

Date: 4/09/2026

To: Shay McDonald
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Bendigo-Ophir Gold Project Fast-track Approval: Review of applicant's response to the Expert Panel's 11th request for further information

1 Background

Matakanui Gold Limited (the applicant) is seeking Fast-track Approval (FTA) for the Bendigo-Ophir Gold Project (BOGP). I have been engaged by the Otago Regional Council (ORC) to undertake technical reviews of the water quality and aquatic ecology components of their substantive application, and provide comment on additional technical assessments generated throughout the FTA process.

1.1 Scope and limitations

The purpose of this memorandum is to outline and address substantive surface water matters that have arisen from the applicant's response to the 11th request for further information (RFI 11) from the Expert Panel for the BOGP FTA process. For the sake of brevity, it does not address all matters raised in RFI 11. Instead, it is limited to documenting any potential effects that I have identified from my review of the applicant's response, but may not be immediately apparent to the Expert Panel from the information provided to date by the applicant and invited parties. Specifically, it is focused only on the potential for adverse water quality effects to arise from the volumes of seepage bypass identified in the technical documents provided with RFI 11.

This memorandum is prepared within the timeframe for response set out in paragraph 9 of Minute 47 of the Expert Panel, which does not allow for detailed surface water modelling. Accordingly, when assessing water quality effects associated with seepage bypass, the analysis is limited to updating the mass-balance approaches previously utilised by the applicant.

The outputs of the water quality assessments presented in this memorandum should not be treated as accurate estimates of future water quality. Rather, they provide an indication of the potential risk of adverse water quality effects occurring under various levels of seepage bypass, thereby informing a meaningful review of resource consent conditions related to seepage containment measures and monitoring/management measures.

1.2 New material considered

In addition to the material identified in Section 2 of my memorandum dated 16/03/2026¹, I have reviewed the following information provided with the applicant's response to RFI 11:

- Bendigo-Ophir Gold Project Water Resources Impact Assessment Summary (EMM 2026);
- Updated Groundwater Modelling for Bendigo Ophir Gold Deposit (Kōmanawa 2026);
- BOGP Groundwater Site Investigation Memorandum (Hydro Geochem Group 2026a);
- Bendigo Ophir Gold Project: Lindis River and Bendigo Creek freshwater ecology survey Boffa Miskell 2026);
- Downstream Catchment Baseline Water Quality (Geocontam Risk Management 2026a);
- Ecotoxicology (Geocontam Risk Management 2026b);
- Assessment of Environmental Effects (Hydro Geochem Group 2026b); and
- Operational Phase Site Wide Water and Load Balance Model (MWM 2026).

2 Substantive surface water matters identified from the applicant's response to RFI 11

The potential for seepage bypass from the BOGP to generate adverse effects on water quality and aquatic ecology in downstream receiving environments has been the topic of some debate through the BOGP FTA process. However, until recently, the applicant has not provided a robust assessment of the potential seepage volumes that may bypass the planned primary collection systems. For example, in his Seepage Risk Assessment² Mr Ryan Burgess simply described the risk of seepage migration off the BOGP site to down valley receptors as “low” while in his response to RFI 2 of the Expert Panel he provided broad estimates such as “*the proposed Shepherds Engineered Landform (ELF) primary seepage collection system [...] will likely collect 90 % or more of seepage load travelling down the valley*”³.

In response to RFI 11, Kōmanawa Solutions Limited (Kōmanawa 2026) has undertaken further groundwater modelling which provides more refined estimates of potential seepage bypass from different parts of the BOGP. These estimates are specific to individual structures. Based on the summary provided in Hydro Geochem Group (2026b), it appears that, within the Shepherds Creek catchment, between 3% and 10% of mine-contaminated seepage may bypass the primary collection system.

In interpreting these results, Kōmanawa Solutions conclude that “[o]verall the modelling suggests that the potential for lost seepage is low, and that should it occur in excess of the likely limits presented above, it is very likely to be detected by the planned monitoring network”. In my opinion, there is insufficient evidence to support this view. Specifically:

1. While the modelled seepage bypass rate may be low in terms of total volume, no consideration has been given to the impact of modelled seepage bypass on contaminant loads to downstream receiving environments such as the Lindis River; and
2. It is not enough for monitoring to be able to detect seepage bypass. Detection must be paired with triggers that generate a management response sufficient to prevent or minimise adverse

¹ Greer, M.J.C. 2026. Matakanui Gold Limited (the applicant) substantive fast-track approval application for the Bendigo-Ophir Gold Project: Update to technical review on freshwater matters. Torlesse Environmental Limited. Christchurch, New Zealand.

² Burgess, R.O. 2026. BOGP MWSF Seepage Risk Assessment. Hydro Geochem Group Limited. Christchurch, New Zealand.

³ Statement of Evidence of Ryan Oliver Burgess on behalf of Matakanui Gold Limited in response to Request for Information: Mine Water Management. Dated 17 April 2026.

effects. Because the applicant has not considered the extent to which modelled seepage bypass could impact the Lindis River, triggers have not been developed to protect against such effects.

These issues are described further in Section 2.1 to 2.2 below

2.1 Issue 1: Potential for modelled seepage bypass to impact downstream receiving environments

2.1.1 Summary of issue

While the estimated seepage bypass rates documented in Kōmanawa 2026 appear low in volumetric terms, even relatively small seepage bypass rates can result in substantial increases in contaminant loads. The original water balance model report⁴ suggests that passive water treatment will be highly effective at removing contaminants (>99% for most parameters). Accordingly, any seepage that bypasses the water treatment plant (WTP) could have a disproportionate impact on future contaminant loads, with this effect increasing with WTP treatment performance. This is demonstrated in Figure 1 below, which shows how a hypothetical contaminant load increases from 1 tonne per year as progressively greater percentages of seepage bypasses a WTP that removed 99% of the contaminant. At a 2% bypass rate, the load almost triples to 2.98 t/yr, while at 10%, load increases by a full order of magnitude (i.e., 10x).

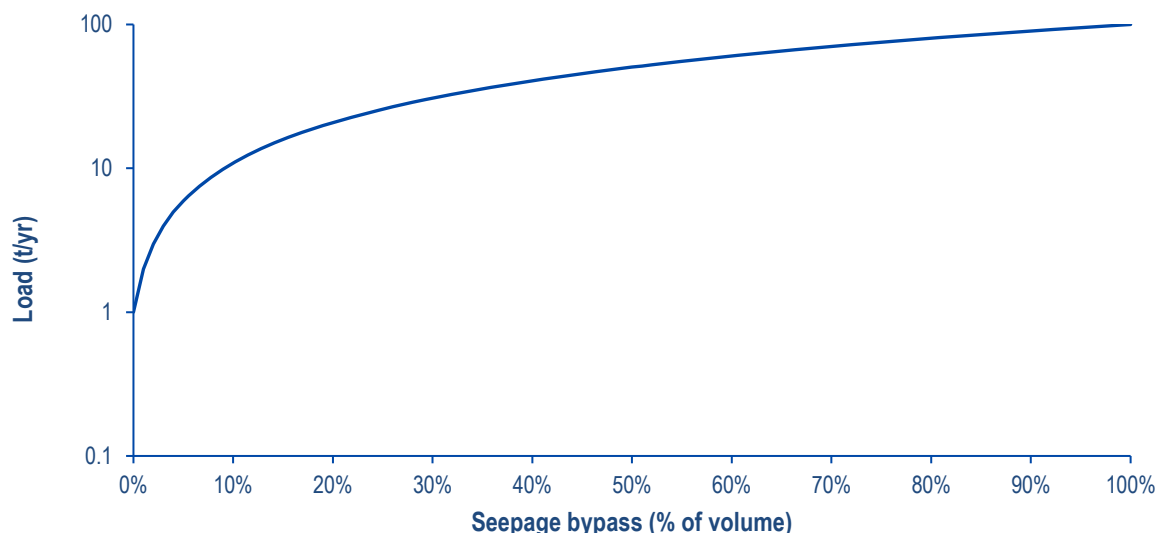


Figure 1: Impact of seepage bypass (as a percentage of total volume) on contaminant load when captured seepage is treated to remove 99% of the contaminant (load at 100% capture = 1 t/yr)

This does not appear to have been considered by the applicant, with the none of the following documents provided in response to RFI 11 raising it as a potential risk:

- EMM 2026;
- Kōmanawa 2026;
- Boffa Miskell 2026;
- Geocontam Risk Management 2026a; or

⁴ Mine Waste Management Limited. 2025. Water and Load Balance Model Report: Bendigo-Ophir Gold Project (Appendix N to B.06 of Substantive application. Mine Waste Management Limited. Christchurch, New Zealand.

- Geocontam Risk Management 2026b

Furthermore, while the updated Water Balance Model provided in MWM 2026 does account for seepage loss during the operation phase of the mine, no consideration is given to potential effects post-closure, when modelled contaminant loads⁵ leaving the BOGP site are highest. To address this information gap, I have updated the analysis conducted by Dr Gregory Ryder in his response to S53 comments received⁶ to provide the Expert Panel with some indication of the scale of risk associated with the predicted level of seepage bypass from primary containment systems.

2.1.2 Methods used to assess magnitude of issue associated with mine impacted seepage bypass

The methodology employed by Dr Ryder (described in paragraphs 27 to 32 of his response to S53 comments received⁶) has been reproduced with the following amendments

- The latest flow and water quality data for the ORC monitoring site in the Lindis River at Ardgour Road have been incorporated;
- Baseline estimates of certain metal concentrations based on minimum values provided in Attachment A of Geocontam Risk Management 2026a have been included to provide an indication of future water quality (rather than estimating change from an unknown baseline); and
- Various seepage bypass rates (3%, 8% and 10%) have been assessed using the following equation:

$$C = C_{curr.} + \Delta C \left(S_{cap.} + \frac{1 - S_{cap.}}{1 - R} \right)$$

Where:

C = Predicted future concentration of a given contaminant

$C_{curr.}$ = Current concentration of that contaminant in the Lindis River

$S_{cap.}$ = Percent of seepage captured

ΔC = Predicted concentration change for the contaminant with 100% seepage capture assumed at year 86 (calculated as per Dr Ryders approach updated to account for updated estimates of baseline water quality and flow in the Lindis River. i.e.,

$$\Delta C = \frac{\text{annual load}^5 / 365}{\text{daily river volume at } Q50 \text{ \& } MALF}$$

R = Assumed percentage contaminant removal from treatment (retrieved from Table of 27 of the original water balance model report⁴).

⁵ Retrieved from Attachment A to Appendix D of Dr Paul Webber's response to RFI 2 of the Expert Panel (Statement of Evidence of Dr Paul Webber on behalf of Matakauui Gold Limited in response to Request for Information: Environmental Geochemistry and Mine Impacted Water. Dated 17 April 2026)

⁶ Statement of Evidence of Gregory Ian Ryder on behalf of Matakauui Gold Limited in response to Section 53 Feedback: Ecotoxicology. Dated 17 April 2026.

The approach described above has also been expanded by first modelling daily baseline nitrate loads in the Lindis River for the period 01/07/2016 to 30/06/2026 using the GENERATEBYBIN function in the [Torlesse Environmental Freshwater Package \(FPack\) Excel Add-in](#)⁷ (see Appendix A for further details). Treated and untreated seepage nitrate loads were then applied uniformly to each day of the record using the following equation:

$$L = L_{mod.} + L_{WBM} \left(S_{cap.} + \frac{1 - S_{cap.}}{1 - R} \right)$$

Where:

L = Predicted future daily nitrate load in the Lindis River at Ardour Road

$L_{mod.}$ = Predicted current daily nitrate load in the Lindis River at Ardour Road (from =GENERATEBYBIN)

L_{WBM} = Predicted daily load from the WBM model at year 86 (calculated from annual loads in Attachment A to Appendix D of Dr Paul Webber's response to RFI 2 of the Expert Panel⁸)

$S_{cap.}$ = Percent of seepage captured

R = Assumed percentage contaminant removal from treatment (Table of 27 of the original water balance model report⁴)

Daily in river nitrate concentrations were then calculated for each day of the record by dividing the derived daily nitrate loads by the daily mean river flow.

2.1.2.1 Notes on methodology

The methodology employed by Dr Ryder has been reproduced here because it was previously used by the applicant's experts to assess the potential effects of contaminant loads leaving the BOGP site on water quality in the Lindis River. The analysis undertaken here applies the same basic mass-balance approach, but incorporates the additional seepage bypass identified through the applicant's updated groundwater modelling and updates the underlying flow and water quality inputs. It therefore provides an indication of the potential consequences of seepage bypass using an assessment methodology previously considered appropriate by the applicant for assessing the effects of contaminant loads from the BOGP on the Lindis River.

The analysis described above assumes that seepage bypass has the same contaminant characteristics as the seepage entering the treatment system. This may or may not be accurate, as the available information does not allow the contaminant characteristics of bypassed seepage to be independently characterised.

2.1.3 Results

The results of the assessment methodologies described in Section 2.1.2 suggest that relatively small seepage bypasses have the potential to significantly degrade water quality in the Lindis River, especially at low flows. For example:

- Under the assumptions of the mass-balance assessment, a seepage bypass rate of 3% is predicted to increase median nitrate concentrations in the Lindis River by 20% (Figure 2). This

⁷ <https://www.tein.co.nz/#Software>

⁸ Statement of Evidence of Dr Paul Webber on behalf of Matakau Gold Limited in response to Request for Information: Environmental Geochemistry and Mine Impacted Water. Dated 17 April 2026.

increases to 37% at 8% seepage bypass and 43% at 10% seepage bypass (Figure 2). The effects are even more pronounced at low flows, when the risk of nutrient induced periphyton growth is highest. While a 3% seepage bypass rate is only predicted to generate a 22% increase in 95th percentile nitrate concentration, a bypass rate of 8% or 10% is projected to result in a 65% and 87% increase respectively. Most concerning is that a seepage bypass rate of 3% to 10% is predicted to result in nitrate concentrations increasing by between 260% and 725% at seven day mean annual low flow (MALF) (Table 1).

- Dissolved zinc concentrations at MALF are predicted to increase by 559% at a 3% seepage bypass rate (Table 1), with 8% and 10% bypass rates generating between 1500% and 1800% increases (Table 1). At median flow, the predicted increases are much smaller, but still significant, ranging from 25% at a 3% seepage bypass rate to 81% at 10% (Table 1).

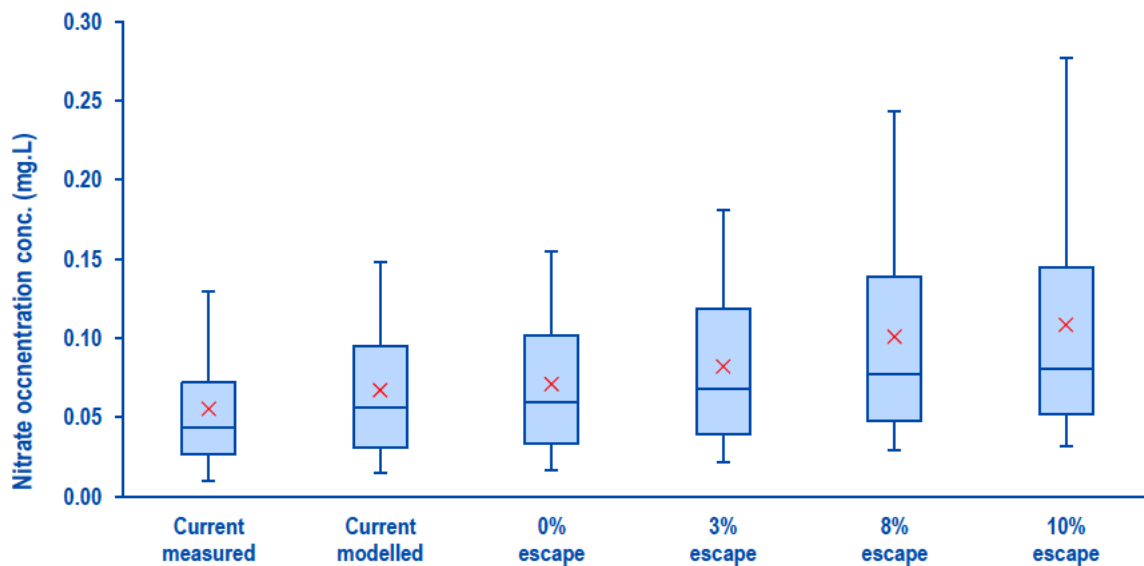


Figure 2: Predicted (using FPack) distribution of nitrate concentrations in the Lindis River at Ardgour Road at seepage bypass rates of 0% to 10%. Current measured and modelled concentrations are provided for context. The whiskers represent 5th and 95th percentile concentrations, the outer limits of the boxes represent 25th and 75th percentile concentrations, while the line and the red crosses represent the median and average concentrations respectively.

Table 1: Predicted (using Dr Ryders approach) concentrations of key parameters in the Lindis River at Ardgour Road (+ predicted increase from baseline where data are available) at median flow and MALF. Green, yellow and orange shaded boxes indicate exceedance of the ANZG (2018) default guideline values (DGVs) for the protection of 99%, 95% and 90% of species respectively. Blue shaded boxes do not exceed the 99% species protection DGV.

Parameter	@Median			@MALF		
	C @ 3% <i>S_{cap}</i>	C @ 8% <i>S_{cap}</i>	C @ 10% <i>S_{cap}</i>	C @ 3% <i>S_{cap}</i>	C @ 8% <i>S_{cap}</i>	C @ 10% <i>S_{cap}</i>
Al	0.016 (+2%)	0.016 (+3%)	0.016 (+3%)	0.023 (+45%)	0.025 (+55%)	0.025 (+59%)
As	0.005 (+4%)	0.005 (+9%)	0.006 (+10%)	0.009 (+83%)	0.014 (+187%)	0.016 (+229%)
Cd	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	<0.001 (+14%)	<0.001 (+29%)	<0.001 (+36%)	<0.001 (+311%)	0.001 (+648%)	0.001 (+783%)
Cr	<0.001 (+7%)	<0.001 (+14%)	<0.001 (+16%)	<0.001 (+151%)	0.001 (+302%)	0.001 (+362%)
Cu	0.001 (+2%)	0.001 (+2%)	0.001 (+2%)	0.001 (+33%)	0.001 (+41%)	0.001 (+45%)
Fe	0.032 (+11%)	0.036 (+24%)	0.038 (+30%)	0.097(+234%)	0.184 (+533%)	0.218 (+653%)
Mn	0.002 (+11%)	0.002 (+14%)	0.002 (+15%)	0.008 (+241%)	0.008 (+306%)	0.008 (+332%)
Mo	0.001	0.001	0.001	0.011	0.022	0.027
NO ₃ -N	0.067 (+12%)	0.076 (+27%)	0.079 (+33%)	0.217 (+264%)	0.413 (+593%)	0.491 (+725%)
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	<0.001	0.001	0.001	0.007	0.013	0.016
SO ₄	1.83	1.868	1.884	40.257	41.109	41.45
Sr	0.016	0.033	0.039	0.359	0.715	0.858
CN	<0.001	<0.001	<0.001	0.001	0.001	0.001
Zn	0.001 (+25%)	0.002 (+65%)	0.002 (+81%)	0.007 (+559%)	0.015 (+1433%)	0.019 (+1783%)

Regarding the potential for the assessed seepage bypass rates to generate adverse ecological effects in the Lindis River:

- A 3% seepage bypass rate at MALF is predicted to result in the ANZG (2018) 99% species protection threshold for dissolved zinc being exceeded, while 8% and 10% bypass is predicted to result in:
 - The 95% and 90% species protection DGVs for zinc being exceeded respectively (Table 1); and
 - The 95% species protection DGVs for arsenic and antimony being exceeded.
 While these results only provide a rough indication of future water quality, they do highlight that unless adequate detection and capture is guaranteed, there is a risk of seepage bypass generating toxicity effects in the Lindis River at the seepage bypass rates described in Kōmanawa 2026.
- Nitrate concentrations are not predicted to increase to the extent that toxicity effect would occur at any of the assessed bypass rates. However, the large proportional and absolute increases predicted at MALF suggest that the potential for the nitrate load in the seepage bypass to drive nuisance periphyton growths during summer low flows cannot be discounted.

It is difficult to calculate the rate of seepage that could bypass the WTP without risking adverse ecological effects in the Lindis River with a high degree of certainty. Ideally, this would have been done by the applicant as part of their response to RFI 11. However, the basic assessment methodologies they have previously employed suggest:

- A bypass rate of less than 4% would ensure that dissolved arsenic, zinc and antimony concentrations in the Lindis River do not increase above the ANZG 95% species protection threshold at MALF; and
- Under the assumptions of the mass-balance assessment, a bypass rate of just 1% is predicted to more than double nitrate concentrations in the Lindis River at MALF, resulting in concentrations in excess of 0.13mg/L. It is not possible for me to determine exactly what effect that would have on periphyton growth in the Lindis River with the data and time available to me at this point in the FTA process. However, it is my opinion it represents a material increase in the risk of nuisance periphyton growth which, based on Boffa Miskell 2026, occurs at the Ardgour Road site under current conditions. Accordingly, it is my opinion that the potential for significant adverse effects at this level of seepage cannot be discounted and that seepage bypass should be maintained at <1%, which provides a conservative basis for ensuring that the ecological effects on the Lindis River are no greater than those described by Dr Ian Boothroyd⁹ and Dr Greg Ryder⁶ in their responses to S53 comments received (i.e., very low).

2.2 Issue 2: Need for triggers and standards that protect the values of the Lindis River

Given the potential risk of adverse effects associated with the discharge of even small amounts of seepage bypass, if the protection of the values of the Lindis River is a purpose of the final consent conditions, it is my opinion that they should stipulate specific water quality triggers for further seepage management. My updates to the applicant's own assessment methodologies suggest that achieving a high degree of certainty that the Lindis River will be protected from significant adverse effects requires close to 100% seepage capture (see Section 2.1.3), and it is my opinion that triggers should ultimately reflect this. Accordingly, the adoption of triggers similar to those proposed by the applicant for the onset of active water treatment (e.g., 50% of the compliance standards) is unlikely to be sufficiently stringent.

While the consent conditions should include robust and stringent quality triggers that apply to both surface water and groundwater, I understand that groundwater triggers are particularly important because seepage bypass is most likely to leave the site undetected through this pathway, since:

- While the updated operational phase water balance model in MWM 2026 suggests any seepage bypass in the Shepherds Valley will discharge to Shepherds Creek upstream of SC01, I understand from Ms Alexandra Badenhop's review of Hydro Geochem Group 2026a that this is unlikely to be the case. Specifically, Ms Badenhop notes that "*in reality uncaptured seepage would not report to SC01, rather will be transported in groundwater*"; and
- If untreated seepage were to enter Shepherds Creek before leaving the BOGP site, even small volumes would likely be detectable. Specifically, seepage bypass with the potential to generate adverse effects on the Lindis River is predicted to result in a clear water quality signature, with concentrations of key contaminants in Shepherds Creek either:
 - No longer reflecting the mass loads discharged from the WTP, to the point where they may exceed those observed in the treated mine water; and/or
 - Exceeding the applicable water quality limits for SC01. For example, a 1% bypass rate at year 86 of the mine is predicted to result in the proposed compliance standards for all parameters except manganese being exceeded at MALF.

⁹ Statement of Evidence of Ian Kenneth Grant Boothroyd on behalf of Matakanui Gold Limited in response to Section 53 Feedback: Aquatic ecology. Dated 17 April 2026.

Due to the predicted sensitivity of the Lindis River to even small volumes of untreated seepage, it is my opinion that groundwater and surface water triggers should be in place for the entire duration of the consent, including the operational phase, during which the updated water balance model indicates that some degree of seepage bypass is expected (based on the updated water balance model in MWM 2026). Furthermore, I consider that there would be benefit in applying surface water compliance standards to the Lindis River at the Ardgour Road site. Such compliance standards would need to account for the sulphate load discharged through the active and passive water treatment plants, but should be sufficiently stringent to ensure that any signal of untreated seepage triggers an immediate response to limit the extent of adverse effects to the fullest extent possible.

Importantly, the latest version of the applicant's proposed conditions (dated 28/08/2026) do not include triggers for further seepage management, or specify how they would be developed under the Water Management Plan. In the absence of such triggers, it is my opinion that the potential effects on the Lindis River could be substantially greater than those previously described by Dr Ian Boothroyd⁹ and Dr Greg Ryder⁶ in their responses to the S53 comments. Indeed, without a comprehensive assessment by the applicant to further test the modelling presented in this memorandum, it is my opinion that the potential for significant adverse effects associated with metal/metalloid toxicity and periphyton growth cannot be discounted.

While, it is my view that surface water and groundwater quality triggers for further seepage management are best stipulated directly in the consent conditions, I note that the applicant has not proffered any numerical triggers that could be adopted, and that Ms Badenhop has stated that she also "*cannot, without further assessment, confidently provide an indication of appropriate triggers for the detection of seepage*". Accordingly, the next best alternative is for the consent conditions to specify how appropriate triggers are to be developed through the Water Management Plan, including the process and criteria to be applied to ensure that any deterioration in groundwater or surface water quality is identified and addressed before untreated seepage can reach the Lindis River.

I acknowledge that the outputs presented in this memorandum can be considered conservative from a methodological perspective, as they assume that 100% of the contaminant load leaving the BOGP site enters the Lindis River. However, they are the only quantitative assessment currently available to me on which to base my recommendations for consent conditions, as the applicant has not undertaken more robust and realistic modelling of the potential effects of the seepage bypass rates modelled in Kōmanawa 2026 on the Lindis River.

3 Summary

In response to RFI 11 the applicant has conducted further groundwater modelling that has refined previous estimates of seepage bypass to a range between 3% and 10% in the Shepherds Creek catchment. Despite, this, none of the technical reports provided with the applicant's response to RFI 11 assess the impact that this level of seepage bypass could have on downstream receiving environments. Instead, the potential for seepage bypass is still described as being low, as it has only been considered in volumetric terms, rather than in terms of the impact it has on contaminant loads leaving the BOGP site.

Re-running and expanding on mass balance approaches previously conducted by the applicant's experts suggests that even at the lower end of the predicted seepage bypass range, there is potential for marked increases in nitrate and metal/metalloid concentrations in the Lindis River at low flows which could generate adverse periphyton and ecotoxicological effects. In the absence of a comprehensive assessment by the applicant's experts to suggest the contrary, it is my opinion that the potential for these

effects to be significant cannot be discounted. Based on the outputs of the analyses described in this memorandum, protection against such effects could require seepage bypass rates to be maintained at <1%. To ensure this, it is my opinion that final consent conditions need to include water quality triggers (surface and ground) that reflect this low level of bypass.

4 References

- Australian and New Zealand Governments and Australian state and territory governments (ANZG), 2018. Australian and New Zealand guidelines for fresh and marine water quality. Governments and Australian state and territory governments, Canberra, Australia.
- Moriasi, D.N., Arnold, J.G., Van Liew, M.W., Bingner, R.L., Harmel, R.D., Veith, T.L., 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Trans. ASABE 50, 885–900.

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Appendix A: Description of baseline water quality model

Model description

To develop a simplified probabilistic baseline nitrate data series for the Lindis River at Ardour Road, monthly river water quality data and daily mean flow data were sourced from the Otago Regional Council Environmental Data Portal. Water quality data were then partitioned into “bins”, based on river flow at time of sampling. The =GENERATEBYBIN function in the Torlesse Environmental Freshwater Package (FPack) Excel Add-in was then used to generate a synthetic record of water quality for every day in the available flow record. This function is based on the PointSIM approach developed by Aquanet Consulting Ltd (now Traverse Environmental Ltd) which has been used extensively in consent processes in the Manawatu-Whanganui Region and Greater Wellington Regional Council’s planning processes.

For each day of the available flow record =GENERATEBYBIN:

1. Applies Box-cox transformations to the measured water quality data collected within the relevant flow bin. This transforms non-normal water quality data into as normal a distribution as possible through the following equation:

$$BoxCox = \frac{Conc_{measured}^{\lambda} - 1}{\lambda}$$

Where λ is the value between -2 and 2¹⁰ where the transformation best normalises the measured water quality data (automatically generated by FPack as part of the =GENERATEBYBIN function).

2. Generates a modelled concentration by:
 - a. Randomly sampling in a normal distribution from the transformed data frequency described above within prescribed lower and upper bounds (which can be modified to calibrate the model) (i.e., sampled results are normally distributed); and
 - b. Back transforming the sampled value to a concentration through the following equation

$$Conc_{modelled} = (\lambda \times BoxCox + 1)^{\frac{1}{\lambda}}$$

A modelled daily load is then manually calculated through:

$$Load_{modelled} = Conc_{modelled} \times Flow_{daily\ mean} \times 86400$$

Model performance

To test the potential performance of the approach described above, it has been applied to water quality (from 61 samples) and flow data from Lindis River at Ardour Road site between 01/07/2016 and 30/06/2026 using the following flow bins:

- <1/2 median flow;
- <1/2 median flow to median flow;
- Median flow to 3 × median flow; and

¹⁰ It is possible to calculate λ from a range of -5 to 5. However, this adds significant compute time compared to 2 to -2, and trial and error revealed little impact on model performance.

- $>3 \times$ median flow.

Figure A1 presents the measured (observed) and modelled (predicted) probability distributions of the nitrate concentrations in the Lindis River at the Ardgour Road monitoring site. The dotted lines represent the observed concentrations plus or minus the standard deviation of the observed data, as a measure of tolerance in variability. This figure shows that the predicted nitrate were within the tolerance range given by the observed concentrations $\pm$ one standard deviation, indicating an acceptable fit between observed and predicted concentrations.

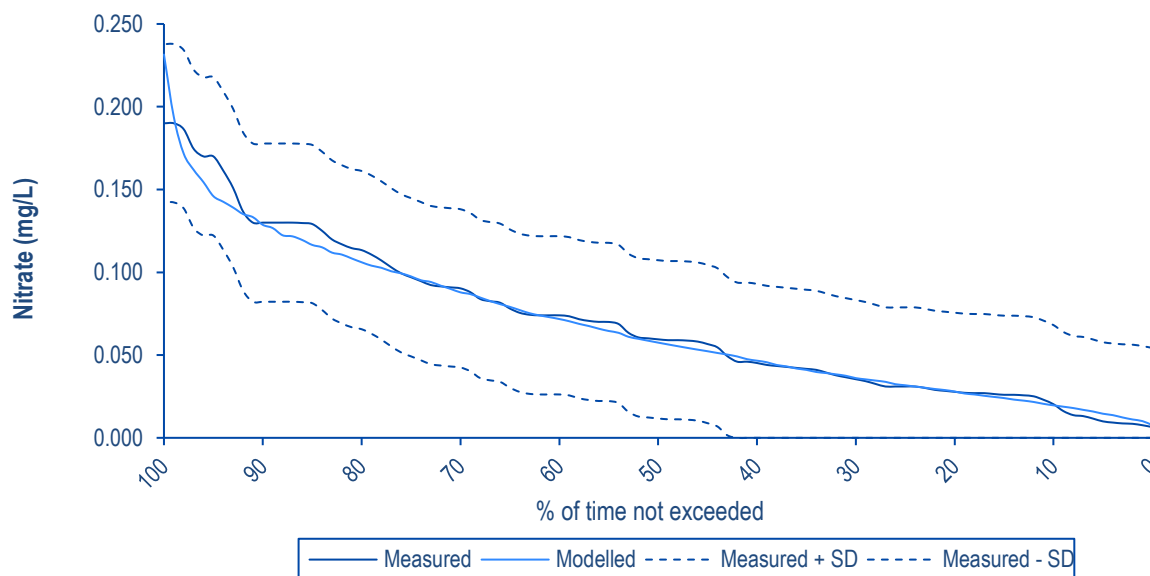


Figure A1: Probability distribution of nitrate concentrations in the Lindis River, as measured in the river (dark blue line) and predicted by the model (light blue line). The dotted black lines represent the measured concentrations plus or minus the standard deviation of the observed data, as a measure of tolerance in variability.

To further assess the performance of the model, the Nash-Sutcliffe Efficiency (NSE) statistic¹¹ was calculated from each percentile¹² (0-100) of the modelled and measured data (shown in Figure A1) and percent bias (PBIAS) has been calculated for:

- Each percentile of the modelled and measured data (shown in Figure A1);
- The average measured and modelled values for each month in the record; and
- The measured and modelled values for each day for which measured data exist.

¹¹ A high NSE calculated from measured and modelled percentile data is an expected outcome of the modelling methodology employed. Generally, if it is mathematically possible to normalise the input water quality data, a randomly selected output dataset can be generated that closely fits that normal distribution. It is not an indication that the model accurately mimics the full suite of environmental factors that impact water quality which is what more complex models attempt to do.

¹² The GENERATEBYBIN function does not attempt to accurately calculate water quality on a specific day, rather it attempts to generate a synthetic record with percentiles that closely match the measured record (as it is percentiles that dictate attribute state) Thus, the NSE has not been calculated based directly on the measured data and the modelled data for the days on which measured data exist.

The NSE and PBIAS are described as:

- NSE is a measure of goodness-of-fit, where less than 0 is poor, 0 indicates an equivalent fit to using the mean of the observed data, and 1 is a perfect fit to observed data; and
- PBIAS is the deviation of data being evaluated, expressed as a percentage. The optimal value is 0, with low-magnitude values indicating accurate model simulation.

The calculated NSE and PBIAS statistics are presented in Table A1. Based on the guidance of Moriasi *et al.* (2007) these statistics indicate the performance of the Cu and Zn models for the Lindis River at Ardgour Road are 'very good'..

Table A1: Model performance statistics.

Statistic	Copper
NSE – Percentiles	0.98 (Very good)
PBIAS – Percentiles	2.36 (Very good)
PBIAS – Monthly average concentration	3.26% (Very good)
PBIAS – Daily measured concentration	5.17% (Very good)