and
- An assessment of the effect of stream reclamation and discharges on the aquatic ecology of the receiving environments.

2 Review of the water quality component of the report

2.1 Review of Water Quality Effects Assessment

James Blyth of Collaborations has provided the following review of the Water Quality Effects Assessment

Subject:	**Oceana Gold Ltd Consent Review – GoldSim Modelling**
Attention:	Aquanet Consulting Ltd
From:	James Blyth
Date	5 February 2020
Copies to:	

1 Introduction

The purpose of this memo is to detail outcomes of a review conducted on Oceana Gold Ltd Assessment of Environmental Effects (AEE) for a consent application to Otago Regional Council, regarding the Deepdell North Stage III Project.

The focus of this review was exclusively on 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 consent application. Water quality current and future state has been considered throughout the review, but not commented on as this is not in scope of our engagement.

Documents reviewed were:

1. Assessment of Environmental Effects – Deepdell North Stage III Project. *216 page report.*
2. Appendix E – Water Quality Effects Assessment. *67 page report.*

Appendix E provided the most detailed overview of the GoldSim modelling approach.

2 Summary of initial assessment

- The 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.
- 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 Oceana Golds ability to meet existing resource consent limits in downstream locations during operation and post closure.
- The water quality model applies a mean concentration for various contaminants (i.e. sulphate, nitrate-N) based on observed monitoring data 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 subsequent downstream concentration.

Each mean concentration has a normal distribution applied with a 20% standard deviation, to provide variability in water quality input parameters.

- Why a value of 20% was chosen is not clear, versus truncating the normal distribution with the observed water quality data statistics (i.e. 5th, median and 95th percentiles), unless the 20% approach is more conservative or represented this observed range suitably.
- Nutrient modelling could also be improved by having a dry weather concentration (DWC) applied to baseflows, and a wet weather concentration applied to storm events (i.e. an event mean concentration, or EMC), partitioned through the Australian Water Balance Model used to simulate flows. This would capture the higher load that would be delivered during runoff events, when currently the normal distribution approach to water quality input parameters could randomly assign a low concentration on a day with high flows, or a high concentration on a day with low flows, which may not be representative of actual nutrient/contaminant pathways.
- It is not clear how the Deepdell Creek baseline water quality was simulated in the model, for example if all catchment area outside of the mining footprint was considered natural landform and the 'natural' water quality modelling parameters were then applied.

* The model is 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, producing a range of probabilistic outcomes for flow and water quality). However, the rainfall record used is only 28 years long, meaning the full record is likely repeated in every iteration, in varying sequences. A longer-term synthetic record would provide greater climatic variability.
* The water balance model calibration only presents data from Deepdell Creek at DC04 and this is only for a three-year period (2015 to 2017 in Appendix E), despite the modelling report (Appendix E) describing a ~6.5 year calibration from May 2011 to November 2017. In addition, DC04 and Shag River have rainfall and flow records of >20 years.
* Figure A3 in Appendix E of the report is an unusual way to present a model calibration. Comparison to Moriasi *et al.* 2007 is a common way to test the fit of hydrological models using Nash Sutcliffe Efficiencies (NSE) and PBIAS. In addition, there is no validation period applied in modelling.
* The calibration to DC04 site represents a ~40.8 km^2 catchment, of which the mining area only makes up a small proportion of this (for example, Table 8 in Appendix E shows the combined footprint of the Deepdell East and Backroad Waste Rock Stacks as ~2 km^2, or ~5% of the catchment). Subsequently, the impact of the mine site on DC04 stream flow may represent a small proportion of runoff and baseflow versus what is coming from other upstream landuses, but a large proportion of catchment water quality loads.
  - Understanding the calibration of the model at sites within the existing mine is therefore important to see if the model runoff parameters assigned to different landuses (e.g. waste rock stack, disturbed areas) are suitable to represent on-site hydrological processes. Useful ways to test this is through calibration to water level observations at sumps and sediment ponds, or spot gaugings

on runoff from toe and diversion drains compared against seepage or simulated flows.

- There is limited calibration data presented for the water quality model, with only monthly observed sulphate concentrations at DC08 being presented graphically for a 3 year period. Calibrating water quality and flow to a site upstream of the mine would be useful to understand the magnitude of change in the receiving water body due to mine discharges.

3 Request for additional information

Based on the summary of the water balance model in Section 2, the following information would be useful to help understand model suitability for predicting water quality.

- Model hydrological calibration:
    - Presentation of the 6.5 year hydrological calibration period (graphically)
    - Analysis and tabulation of model performance by comparing simulated flows to observed based on Moriasi *et al.* 2007, using hydrological parameters NSE and PBIAS.
    - Presentation of any calibration data for runoff or water levels within the existing mine site, to assess suitability of the water balance model for simulating disturbed site flows (and subsequently, predicting water quality loads).
- Water quality modelling:
    - Provide context on why the normal distribution was utilised versus a DWC/EMC approach, and how the 20% standard deviation applied to these distributions captures the range of observed concentrations from monitoring data.
    - Describe how the Deepdell Creek and wider Shag River catchments outside of the mining domain were simulated for water quality. This may include describing any landuse mapping that was undertaken, or if 'natural' water quality modelling parameters were applied to any landuse outside of the mining footprint.
    - Describe (and present) how the baseline water quality model was calibrated for Deepdell Creek and Shag River based on the current state (including current mining operations) in order for scenarios of the Deepdell North Stage III project to be assessed.

4 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

2.2 Effects on water quality

2.2.1 Deepdell Creek and Shag River.

The compliance criteria presented in Section 3.1 of the proposed conditions (attached to the report as Appendix S) are the same as those set out in existing consents held by Oceana. Thus, when these consents are considered as part of the existing environment, the proposed activity will not result in any further degradation of the water quality parameters listed in the proposed conditions. These are:

- pH
- Arsenic
- Cyanide$_{WAD}$
- Copper
- Iron
- Lead
- Zinc
- Sulphate

However, I do note that the standards for copper in both Deepdell Creek and Shag River exceed the ANZECC guideline for the protection of 80% of species, as does arsenic in Deepdell Creek (if standard applied to AsV), and if considered in an unimpacted stream would be sufficient to cause significant adverse effects.

In both the Water Quality Effects Assessment and the Ecological Effects Assessment there is discussion about setting nitrate standards that reflect the NPS-FM attribute state B threshold (median = 2.4 mg/L, 95th percentile = 3.5 mg/L). However, based on the nitrate data presented in Figures 10 and 11 of the Water Quality Effects Assessment, it appears that these standards would allow for a significant increase in nitrate in both the Deepdell Creek and the Shag River (max concentration at both sites in 2018-2019 <0.5 mg/L). Thus, while I agree that nitrate limits should be applied in the consent conditions (they current are not), it is my opinion that they should be set based on periphyton growth or (at a maximum) the NPS-FM attribute state A thresholds (median = 1.0 mg/L, 95th percentile = 1.5 mg/L). Accordingly, to finalise my assessment I need the applicant to provide all the available nutrient data for the DC08 and Loop road sites, and to provide a far more detailed assessment of what suitable nutrient guidelines would be to control periphyton growth. As the Ecological Effects Assessment states that dual nutrient management be considered, standards should be provided for both dissolved inorganic nitrogen and dissolved reactive phosphorus.

2.2.2 Highlay Creek

As I understand it, contaminants discharged from the proposed rock stack will enter a Western Tributary (location shown in Figure 1) of Highlay Creek via surface drainage (flowing through sediment ponds) and groundwater contaminated with seepage. However, very little effort has been made to assess the effects that the activity will have on the water quality of the Western Tributary or Highlay Creek itself. Given the presence of koura and flathead galaxiids in both of these streams and the good condition of the macroinvertebrate community (MCI-108 to 111) protection of aquatic fauna against toxic contaminants is of vital importance.

In the section 5.12.8 of the report it is stated that "*there may be some elevation in contaminant levels in Highlay Creek overtime, however not to the extent that these would be beyond* *compliance values applicable at DC08*"(Deepdell Creek). In my opinion the existing compliance standards for the DC08 site would not protect against significant adverse effects in Highlay Creek (copper and arsenic (AsV) values exceed the ANZECC guidelines for the protection of 80% of species). Thus, to complete my assessment I require the applicant to determine likely contaminant concentrations in both Highlay Creek and the Western Tributary and propose water quality standards for these creeks that can be applied in consent conditions. For nutrients, these standards should be set to control plant growth rather than toxicity.

3 Review of the ecological component of the report

The Ecological Effects Assessment provides a thorough summary of the values of the impacted water ways. However, I have found a number of issues that mean that I am unable to complete a full assessment.

3.1 Discharges to Highlay Creek and its tributaries

In my opinion the effects of the discharge of contaminants to Highlay Creek or its Western Tributary (location shown in Figure 1) have not been properly assessed in the Ecological Effects Assessment. In that report, they have only discussed the potential to effects to arise from sulphate and nitrate. However, the effects of toxicants such as arsenic have not been considered. To complete my full assessment, I require the applicant to assess the ecological effects of the discharge standards requested for Highlay Creek in Section 2.2.2. (including nutrients and their effects on periphyton).

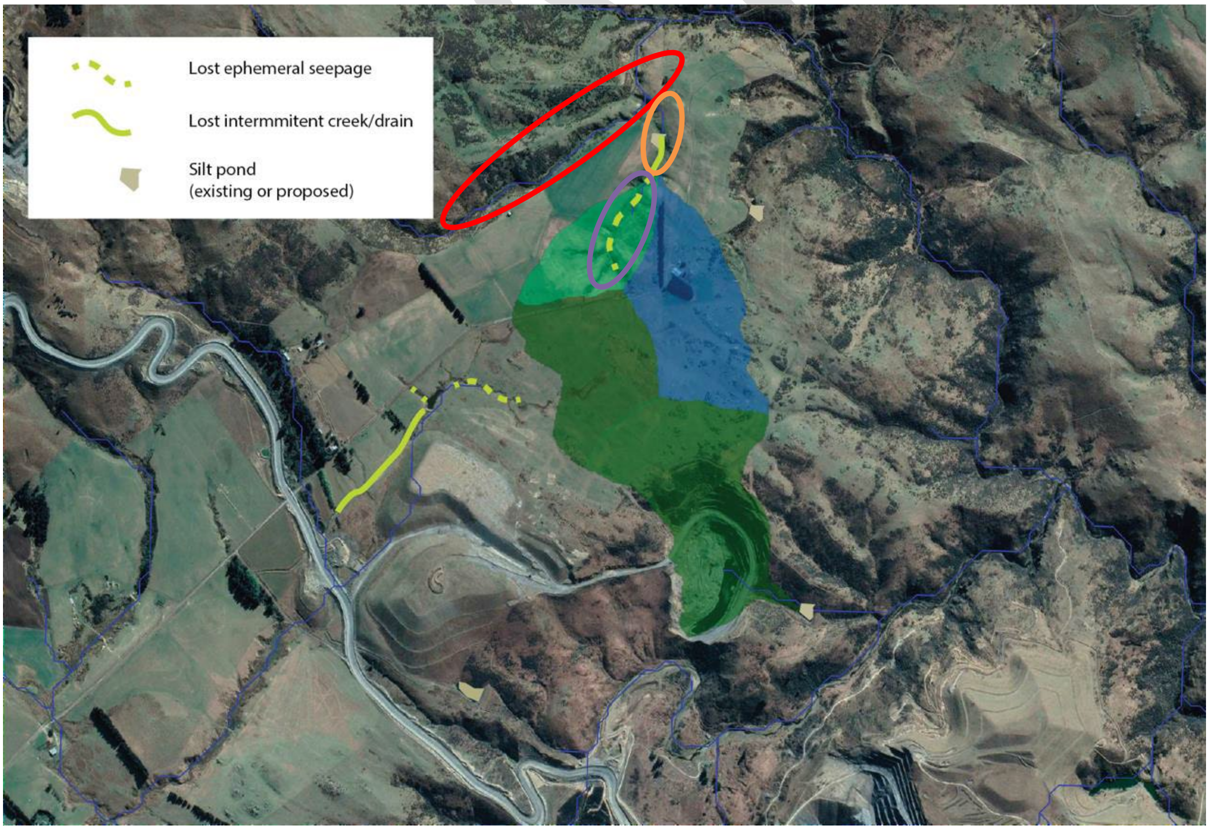

Figure 1: Watercourse map. The western tributary of Highlay Creek that could be impacted by discharges is indicated by red oval, the Gully Stream which will be reclaimed is indicated by the purple oval and the Highlay Tributary that will be culverted is indicate by the orange oval. .

3.2 Reclamation of tributaries of Highlay Creek

The applicant is proposing to reclaim approximately 480 metres of stream in the Highlay Creek catchment (hereafter referred to as the "Gully Stream" (location shown in Figure 1)) that runs down a gully within the proposed project footprint. In the Ecological Effects Assessment it is estimated that approximately 250 metres of this is ephemeral and the remaining 130 metres is potentially intermittent. The Ecological Effects Assessment also suggests that these reaches do not support fish or typical stream invertebrate habitat and associated communities, and are unlikely to carry surface flow during warmer months of the year. Based on this assessment it is concluded that the effects of reclamation will be minor in the report.

The photographs presented in the Ecological Effects Assessment support the applicant's assessment of flow permanence, as does a review of the available aerial imagery. As such I agree that the effects of reclaiming the ephemeral and intermittent reaches of the Gully Stream are unlikely to be more than minor. However, to finalise this assessment I require a breakdown of the total length of reclamation undertaken by Oceana Gold in the Deepdell Creek catchment to date. This will allow me to understand the potential for cumulative effects.

3.3 Culverting of a tributary of Highlay Creek.

In addition to reclaiming 480 metres of the Gully Stream, the applicant is proposing to construct a 51m culvert in an intermittent reach further downstream (hereafter referred to as the "Highlay Tributary" (location shown in Figure 1)) as part of a road realignment. The effects of this culvert have not been explicitly assessed in the Ecological Effects Assessment. While not a major issue, some form of assessment is needed, particularly around construction effects (habitat effects are likely the same as those caused by the reclamation of the Gully Stream).

3.4 Effects of discharges on Deepdell Creek and Shag River

Given that toxicant concentrations are not expected to change significantly in Deepdell Creek of Shag River (water quality limits in consent conditions to remain unchanged from existing consents), then the potential for toxicity related adverse effects on aquatic life is unchanged. However, the increase in nitrate concentrations suggested by the Water Quality Effects Assessment and the Ecological Effects Assessment (median = 2.4 mg/L, 95th percentile = 3.5 mg/L) could well increase the risk of periphyton growth to the extent that adverse effects could occur. Accordingly, to finalise my assessment I need the applicant to assess the effects of the expected increase in nitrate concentration on periphyton growth based on existing water quality and ecological data. In my opinion the Ecological Effects Assessment does not do this to an appropriate standard.

3.5 Reclamation of tributaries of Camp Creek

The pit excavation will result in the loss of approximately 200m of ephemeral seepage in the Camp Creek catchment and an approximately 480m length of a highly modified, intermittent Camp Creek tributary which will be diverted out of the Camp Creek catchment. While this represents the loss of a significant amount of potential habitat, in my opinion these effects will be offset by the creation of new koura habitat required by Condition 6 of Section 1.2 of the proposed conditions (attached to the report as Appendix S).

3.6 Effects of sediment on Highlay Creek and Deepdell Creek

Provided the discharges comply with the standards set out in Condition 5 and 6 of Section 1.6 of the proposed conditions (attached to the report as Appendix S), the effects of sediment discharged to Highlay Creek and Deepdell Creek from the proposed silt ponds should not have significant adverse effects (note – most of the S.107(10) standards are set out in these conditions). However, it is important that appropriate monitoring protocols are established in the Water Quality Management Plan to ensure that compliance with these conditions can be monitored. At a minimum this should include suspended solids monitoring in the discharges; upstream and downstream water clarity, turbidity deposited sediment and suspended solids monitoring; and appropriate ecological monitoring.

4 Additional information required

To finalise my assessment, I require the following additional information from the applicant.

- All of the available nutrient data for Deepdell Creek and Shag River, and a detailed assessment of what suitable nutrient guidelines would be to control periphyton growth. As the Ecological Effects Assessment states that dual nutrient management be considered, standards should be provided for both dissolved inorganic nitrogen and dissolved reactive phosphorus.
- A breakdown of the total length of reclamation undertaken by Oceana Gold in the Deepdell Creek catchment to date. This will allow me to understand the potential for cumulative effects.
- The likely contaminant concentrations in both Highlay Creek and its Western Tributary (location shown in Figure 1) and proposed water quality standards for these creeks that can be applied in consent conditions. For nutrients, these standards should be set to control plant growth rather than toxicity.
- Some form of assessment of the effects of culverting the "Highlay Tributary" (location shown in Figure 1), particularly around construction effects (habitat effects are likely the same as those caused by the reclamation of the Gully Stream).
- An assessment of the the effects of the expected increase in nitrate concentration (see figures 10, 11, 17 and 18 of Appendix E to the report) on periphyton growth in Deepdell Creek and Shag River based on existing water quality and ecological data. In my opinion the Ecological Effects Assessment does not do this to an appropriate standard.

James Blyth of Collaboration also requests the following information to help understand model suitability for predicting water quality.

- Model hydrological calibration:
  - Presentation of the 6.5 year hydrological calibration period (graphically)
  - Analysis and tabulation of model performance by comparing simulated flows to observed based on Moriasi *et al.* 2007, using hydrological parameters NSE and PBIAS.
  - Presentation of any calibration data for runoff or water levels within the existing mine site, to assess suitability of the water balance model for simulating disturbed site flows (and subsequently, predicting water quality loads).
- Water quality modelling:
  - Provide context on why the normal distribution was utilised versus a DWC/EMC approach, and how the 20% standard deviation applied to these distributions captures the range of observed concentrations from monitoring data.

- Describe how the Deepdell Creek and wider Shag River catchments outside of the mining domain were simulated for water quality. This may include describing any landuse mapping that was undertaken, or if 'natural' water quality modelling parameters were applied to any landuse outside of the mining footprint.
- Describe (and present) how the baseline water quality model was calibrated for Deepdell Creek and Shag River based on the current state (including current mining operations) in order for scenarios of the Deepdell North Stage III project to be assessed.

5 Recommendations on consent conditions

I recommend that consent conditions include:

- Water quality limits for nitrogen and phosphorus in Deepdell Creek and Shag River; and
- Water quality limits for Highlay Creek.

6 Summary

In summary, while large parts of the Assessment of Environmental Effects have been carried out to a high standard, additional information is still required in order to understand the potential water quality and ecological effects. Information gaps are primarily around the current and future water quality of Highlay Creek, and the overall water quality modelling process.

Prepared by:

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