Date: 28/04/2020

To: Elyse Neville
Senior Consents Planner
Otago Regional Council

Oceana Gold Deepdell North Stage III project – Final review

Dear Elyse,

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.

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;
- The Ecology Effects Assessment (Appendix O of the report);
- The Water Quality Effects Assessment (Appendix E of the report);
- The Proposed Consent Conditions (Appendix S of the report); and

- The S.92 response – "*Oceana Gold (NZ) Ltd - Deepdell North Stage III – Request for further information*"

In Section 1 of this memorandum I provide our initial review of the methodology and conclusions of the Aquatic Ecology Effects Assessment and the Water Quality Effects Assessment, outline the additional information we requested to finalise our assessment and present recommendations on the Proposed Consent Conditions. In Section 2 of this memorandum I provide an updated review of the Aquatic Ecology Effects Assessment and the Water Quality Effects Assessment based on the additional information provided with the S.92 response and provide an updated assessment of the proposed Consent Conditions.

1.1 Initial assessment – Provided for context

In this part of the memorandum our preliminary assessment (written on the 10/02/2020) of the application is provided for context. Included is:

- A review of the water quality component of the application (partly conducted by Collaborations);
- A review of the ecology components of the application;
- An outline of the additional data required to complete a full review; and
- Preliminary recommendations of consent conditions.

1.2 Review of the water quality component of the report

1.2.1 Review of Water Quality Effects Assessment

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

Collaborations

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

1.2.2 *Effects on water quality in Deepdell Creek and Shag River.*

The compliance criteria presented in Section 1.3 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; and
- Sulphate.

However, I do note that the standards for copper in both Deepdell Creek and Shag River exceeds the ANZECC (2000) 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 compliance 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.

1.2.3 *Effects on water quality in 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 (2000) 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.

1.3 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.

1.3.1 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 for 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 1.2.3. (including nutrients and their effects on periphyton).

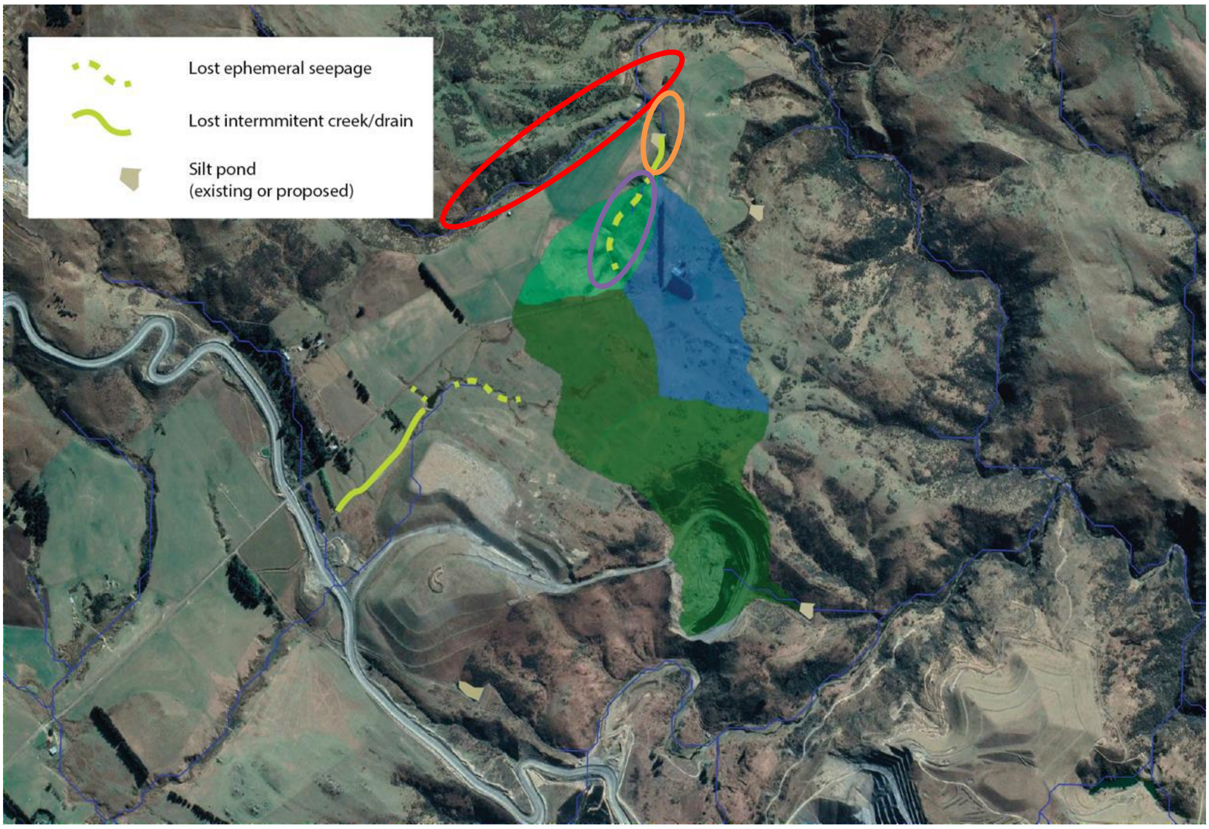

Figure 1: Watercourse map. The western tributary of Highlay Creek that could be impacted by discharges is indicated by red oval, the Gully Stream which will be reclaimed is indicated by the purple oval and the Highlay Tributary that will be culverted is indicate by the orange oval.

1.3.2 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.

1.3.3 Culverting of a tributary of Highlay Creek.

In addition to reclaiming 480 metres of the Gully Stream, the applicant is proposing to construct a 51 metre 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).

1.3.4 Effects of discharges on Deepdell Creek and Shag River

Given that toxicant concentrations are not expected to change significantly in Deepdell Creek or 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 will be unchanged. However, the increase in nitrate concentrations suggested by the Water Quality Effects Assessment and the Ecological Effects Assessment (median = 2.4 mg/L, 95^{th} 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.

1.3.5 Reclamation of tributaries of Camp Creek

The pit excavation will result in the loss of approximately 200 metres of ephemeral seepage in the Camp Creek catchment and an approximately 480 metre 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).

1.3.6 *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.

1.4 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 should 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); and
- An assessment of 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; and
  - 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.

1.5 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.

1.6 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.

2 Updated assessment

2.1 Review of the water quality component of the report

2.1.1 Review of Water Quality Effects Assessment

Subject:	**Oceana Gold Ltd Consent Review – GoldSim Modelling**
Attention:	Aquanet Consulting Ltd
From:	James Blyth
Date	16 April 2020
Copies to:	

1 Introduction

The purpose of this memo is to provide a summary of the updated information provided by GHD as part of the S92 request relating to the Oceana Gold Ltd Assessment of Environmental Effects (AEE) consent application to Otago Regional Council, regarding the Deepdell North Stage III Project.

This is in response to the request for more information relating to GoldSim modelling, titled 'Oceana Gold Ltd Consent Review – GoldSim Modelling' (Blyth 2020).

Documents reviewed from the S92 request 2 April 2020 were:

1. Appendix E - GHD Response to ORC RFI. *16-page report.*

2 Request for additional information and response

The following sections provides professional opinion on the data provided by GHD in response to the S92 requests in Blyth 2020.

2.1 Model hydrological calibration

2.1.1 Presentation of the 6.5-year hydrological calibration period (graphically)

Model performance was considered unsatisfactory for the Nash Sutcliff Efficiency (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. The suitable calibration at low to moderate flows suggest this model would be appropriate to simulate flow and can be linked to a water quality model to estimate loads and concentrations (see Section 2.2.1).

2.1.2 Analysis and tabulation of model performance by comparing simulated flows to observed based on Moriasi et al. 2007, using hydrological parameters NSE and PBIAS.

Suitable results for model performance, see Section 0. The simulated and modelled mean annual volume provide useful comparisons of the models underprediction of total runoff volume, which is conservative when considering water quality concentrations.

2.1.3 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).

Unfortunately, no data were available within the mine to help calibrate mine site runoff. The subsequent approach of using the rational method with runoff coefficients is typical in many mine water balances. However, given mine runoff and seepage are the primary delivery pathways for nutrient and contaminant loads off site, it would be the authors recommendation that future monitoring of flows or water levels be conducted at appropriate mining locations/infrastructure (such as sediment ponds or collection drains) should this consent application be granted. This is on the basis that mining may continue at this site and future model uses (from recalibration/validation to discrete water balance/quality investigations) would benefit from this data and also help identify if any model assumptions relating to seepage and runoff are acceptable. A significant divergence from model assumptions (such as a greater seepage volume) could mean the model under-predicts receiving environment water quality impacts.

This is of importance given that while the hydrological model underpredicts volumes (compared to observed data at the calibration site) and could be considered conservative for water quality concentrations, seepage and runoff from the waste rock stack (likely contributing the greatest contaminant load) is essentially uncalibrated due to a lack of additional on-site hydrological monitoring to inform the model parameterisation.

2.2 Water quality modelling:

2.2.1 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.

The modeler's have applied a truncated normal distribution for water quality parameters. This means on every day of the simulation, a water quality concentration is randomly selected from the truncated normal distribution and applied in the model (to flow), 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.

Figure 3-3 to Figure 3-8 of the Appendix E S92 response details the mean, upper and lower concentration bounds of the truncated normal distributions for sulphate. No other modelled water quality parameters have been presented (i.e. nitrate-nitrogen, arsenic, lead) and subsequently, cannot be assessed. Assuming the truncated distribution for these other parameters captures the observed data as per the sulphate examples, this would be considered acceptable, however any sites that show an increasing trend in concentrations should be monitored as per comments below.

The modelled sulphate distributions are considered to be suitable to represent the range of observed concentrations to date. However, concentrations at some locations are increasing (e.g. Figure 3-4 Coronation Silt Pond) and may exceed the upper threshold applied in modelling, in the future. The lower flows simulated in the model 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. This cannot be confirmed (see Section 2.1.3).

The current upper threshold in GHD's Figure 3-4 (see image below) for sulphate exceeds the highest recorded observed concentration by ~20%, providing margin for the water quality modelling. Ongoing monitoring is recommended at this site and after 3-4 years should be compared to the modelled truncated normal distribution (i.e. Figure 3-4) to validate the model assumptions. This could be considered in conjunction with flow and water level monitoring recommended in Section 2.1.3 to provide confidence the model suitably captured water quality loads and flow from the disturbed areas of the mine.

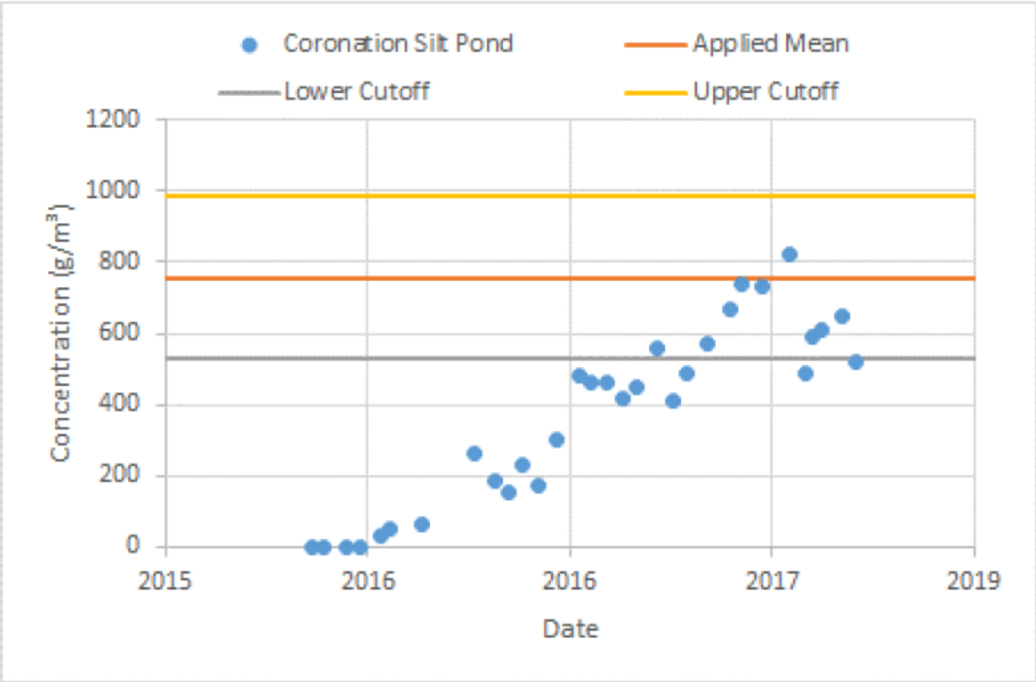

Figure 3-4 Coronation Silt Pond Sulfate concentrations

2.1.2 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.

No landuse mapping was undertaken, meaning the model lacks representation of the daily, monthly and annual fluctuations in water quality from other landuses outside of the mining domain (the wider catchment). The approach of applying mean concentrations to the river to represent natural load is considered acceptable, given sulphate monitoring data of DC01 shows low background concentrations. However, monitoring is very limited for nitrate-nitrogen concentrations (only 4 monitoring points) and subsequently applying a background value of 0.05 g/m^3 may not represent the full range of river concentrations, which can fluctuate significantly over a year depending on upstream farming practices. The 'natural' background 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).

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

2.2.3 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.

The data presented shows 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 3-13 presented below from GHD) 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. See section 2.2.2 for recommendations.

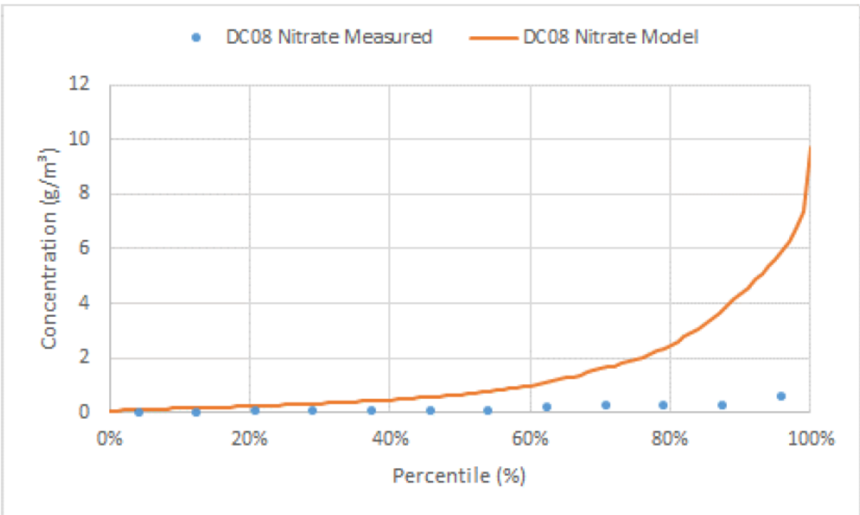

Figure 3-13 Comparison of measured and modelled Nitrate concentrations at DC08 for 2015-2018

3 References

Blyth, J. 2020. Oceana Gold Ltd Consent Review – GoldSim Modelling. Request for more information. 5 February.

2.1.2 Effects on water quality in Deepdell Creek and Shag River.

The compliance criteria presented in Section 1.3 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:

- pH;
- Arsenic;
- $Cyanide_{WAD}$;
- Copper;
- Iron;
- Lead;
- Zinc; and
- Sulphate.

In my initial assessment I asked that the applicant provide all the available nutrient data for the DC08 and Loop Road compliance sites and a far more detailed assessment of what suitable nutrient guidelines would be to control periphyton growth (see Section 1.2.2 for further information). Unfortunately, the applicant has not provided the requested information in their S.92 response.

In Appendix F of the S.92 response Ryder Environmental Limited has assessed the available water quality data for a number of sites on both Deepdell Creek and Shag River. However, they have not analysed data for the compliance monitoring sites specified in the Proposed Conditions (DC08 for Deepdell and Loop Road for the Shag). As these are the sites where water quality standards will apply, the development of those standards should be based on data collected from those sites (not from data collected 15 km downstream as is the case for the Shag River). Water quality data do exist for the DC08 and Loop Road sites (included in Water Quality Effects Assessment – DRP data may be limited), so it is unclear why they have not formed the basis of this part of the S.92 response. Furthermore, if the available data are insufficient to inform this sort of analysis the appropriate response should have been to collect additional data, not exclude it from the analyses.

In addition to the data issues described above, the underlying approach used by Ryder Environmental Limited to develop the DIN and DRP standards proposed in the S.92 request is not appropriate. The standards are based on the DIN and DRP attribute states set out in the Draft NPS. The use of these attribute states in a consenting framework is fraught with problems. Specifically:

- They are not based on cause-effect relationships between nutrients and plant growth, but correlations between DIN and DRP and a range of attributes which include periphyton. From a resource management perspective, using these numbers is the same as implementing standards for the percent of catchment in indigenous land cover (which is also strongly correlated to most freshwater attributes, including DIN and DRP);
- They are based on a multiple lines of evidence approach put forward by Fish & Game in multiple Schedule 1 processes. Despite making it into the Draft NPS-FM, that approach is yet to meet the standard for publication in a peer reviewed journal (based

on a search of google scholar and the cited journal), or widespread acceptance in the scientific community; and

- These numbers currently have no legal standing, as the version of the NPS-FM in which they are set out is still in draft.

Based on the nitrate data presented in Figures 10 and 11 of the Water Quality Effects Assessment, the standards proposed in the S.92 response would allow for a significant increase in DIN in both the Deepdell Creek and the Shag River. The maximum nitrate concentration at both the DC08 and Loop Road Sites in 2018-2019 were less than 0.5 mg/L. Thus, setting a standard for the 95th percentile concentration of 1.1 mg/L would allow for significant degradation.

In short, the DRP and DIN standards set out in Appendix F of the S.92 have been developed using an unsuitable method and inappropriate data It is also likely they will allow for a significant degradation in DIN at both the DC08 and Loop Road sites, and there is no guarantee that they will control periphyton growth at the current level (analysis of effects on periphyton growth limited to sites 15 km downstream of mine on Shag River). Furthermore, it is still unclear whether the applicant is actually willing to include DIN and DRP standards in the consent conditions.

2.1.3 1.2.2 Effects on water quality in Highlay Creek

In my initial assessment I requested the applicant determine the 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, I suggested that these standards should be set to control plant growth rather than toxicity.

The applicant has provided the requested data in Appendix E of the S.92 response but has not gone so far as to suggest water quality limits (DIN and DRP limits are proposed in Appendix F). While the data provided by the applicant supports my initial assessment that compliance standards for the DC08 site would not protect against significant adverse effects in Highlay Creek, it does show that significant adverse toxicity effects are not likely. A summary of the current and future (based on full implementation of the WRS) 95th percentile toxicant concentrations for Highlay Creek, and suggested water quality standards based on the ANZECC (2000) and Hickey (2013) (nitrate only) guidelines are provided in Table 1. The proposed standards are appropriate for slightly to highly disturbed ecosystems and should apply at HC02.

While I have suggested a nitrate standard for toxicity in Table 1, it must be noted that this will not control for periphyton growth. Indeed, looking at the expected nitrate concentrations, it is clear that the activity will increase nutrients to the extent that the risk of periphyton growth will be significantly increased. While Appendix F of the S.92 response does propose DIN and DRP standards as requested, they align with proposed NPS attribute state C thresholds which are not appropriate for the reasons set out in Section 0. Furthermore, based on the analysis provided in Appendix E of the S.92 response, it is very unlikely that the proposed DIN standards could be met (95%ile concentrations @ HC02 = 3.4 mg/L; standard = 2.05 mg/L).

In short, while discharges to Highlay Creek are unlikely to cause toxicity effects, the expected increase in nitrogen may increase the risk of plant growth significantly.

Table 1: Current and future contaminant concentrations in Highlay Creek, and suggested compliance criteria standards for HC02. Note standards are based on existing species protection thresholds.

Parameter	DC08 standard	Loop Rd. standard	Current 95th %ile conc.	Future 95th %ile conc.	Current species protection level	Rec. stand. For HC02 (protection level)	% species protection guidelines (ANZECC (2000)/Hickey (2013)) 80%	90%	95%	99%
Arsenic	0.15	0.01	0.002	0.013	95%	0.042 (90%)	0.14	0.042	0.013	0.0008
Cyanide	0.1	0.1	-	-	N/A	0.018 (80%)	0.018	0.011	0.007	0.004
Copper	0.009	0.009	0.0013	0.001	95%	0.0014 (95%)	0.0025	0.0018	0.0014	0.001
Lead	0.0025	0.0025	0.0001	0.002	99%	0.0034 (95%)	0.0094	0.0056	0.0034	0.001
Zinc	0.12	0.12	0.0025	0.002	99%	0.008 (95%)	0.031	0.015	0.008	0.0024
Nitrate (med./95th%ile)	N/A	N/A	0.09/0.41	0.9/4.1	99%	2.4/3.5 (95%)	1.0/1.5	2.4/3.4	3.8/5.6	6.9/9.8

2.2 Review of the ecological component of the report

2.2.1 Discharges to Highlay Creek and its tributaries

In my initial assessment I opined that the effects of the discharge of contaminants to Highlay Creek and its Western Tributary (location shown in Figure 1) have not been properly assessed in the Ecological Effects Assessment. Appendix F of the S.92 response provides very little additional information and has limited its assessment to DIN and DRP. Nevertheless, based on the water quality data contained in Appendix E, it is my opinion that discharges to Highlay Creek and its western tributary will not have significant toxicity effects on aquatic life (more than minor toxicity effects are possible but not likely). While some contaminants will exceed the relevant 99% species protection thresholds when the WRS is implemented, this is unlikely to have an effect, as the 1% of species that could be impacted are probably already affected by other stressors.

While more than minor or significant toxicity effects are unlikely in Highlay Creek, the increase in nitrogen concentrations may increase the risk of periphyton growth. While the effect of this on aquatic life may not be significant, I still recommend that periphyton targets or standards are included in the conditions of the consent to manage this risk.

2.2.2 Reclamation of tributaries of Highlay Creek

In my initial assessment I agreed with the applicant that the effects of reclaiming the ephemeral and intermittent reaches of the Gully Stream are unlikely to be more than minor. However, to finalise my assessment I requested a breakdown of the total length of reclamation undertaken by Oceana Gold in the Deepdell Creek catchment to date. This information is provided in Point 23 of Appendix F and confirms that the length of new reclamation is negligible in terms of catchment length and the length already reclaimed. As such the effects are unlikely to be more than minor at the catchment scale.

2.2.3 Culverting of a tributary of Highlay Creek.

Based on the information provided in Appendix F of the S.92 request, I agree that the construction of a 51 metre culvert in an intermittent reach of the "Highlay Tributary" (location shown in Figure 1) will not have more than minor effects on aquatic life, provided that construction is undertaken in a manner consistent with the methodology described in Point 21 of Appendix F of the S.92 response.

2.2.4 Effects of discharges on Deepdell Creek and Shag River

In my initial assessment I requested that the applicant 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 additional assessment provided in Appendix F of the S.92 request does not do this. Phosphorus concentrations are not provided for Deepdell Creek and water quality data collected at the DC08 or Loop Road monitoring sites are not presented (See Section 0 for more information).

2.2.5 Reclamation of tributaries of Camp Creek

In my opinion the adverse effects of reclaiming approximately 200 metres of ephemeral seepage and 480 metres of highly modified stream in the Camp Creek tributary 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).

2.2.6 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.

2.3 Information not provided with S.92 response

While not needed to inform this assessment, some of the information requested has not been provided. This information may be useful if this consent application goes to a hearing: Accordingly, I have listed it below:

- The available nutrient data for the Deepdell Creek (DC08) and Shag River (Loop Road) compliance sites were not provided;
- A detailed assessment of what suitable nutrient guidelines would be to control periphyton growth in Deepdell Creek, Highlay Creek and Shag River has not been provided. The provided analysis of the effects of nutrients on periphyton growth is limited to sites 15 km downstream of mine on Shag River; and
- It is still unclear whether the applicant is willing to include DIN and DRP standards in the consent conditions.

2.3 Recommendations on consent conditions

We recommend that consent conditions include:

- Water quality limits for nitrogen and phosphorus in Deepdell Creek and Shag River. Note, the limits proposed in Appendix F of the S.92 request are not appropriate;
- Water quality limits for Highlay Creek (see Table 1); and
- Periphyton standards for Highlay Creek, Deepdell Creek and Shag River that reduce the risk of increases in nitrate causing nuisance periphyton blooms;
- A requirement for additional monitoring to be used to validate the water quality model (from James Blyth):
    - There is a lack of water level/flow data used to calibrate the mine site. This is important as most of the contaminant load from seepage and runoff is from the mine, yet is uncalibrated;
    - As such monitoring conditions are needed that ensure this hydrology information, and additional WQ data, is captured;
    - Measured water quality data should be compared to the modelled inputs (such as the mine water concentration ranges applied in modelling) and outputs (the receiving water bodies concentrations) in 4 years' time; and
    - Should there be a significant divergence from the modelling (e.g. higher concentrations) then a condition should be triggered that would require an investigation into whether the modelling predictions (of water quality in receiving environments) are still valid.
- A requirement for the Water Quality Management Plan to include appropriate monitoring of the effects of sediment pond discharges to Highlay and Deepdell Creeks. This should include:
    - Monitoring of suspended solids in the discharges;
    - Upstream and downstream monitoring of water clarity, turbidity deposited sediment and suspended solids monitoring; and
    - Appropriate ecological monitoring.

2.4 Summary

- Discharges to Highlay Creek, Deepdell Creek and Shag River are unlikely to cause toxicity effects on aquatic life;
- Increases in nitrate in Highlay Creek, Deepdell Creek and Shag River due to the proposed discharges could increase the risk of nuisance periphyton growth. Accordingly, periphyton standards should be included in consent conditions to ensure that blooms do not cause significant effects on aquatic life;
- The proposed stream reclamation and culverting is unlikely to have more than minor effects at the catchment scale; and
- The modelling supporting this application is appropriate (on the basis of the GoldSim modelling alone). However, 'validation' monitoring is needed as a condition of this consent to ensure that the water quality effects are not worse than expected (From James Blyth).

3 References

ANZECC, 2000. Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council, Canberra, Australia.

Hickey, C.W. 2013. Updating nitrate toxicity effects on freshwater aquatic species (Client Report No. HAM2013- 009). NIWA, Hamilton, New Zealand.

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