TECHNICAL MEMORANDUM

DATE 5 March 2021 **Project No.** 19127735-614-01_F

TO [redacted] Department for Infrastructure

CC [redacted]

FROM [redacted] **EMAIL** [redacted]

DALRADIAN PROPOSED CURRAGHINALT PROJECT SURFACE WATER QUALITY REVIEW

1.0 INTRODUCTION

Outlined in this memorandum are the findings of our review of reports and associated models/ calculations regarding the analysis of the impact to surface water quality from the proposed Curraghinalt project underground mine and associated infrastructure.

2.0 DATA PROVIDED

Surface water quality modelling is reported in the report "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[1]. A review of the potential impacts on flow rates is presented in "Dalradian Proposed Curraghinalt Gold Mine Project - Water Balance Review"[2]. Table 1 outlines the key files which have been provided to Golder.

Table 1: Key Water Quality Files provided to Golder

File Name
Sample Data - Owenreagh at Mouth.csv
Sample Data - Owenreagh at Pollanroe.csv
Sample Data – Pollanroe.csv
Input Table for Forwards Runs - Owenreagh at Mouth.docx
Curraghinalt_WB_Oct_2020_Monthly FINAL_Base_WQ.gsm
Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx
Attagh Burn Closure Calculations Oct 2020.xlsx
Curraghinalt Burn Closure Calculations Oct 2020.xlsx

[1] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

[2] Golder Associates. 2021. Dalradian Proposed Curraghinalt Project - Water Balance Review. Document Control No. 19127735-613-01_D. January 2021

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File Name
Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx
Owenkillew River (at Owenreagh) Closure Calculations Oct 2020

In addition to these key files, 168 input text files to the Environment Agency River Quality Planning Tool (Monte Carlo)[3] were provided to Golder by Kaya Consultants.

3.0 SUMMARY OF REVIEW COMMENTS - OPERATIONS

3.1 Modelling Software and Objectives

As stated within the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[4], the impacts on downstream watercourses during operations were supported through modelling in the River Quality Planning (RQP) Monte Carlo tool (Version 2.5). The objectives of the water quality modelling were described as follows:

- To estimate maximum discharge concentrations for the parameters outlined in Table 1-1 and Table 1-2 of Annex B of the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[4] report. These parameters are outlined in Section 3.2.2 (Table 3).
- To calculate the effect of the discharge on receiving waters.

Golder comment

The water quality modelling objectives are clearly defined and sufficiently address the requirements of the Environment Statement[5].

The use of the River Quality Planning (RQP) Tool was considered as per instructions from the Northern Ireland Environment Agency (NIEA), as stated in the report "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[4]. This tool was developed by the UK Environment Agency (EA) and is suitable for the water quality model objectives listed above, as outlined by the EA publication "Modelling: surface water pollution risk assessment"[6].

Conclusion: The approach taken to modelling water quality in the receiving water bodies using the RQP Tool is adequate.

3.2 Validity of Key Assumptions and Conclusions

3.2.1 Conceptual Site Models

Conceptual site models for operating conditions for Years 6, 12 and 20 of the Mine Life are presented in Section 6 of "Curraghinalt Gold Mine Project Site Water Balance 2020 Update"[7].

[3] Environment Agency. 2012. Introduction to River Quality Planning Setting Permits and Assessing Compliance.

[4] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. Annex B – Proposed Discharge Criteria for Owenreagh River and Pollanroe Burn, County Tyrone, BT79 7SF October 2020

[5] SRK Consulting. 2017. Environmental Statement for the Curraghinalt Project, County Tyrone, Northern Ireland. Volumes 1, 2 and 3.

[6] Environment Agency. 2014. LIT 10419 Modelling: surface water pollution risk assessment.

[7] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Golder comment

- The conceptual site models presented provide description of flow rates and direction both within the site and through environmental discharges. The descriptions provided are in line with what would be expected for a conceptual site model (CSM).
- No CSMs were provided for closure or existing conditions. While it would be useful for a CSM to be provided to illustrate the anticipated changes during closure, enough information was presented within the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[8] to facilitate Golder's understanding of the site water interactions during closure to allow the assessment to be undertaken.

Conclusion: While it would be useful for a CSM to be provided to illustrate the anticipated changes during closure, enough information has been presented within the relevant reports to allow for the review of the models and model results.

3.2.2 Model Scenarios and Modelled Water Quality Parameters

As mentioned previously in Section 3.1, the RQP models were run in order to:

- Estimate maximum discharge concentrations for the water quality parameters outlined in Table 3. This is described as "**backwards**" modelling[9]. The "backwards" modelling was carried out for (i) Owenreagh upstream of Pollanroe Burn and (ii) Owenkillew River at Curraghinalt Burn.
- Calculate the effect of the discharge on receiving waters for the water parameters outlined in Table 3. This is described as "**forwards**" modelling[9]. The "forwards" modelling was carried out for the following locations: (i) Pollanroe Burn at Mouth, (ii) Owenreagh River at Pollanroe Burn and (iii) Owenreagh River at the Mouth, (iv) Owenkillew River at Curraghinalt Burn, (v) Owenkillew at the Mouth and (vi) Curraghinalt Burn.

These scenarios are summarized in Table 2 below.

Table 2: Model scenarios - Operations

Type of Modelling ("Forwards" or "Backwards")	Location
Backwards	Owenreagh River upstream of Pollanroe Burn
	Owenkillew River at Curraghinalt Burn
Forwards	Pollanroe Burn at Mouth
	Owenreagh River at Pollanroe Burn
	Owenreagh River at the Mouth
	Owenkillew River at Curraghinalt Burn
	Owenkillew River at the Mouth
	Curraghinalt Burn

[8] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

[9] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Table 3 presents the water quality parameters included in the “backwards” and “forwards” modelling exercise.

Table 3: Parameters considered in water quality modelling (Operations)

Parameter	Unit
TSS	mg/L
BOD	mg/L
Total Ammonia	mg/L as N
Nitrate	mg/L as N
Nitrite	mg/L as N
Chloride	mg/L
Fluoride	mg/L
Sulphate	mg/L
Aluminium	mg/L
Antimony	mg/L
Arsenic	mg/L
Barium	mg/L
Boron	mg/L
Cadmium	mg/L
Chromium III	mg/L
Chromium VI	mg/L
Chromium III + VI	mg/L
Cobalt	mg/L
Copper	mg/L
Iron	mg/L
Lead	mg/L
Manganese	mg/L
Mercury	mg/L
Molybdenum	mg/L

Parameter	Unit
Nickel	mg/L
Selenium	mg/L
Silver	mg/L
Sodium	mg/L
Uranium	mg/L
Zinc	mg/L

The water quality parameters pH and Oil and Grease were excluded from this modelling exercise.

In addition to the scenarios listed above which used the RQP models, the impacts on the Owenreagh river of events in excess of design conditions (prediction in Owenreagh River) were considered, based on an assessment of water quality within the ponds and applying dilution calculations to determine the impact on the river. The same parameters outlined in Table 3 were considered. The following events were considered:

- 1-in-1,000 year, 48-hour event
- 2 consecutive 1-in-100 year, 24-hour events.

Golder comment

Based on the stated model objectives, these modelled scenarios are appropriate.

Regarding the list of parameters considered in water quality modelling, the report states that there is no NI standard for Orthophosphate. While this statement is correct, there is a NI standard for reactive phosphorous in rivers defined in Schedule 1 - Part 2 - paragraph 3 of SR351, but reactive phosphorous has not been modelled. Therefore, it has not been possible to assess the potential impact of the proposed project on reactive phosphorus levels in the surface water receptors.

However, phosphorous is not typically a constituent of concern (COC) in orogenic gold deposits such as the Curraghinalt deposit. Geochemical laboratory tests on rocks from the deposits displayed phosphorous concentrations at or close to the analytical detection limit for most samples. It is therefore considered unlikely that reactive phosphorous could be a COC at Curraghinalt.

Apart from phosphorous, the remaining list of parameters is considered appropriate based on the type of mine, regulations, and downstream conditions.

Conclusion: The exclusion of reactive phosphorus from the modelling exercise is not expected to have a meaningful impact on the overall outcome of the surface water impact assessment.

3.2.3 Model Simulation Inputs

3.2.3.1 "Backwards" modelling

For the "backwards" modelling, the RQP Monte Carlo tool required the following inputs:

- Water quality standards or EQS (Environmental Quality Standards) for relevant parameters;

- Flow data for discharge and receiving waters (i.e., Curraghinalt Burn, Pollanroe Burn and Owenreagh River); and
- Background water quality in receiving waters.

As stated in Section 3.2.2, the "backwards" modelling was carried out for the (i) Owenkillew River at Curraghinalt Burn and (ii) Owenreagh River upstream of the Pollanroe Burn, to determine discharge criteria which are protective of EQS and ensure that the chemicals and elements are not a potential risk to the environment.

For parameters with no EQS values, drinking water standards were taken forward as the proposed discharge criteria.

The flow data for discharge and receiving waters was determined based on a detailed hydrological assessment which had been undertaken as part of the Curraghinalt Mine Environmental Impact Assessment. Annual average flows and 95%ile low flows within the Owenkillew River and Owenreagh River (upstream of the Pollanroe Burn) were used for these calculations.

Background water quality in receiving waters was obtained from the baseline assessment and were entered into the RQP tool as non-parametric values.

Golder comment

The methodology for "backwards" modelling is considered to be consistent with NIEA and EA guidance.

The calculations and assumptions to determine the discharge criteria, as well as flows for discharge and receiving waters have been reviewed and are considered appropriate.

Golder carried out a screening assessment of the results of the backwards modelling for all parameters, based on simple dilution calculations. The simple screening tests showed an overall agreement with the reported results. In addition, detailed screening tests of the hazardous parameters Chromium (VI), Lead, Mercury and Arsenic were carried out through use of the RQP Monte Carlo tool. The results of these tests for Chromium (VI) and Lead showed a reasonable match with the reported values, and Golder can corroborate these results. Golder notes the following points for the Owenreagh Catchment:

- The inputs for Arsenic, based on the snapshot of the RQP model inputs/ results, show the mean quality and standard deviation for the upstream river data to be 0.15 ug/L and 0.2 ug/L, respectively[10]. However, the mean quality and standard deviation for the baseline data is 0.56 ug/L and 0.36 ug/L, respectively, resulting in a maximum allowable discharge concentration of 191 ug/L (as opposed to the 203 ug/L reported). However, as the drinking water standard of 10 ug/L is assigned for Arsenic in the "forwards" calculations, this discrepancy has no bearing on the results.
- The results of the "backwards" calculations for Mercury (presented in Table 3-2)[10] indicate a maximum allowable discharge concentration of 0.094 ug/L. Golder is unable to corroborate this result as based on the snapshot of the RQP model inputs/results[10], the mean quality (based on 95%ile values) for the discharge data is 0.0058 ug/L, which is different from the baseline (95%ile) values reported of 0.005 ug/L (Table 3-1).

[10] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland - Annex B (Proposed Discharge Criteria for Owenreagh River and Pollanroe Burn, Gortin, County Tyrone, BT79 7SF)

Conclusion: The approach taken towards the "backwards" modelling is adequate. While some issues with the "backwards" modelling have been identified, the impact of the issues raised above on the simulated river water qualities is expected to be minor.

3.2.3.2 "Forwards" modelling

For the "Forwards" modelling, the RQP Monte Carlo tool required the following inputs:

- Average and 95%ile flows for the receiving waters. This is based on the baseline hydrological assessment;
- Average and standard deviation of flow from the site. This is based on outputs from the water balance model which predicts discharge rates from the water treatment plant;
- Average and standard deviation of the discharge water quality. The average is set to the maximum allowed concentration in the proposed discharge criteria with the standard deviation set to zero, forcing all the discharge to be set to the maximum allowed concentration for all calculations.
- Statistics for receiving water quality. This is based on the baseline water quality set.

As stated in Section 3.2.2, the "forwards" modelling was carried out for the (i) Pollanroe Burn at Mouth, (ii) Owenreagh River at Pollanroe Burn and (iii) Owenreagh River at the Mouth (iv) Owenkillew River at Curraghinalt Burn and (v) Owenkillew River at the Mouth and (vi) Curraghinalt Burn.

Golder comment

Golder carried out screening for the average and standard deviation values used as the inputs (statistics) for the receiving water quality, based on sample data. The values used in the modelling exercise are in line with the screening exercise.

Furthermore, a simple screening assessment of the results of the 'forwards' modelling was carried out for all parameters, based on arithmetic dilution calculations. The simple screening tests showed an overall agreement with the reported results. In addition, detailed screening tests of the hazardous parameters Chromium (VI) and Lead were carried out through use of the RQP Monte Carlo tool. The results of these showed a reasonable match with the reported values.

Conclusion: The approach taken towards the "forwards" modelling is adequate and no issues have been identified by Golder.

3.2.3.3 Events in Excess of Design Conditions

For the modelling of impacts on the Owenreagh River during events in excess of design conditions, the water quality in the ponds was ascertained through transport modelling in GoldSim ("Curraghinalt_WB_Oct_2020_Monthly FINAL_Base_WQ.gsm"), using the same hydrologic inputs and simulation settings as in the base model.

Golder Comment

Golder has reviewed the water quality simulations in the GoldSim model file "Curraghinalt_WB_Oct_2020_Monthly FINAL_Base_WQ.gsm", with the following observations:

- Source term water quality for surface runoff from active areas of the DSF: The solute concentrations shown in Table 9-25 of the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[11] do not match the values implemented in the GoldSim model for some of the parameters

[11] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

(e.g. Cl, F, SO4, Al), also some parameter values in Table 9-25 do not match the geochemical modelling results reported in the 2020 Geochemical Characterisation Report[12].The impact of these discrepancies on modelling results is expected to be minor, because the concentrations in DSF runoff predicted by geochemical modelling are much lower than those predicted for DSF seepage and underground mine water, and DSF runoff is only a minor component of the pond water balance.

- Source term water quality for runoff from the mine site area: The report states "Given the low concentrations of runoff over the active DSF (which would be considered as representative of runoff over exposed mine waste material), runoff concentrations from these areas of the mine are set to Pollanroe baseline water quality." Golder notes that this is a conservative assumption for all parameters except total ammonia and nitrate, for which concentrations are significantly higher in active DSF runoff than in the Pollanroe baseline.

Conclusion: The impact of the issues raised above on the simulated pond water qualities is expected to be minor. Overall, the modelling approach taken is adequate.

3.3 Assessment of associated levels of uncertainty

The results of a scoping assessment were presented within the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[13] report. The purpose of this assessment was to consider the potential impacts of various components of the development on surface water quality and to assess the level of detail required in the impact assessment.

Golder Comment

The scoping assessment provides some insight in the potential sources of uncertainty to the impact assessment, however, there is no discussion regarding potential sources of uncertainty in the modelling exercise. Golder has identified several sources of uncertainty, based on the review of the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[13] report:

- Flows in the receiving water bodies;
- Discharge flows from the mine site;
- Baseline water quality (in receiving water bodies);
- Water quality of source terms for mine water discharges.

Key conclusion: Some discussion on the levels of uncertainty in inputs and outputs, and the implications of these uncertainties, would be helpful as it would increase the robustness of the model results. However, the exclusion of this discussion has no bearing on the validity of the modelled results. Further comment is provided in Section 3.4 (below) as well as Section 4.3.

3.4 Assessment of sensitivity analysis of the inputs and outputs

No sensitivity analyses were carried out for surface water quality calculations for operational conditions.

Golder Comment

The assessment of East and West Pond water quality in the GoldSim model is based on estimates of water flows and water quality of different source terms, all of which have associated uncertainties. It is considered

[12] SRK Consulting. 2020. A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland. Prepared for Dalradian Gold Limited. October 2020

[13] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

good practice to carry out a sensitivity analysis regarding both flows and qualities to assess their effects on the calculated pond water qualities.

Conclusion: The exclusion of this sensitivity analysis has no bearing on the validity of these calculated qualities. However, a sensitivity analysis should be carried out in the next phase of design (subject to planning approval) to better understand the potential range of surface water concentrations in the ponds during operations.

3.5 Assessment of Key Conclusions

The key conclusions regarding surface water quality during **Operations** are as follows[14]:

- Changes to baseline concentrations are consistent with the aims of the discharge criteria calculations; i.e., increases in baseline concentrations of 3% or 10% of the EQS maximum depending on whether baseline concentrations already exceed EQS or not.
- During events exceeding design conditions:
  - The results show slightly elevated concentrations from baseline in the Owenreagh River, but these increases are small given the large volume of water in the Owenreagh River compared to overflow from the water management ponds.
  - The predicted concentrations in the Owenreagh River are below the 95%ile (high) observed concentrations in the Owenreagh River, for all parameters apart from nitrite, mercury, selenium and uranium (however all measurements in the baseline data set are recorded below detection concentrations, as such the average and 95%ile values are the same).
  - Overall, the predicted increases are within the range of values seen in the river under baseline conditions.
  - The events considered are particularly extreme; any impacts would be transient and last for up to a few hours only while the flood passes.

Conclusion: It is Golder's opinion that based on the results presented, the overall conclusions regarding "backwards" and "forwards" modelling during normal operations are sound.

4.0 SUMMARY OF REVIEW COMMENTS - CLOSURE

4.1 Modelling Software and Objectives

Impacts on downstream watercourses during closure were calculated using dilution calculations carried out in the following Microsoft Excel™ spreadsheets:

- "Attagh Burn Closure Calculations Oct 2020.xlsx"[15]
- "Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx"[16]
- "Curraghinalt Burn Closure Calculations Oct 2020.xlsx"[17]

[14] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

[15] Kaya Consultants. 2020. Attagh Burn Closure Calculations.xlsx. October 2020

[16] Kaya Consultants. 2020. Closure WQ Calculations for Proposed Infrastructure Site (sent Golders).xlsx. October 2020

[17] Kaya Consultants. 2020. Curraghinalt Burn Closure Calculations Oct 2020.xlsx. October 2020

- "Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx"[18]
- "Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx"[19]

No modelling software was used to determine downstream impacts after closure. The objectives of the dilution calculations were as follows[20]:

- To assess downstream effects of any runoff or seepage from reclaimed mine areas; and
- To assess downstream effects of discharges from the adit at closure.

Golder comment

The objectives of the dilution calculations are clearly defined and sufficiently address the requirements of the Environment Statement[21].

Conclusion: The dilution calculations are considered suitable for the outlined model objectives.

4.2 Validity of Key Assumptions and Conclusions

As mentioned in Section 3.1.2, dilution calculations were used to assess downstream impacts during closure.

4.2.1 Conceptual Site Model

No conceptual site models were provided for closure.

Golder Comment

While it would be useful for a CSM to be provided to illustrate the anticipated changes during closure, enough information was presented within the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[22] to facilitate Golder's understanding of the site water interactions during closure to allow the assessment to be undertaken.

4.2.2 Model Scenarios

The closure calculations considered (i) impacts to the Owenkillew Catchment and (ii) impacts to the Owenreagh Catchment.

4.2.2.1 Owenkillew Catchment

Post-closure water quality calculations for the Owenkillew Catchment were carried out to consider mine flows throughout various periods of closure. Table 4 shows the water quality parameters assessed in the dilution calculations for the Owenkillew Catchment, as calculated in the following spreadsheets:

- "Attagh Burn Closure Calculations Oct 2020.xlsx"[23]
- "Curraghinalt Burn Closure Calculations Oct 2020.xlsx"[24]
- "Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx"[25]

[18] Kaya Consultants. 2020. Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx. October 2020
[19] Kaya Consultants. 2020. Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx. October 2020
[20] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020
[21] SRK Consulting. 2017. Environmental Statement for the Curraghinalt Project, County Tyrone, Northern Ireland. Volumes 1, 2 and 3.
[22] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.
[23] Kaya Consultants. 2020. Attagh Burn Closure Calculations.xlsx. October 2020
[24] Kaya Consultants. 2020. Curraghinalt Burn Closure Calculations Oct 2020.xlsx. October 2020
[25] Kaya Consultants. 2020. Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx. October 2020

- "Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx"[26]

Table 4: Water Quality Parameters Assessed for Existing Infrastructure Site

Parameter	Unit
TSS	mg/L
BOD	mg/L
Total Ammonia	mg/L as N
Nitrate	mg/L as N
Nitrite	mg/L as N
Chloride	mg/L
Fluoride	mg/L
Sulphate	mg/L
Aluminium	mg/L
Antimony	mg/L
Arsenic	mg/L
Barium	mg/L
Boron	mg/L
Cadmium	mg/L
Chromium III	mg/L
Chromium VI	mg/L
Chromium III + VI	mg/L
Cobalt	mg/L
Copper	mg/L
Iron	mg/L
Lead	mg/L
Manganese	mg/L
Mercury	mg/L

[26] Kaya Consultants. 2020. Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx. October 2020

Parameter	Unit
Molybdenum	mg/L
Nickel	mg/L
Selenium	mg/L
Silver	mg/L
Sodium	mg/L
Uranium	mg/L
Zinc	mg/L

The calculations were carried out for average and low flow conditions in the watercourses, and were reported for (i) Curraghinalt Burn for Years 1, 7, 13 and 50+ after the end of mine operations, (ii) Attagh Burn for Years 13 and 50+ after the end of mine operations, (iii) Glenealy Burn for Years 13 and 50+ after the end of mine operations, (iv) Owenkillew River (downstream of Curraghinalt Burn) for Years 13 and 50+ after the end of mine operations and (v) Owenkillew River (upstream of Owenreagh River) for Years 13 and 50+ after the end of mine operations. The reasoning for the assessment in these years is as follows[27]:

- Year 1 considered for the Curraghinalt Burn as the highest adit water quality concentrations are predicted in this year during the early closure period.
- Year 7 is considered for the Curraghinalt Burn as it is the year when groundwater is able to flow from the main underground mine to the adit. Note that neither Year 1 nor Year 7 are considered for the other points of interest as there is no adit flow to the other locations.
- Year 13 is considered for the rivers as it is the year the underground mine is fully infilled and the groundwater system reconnected close to pre-development conditions. As such, groundwater originating from the underground mine might be able to impact the burns and subsequently the receiving rivers. Note that there are no loadings from the adit or groundwater to the Glenealy Burn.
- Year 50 is considered for all points of interest as adit and underground mine water concentrations approach a steady state; results at this time are considered indicative of long-term predictions of water quality.

As small to negligible changes in water quality in the Owenkillew near the Curraghinalt Burn and Attagh Burn were predicted, and negligible changes in the Owenreagh River at closure were also predicted, no quantitative predictions of water quality were made for the Owenkillew River downstream of the Owenreagh River[27].

Impacts of climate change (RCP 4.5) were considered in the dilution calculations; the average, annual low flow and summer low flow rates for Years 1, 7, 13 and 50+ were adjusted to consider variations in flow rates throughout various stages of closure.

[27] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Golder Comment

Golder has checked the water quality and flow calculations for closure and the assessment for the Owenkillew Catchment is considered appropriate.

The RCP 4.5 climate scenario was considered in all dilution calculations. Golder notes that no climate change assessment was carried out for the RCP 8.5 climate scenario. While Golder is not aware of any regulatory requirement to consider the RCP 8.5 scenario, it would be considered best practice to consider this scenario in the next phase of design (subject to planning approval) to (i) better understand the potential range of surface water concentrations during closure, and (ii) reflect the uncertainty inherent in climate change predictions.

Conclusion: Golder has checked the water quality and flow calculations for closure and the assessment for the Owenkillew Catchment is considered appropriate. However, it would be considered good practice for the calculations to take the RCP 8.5 scenario into account in the next phase of design (subject to planning approval).

4.2.2.2 Owenreagh Catchment

Post-closure water quality calculations for the Owenreagh Catchment were performed for various phases of closure. Calculations of the impact of seepage and runoff from the DSF on the Pollanroe Burn and Owenreagh River were undertaken for the parameters where predicted concentrations in DSF seepage and/or runoff are higher than Pollanroe Burn baseline water quality[28]. Table 5 shows the water quality parameters assessed in the dilution calculations for the Owenreagh Catchment, as calculated in the spreadsheet "Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx"[29]. The spreadsheet applies simple mixing and dilution calculations of the different water types and flows to predict monthly water qualities for Year 2 and Year 20 after closure in (i) Pollanroe Burn at the Water Treatment Plant (WTP) outfall, (ii) Pollanroe Burn at Mouth, (iii) Owenreagh downstream of Pollanroe Burn, and (iv) Owenreagh at the mouth.

Table 5: Water Quality Parameters Assessed for Proposed Infrastructure Site

Parameter	Unit
Total Ammonia	mg/L as N
Nitrate	mg/L as N
Sulphate	mg/L
Antimony	µg/L
Arsenic	µg/L
Barium	µg/L
Boron	µg/L
Cobalt	µg/L
Chromium VI	µg/L

[28] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

[29] Kaya Consultants. 2020. Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx. October 2020

Parameter	Unit
Total Chromium	µg/L
Molybdenum	µg/L
Nickel	µg/L
Selenium	µg/L
Uranium	µg/L
Zinc	mg/L

Golder Comment

Golder has checked the water quality and flow calculations for closure and the assessment for the Owenreagh Catchment is considered appropriate.

The RCP 4.5 climate scenario was considered in all dilution calculations. Golder notes that no climate change assessment was carried out for the RCP 8.5 climate scenario. While Golder is not aware of any regulatory requirement to consider the RCP 8.5 scenario, it would be considered best practice to consider this scenario in the next phase of design (subject to planning approval) to (i) better understand the potential range of surface water concentrations during closure, and (ii) reflect the uncertainty inherent in climate change predictions.

Conclusion: Golder has checked the water quality and flow calculations for closure and the assessment for the Owenreagh Catchment is considered appropriate. However, it would be considered good practice for the calculations to take the RCP 8.5 scenario into account in the next phase of design (subject to planning approval).

4.2.3 Calculation Inputs

4.2.3.1 Owenkillew Catchment

As mentioned previously, no probabilistic modelling was carried out for closure. Instead, dilution calculations were carried out.

The following inputs were used for the closure dilution calculations:

- Adit and underground mine water flows for baseline conditions, as well as for key years after closure;
- Average, annual and low flows for the Curraghinalt Burn, Attagh Burn and Owenkillew River, for key years after closure;
- Average baseline concentrations in the Curraghinalt Burn, Attagh Burn and Owenkillew River; and
- Source term concentrations for adit discharge and underground mine water from geochemical modelling, for key years after closure.

Golder Comment

Conclusion: These inputs are considered appropriate for achieving the model objectives.

4.2.3.2 Owenreagh Catchment

The following hydrological and flow inputs were used for the closure dilution calculations:

- Seepage from the Reclaimed DSF;

- Runoff from the Reclaimed DSF;
- Runoff from the Natural Catchment;
- Drain Down (Year 2 after closure);
- Seepage through the DSF liner;
- Average monthly flows in Pollanroe Burn;
- Average monthly flows in Owenreagh River at Pollanroe Burn; and
- Average monthly flows in Owenreagh River at the Mouth.

Loadings from the following sources were considered:

- Seepage from the DSF at end of reclamation;
- Seepage from the DSF post-closure;
- Runoff from closed DSF
- Baseline conditions in Pollanroe Burn and Owenreagh River.

Golder Comment

Conclusion: Based on the description of the proposed mine facilities provided during closure in the SWIA[30], the above inputs are suitable for the closure model.

4.3 Assessment of associated levels of uncertainty

The results of a scoping assessment were presented within the report "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[30]. The purpose of this assessment was to consider the potential impacts of various components of the development on surface water quality and to assess the level of detail required in the impact assessment.

Golder Comment

Golder has identified several sources of uncertainty, based on the review of the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[30] report:

- Flows in the receiving water bodies;
- Discharge flows from the mine site;
- Baseline water quality (in receiving water bodies);
- Water quality of source terms for mine water discharges
- Climate change predictions.

Golder notes that consideration has been given to the uncertainty in climate change predictions, through the consideration of the RCP 4.5 climate change scenario in the dilution calculations. However, Golder notes the

[30] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

lack of discussion pertaining to the uncertainties associated with water quality and flow inputs to the closure calculations.

Conclusion: Some discussion on the levels of uncertainty in inputs and outputs, and the implications of these uncertainties, would be helpful. However, the exclusion of this discussion has no bearing on the validity of the modelled results.

4.4 Assessment of sensitivity analysis of the inputs and outputs

Based on information reviewed by Golder, no sensitivity assessments were carried out for closure water quality calculations, for either the Owenreagh or Owenkillew catchments.

Golder Comment

As stated in Section 4.3, when carrying out water quality calculations, it is considered good practice to carry out a sensitivity analysis regarding both flows and qualities. The exclusion of this sensitivity analysis has no bearing on the validity of these calculated qualities. However, sensitivity analyses should be carried out to in the next phase of design (subject to planning approval), to better understand the potential range of surface water concentrations during closure in the Owenreagh and Owenkillew Catchments.

4.5 Assessment of Key Conclusions

4.5.1 Owenkillew Catchment

The **key** conclusions regarding surface water quality during closure within the Curraghinalt Burn, as presented in the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland" report[31] include the following:

- In the first 7 years after the end of operations, nitrate, antimony and molybdenum concentrations in adit water are predicted to exceed the operational discharge criteria without further treatment, with manganese concentrations exceeding the discharge criteria after year 13.
- Concentrations of total ammonia in groundwater entering the Curraghinalt Burn from the underground mine (after year 7) are predicted to exceed the discharge criteria for year 7 only, with manganese the only other parameter with concentrations in excess of the discharge criteria values (after year 25).
- The results show no exceedances of the discharge consent limits in the Curraghinalt Burn until year 13 when manganese concentrations are predicted to exceed baseline and discharge limits in the burn. Concentrations increase further 50+ years after the end of operations. Manganese concentrations in adit and underground water are predicted to reach 293 µg/L 50 years after the end of operations.

The **key** conclusions regarding surface water quality during closure within the Attagh Burn, as presented in the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland" report[31] include the following:

- No parameters exceed drinking water standards apart from iron and manganese which exceeded the standards under baseline conditions.

The **key** conclusions regarding surface water quality during closure within the Owenkillew River, as outlined in the report "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[31] include the following:

[31] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

- The results show no exceedances of EQS other than silver which exceeded EQS under baseline conditions, due to the EQS being lower than the detection limit for that parameter. No change in the concentration is predicted in the Owenkillew River for silver at closure.
- The predictions for average concentrations are less than during operations, apart from manganese.
- By 50 years after closure, the predicted changes in concentration in the Owenkillew are even lower, with very small changes from baseline conditions.

Golder Comment

The adit and underground water will discharge to the Curraghinalt Burn (within the Owenkillew catchment) after closure. The concentration of manganese in this water 50 years after closure is predicted to be 293 µg/L[31]. To add some additional context around this discharge concentration, Golder has carried out a high-level assessment and compared this concentration to baseline concentrations at sampling points along the Attagh Burn (SW31 and SW32) and Glenealy Burn (SW03), both of which are local tributaries to the Owenkillew. Similarly to the Curraghinalt Burn, both the Attagh Burn and Glenealy Burn drain catchments which lie south of the Owenkillew River. The Curraghinalt Burn was not used for this comparison as it is already impacted by discharges from the existing adit.

Golder has calculated the average of the mean baseline manganese concentrations at the three sampling points as being 211.7 µg/L. The concentration of manganese in the adit and underground water 50 years after closure is higher than this calculated average. However, it is lower than the maximum concentrations at SW31 and SW32 (Attagh Burn) and SW03 (Glenealy Burn).

As of year 13 of closure, the Curraghinalt Burn (downstream of the mine water discharge) is predicted to have average manganese concentrations of 124 µg/L, which exceeds the reported average baseline manganese concentration in the Curraghinalt Burn of 69.7 µg/L upstream of the mine water discharge (SW02). However, this predicted average manganese concentration is lower than Golder's calculated average baseline concentration (211.7 µg/L) at the three sampling locations (SW31, SW32 and SW03). It is also only slightly higher than the Environmental Quality Standard for manganese of 123 µg/L[32]. Golder also notes that the Curraghinalt Burn has been considered to be of Low Sensitivity[32].

It is therefore possible that long-term active or passive treatment of manganese in the adit flows may have to be considered in the closure planning. The next phase of design, operational monitoring and more detailed closure planning (subject to planning approval and permitting) should place particular focus on manganese to assess whether long-term adit discharge treatment after closure may be required.

Conclusion: It is Golder's opinion that the overall conclusions noted above are sound based on the models and results presented. Golder notes however that long-term active or passive treatment of the adit and underground water may be required and should be considered in operational and closure planning.

4.5.2 Owenreagh Catchment

The **key** conclusions regarding surface water quality during closure within the Pollanroe Burn, as presented in the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland" report[33], include the following:

[32] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

[33] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

- Only total ammonia, nitrate and sulphate concentrations are predicted to exceed average baseline concentrations.
- The results show no exceedances of drinking water standards for any of the parameters with concentrations above baseline, apart from background iron and manganese.
- Background iron and manganese concentrations in the Pollanroe Burn are already above drinking water standards, but as predicted DSF seepage and runoff concentrations for these parameters are below average baseline concentrations in the Pollanroe Burn, there is expected to be no adverse change at closure.

The **key** conclusions regarding surface water quality during closure within the Owenreagh River, as presented in the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland" report[33] include the following:

- Runoff and seepage from the DSF have no measurable impact on baseline concentrations in Owenreagh.
- Nitrate concentrations exceed baseline conditions two years after closure, however after 20 years from the end of mining operations the nitrate concentration is predicted to have fallen to baseline conditions in the Owenreagh River at the confluence with the Pollanroe Burn.
- Average molybdenum concentrations are predicted to exceed baseline conditions as of closure, but still fall within the increased EQS allowance.

Golder Comment

It is Golder's opinion that the overall conclusions noted above are sound based on the results presented. Although some points have been noted, it is not anticipated that these overall conclusions would change substantially.

5.0 SUITABILITY OF WATER QUALITY MODELS AND CALCULATIONS (FIT FOR PURPOSE)

It is Golder's opinion that the surface water quality models and calculations are fit for purpose and achieve the overall objectives stated in Section 1.0. Any points raised above are summarized below, however as previously mentioned it is not anticipated that they would affect the overall conclusions in a meaningful way. These points are as follows:

- There is no conceptual site model presented outlining flows and flow directions during closure. However, this has no impact of the validity of the model results.
- The assessment of East and West Pond water quality in the GoldSim model is based on estimates of water flows and water quality of different source terms, all of which have associated uncertainties. No sensitivity analyses were carried out to consider uncertainties in the calculation inputs. These assessments should be considered in the next phase of design (subject to planning approval).
- With the exception of climate change inputs during closure, there is no discussion regarding potential sources of uncertainty within the modelling exercises/ calculations.
- No sensitivity analyses were carried out to consider uncertainties in the calculation inputs (flows and water quality inputs) for the dilution calculations during closure. These assessments should be considered in the next phase of design (subject to planning approval).

- Upon review of the dilution calculations for closure, it was noted that the RCP 8.5 climate change scenario was not considered. This assessment should be considered in the next phase of design (subject to planning approval).
- The RQP model inputs for the “backwards” modelling for the parameters Arsenic and Mercury are not consistent with the reported baseline values (for the Owenreagh Catchment).
- As noted in section 3.2.3.3, the source term water quality data for surface runoff from active areas of the DSF in the GoldSim water quality modelling of events in excess of design conditions contains some erroneous values, which may affect the simulated pond water quality during extreme events. However, the impact of these discrepancies on the simulated pond water quality is expected to be minor.
- Golder notes that long-term active or passive treatment of the adit and underground water may be required after mine closure and should be considered in the long-term operational and closure planning.

[redacted]

[redacted]

[redacted]