Technical Review

To:	Alexandra Smith	**Date:**	29/11/2024
Authority:	Environment Southland	**Ref:**	24116_2B
Consent:	Waikaka Gold Mines LTD		

From	**Role in Audit**	**Internal Reviewer**
Alexandra Badenhop	Groundwater and AMD Review	Simon Bloomberg

1 Project Summary

Waikaka Gold Mines LTD proposes to establish a gold mine near the Waikaka Stream in Southland and has applied for resource consents to Environment Southland (ES) and the Gore District Council. ES have engaged e3Scientific to complete a review of the groundwater and acid mine drainage components of the application.

1.1 Activity

The applicant proposes to mine gold from a 95 ha site located near 972 Waikaka Road. The gold bearing wash layer is present between 20 – 50 m below ground level. Groundwater is to be abstracted so this layer may be mined via an open pit under dry conditions. The site's surface water features comprise the Waikaka Stream, Shepherds Creek, and unnamed ditches and ponds. The applicant proposes to disturb the land, take water, discharge to water, and to divert the Waikaka Stream as part of the gold mine operation.

1.2 Scope

The scope of the review is to:

1 Review and comment on the assessment of effects and technical reports in the application document for resource consents by Waikaka Gold Mines Limited (APP-20242608), specifically:

Background information:

- Application: Section 3 - Description of the proposal, at pages 109-135;
- Application: Section 5 - Assessment of effects, at pages 147-182;

Technical reports provided with the application:

- Hydrogeology - Attachment K at pages 425-471, and separate appendices;
- Acid mine drainage - Attachment P at pages 593-705;
- Water Settlement Report – Attachment T at pages 851-877; and

2 Review and confirm the proposed conditions of consent as relevant to the reviewer's area of technical expertise;

- Proposed conditions - Attachment I at pages 341-353; and

Note that Attachment H – Mining Methodology, and Attachment J were also reviewed to ensure consistency.

Note that Freshwater Ecology and contaminated land reviews have been provided separately.

2 Summary of Information Provided

2.1 Groundwater

Groundwater is understood to be present in three main layers at the site separated by clays and clayey silts:

1. A shallow alluvial layer with a saturated thickness of approximately 2 m that has previously been dredged and is likely hydraulically connected with, and discharges to, Waikaka Stream.
2. Discontinuous confined gravel layers of saturated thickness of approximately 3 m.
3. The deeper gold bearing wash layer which has a saturated thickness of approximately 10 m and is under artesian or near artesian pressures.

Groundwater is to be used for processing, some site dust suppression and rehabilitation. Some discharge to land may occur during the treatment process (flocculation and sedimentation), however the majority of groundwater will be

discharged to Waikaka Stream. The assessment of the discharge assumes that the discharge will only contain suspended sediment and does not address the issues of AMD.

Aquifer testing was conducted at five sites (2 recent tests, and 3 completed by AquaFirma in the late 1990's) along a transect running from south-east to north-west. The aim of the testing was to determine dewatering flows. Pumping tests were only completed in the wash layer. No testing was completed in close proximity to Waikaka Stream.

For an application of this scale, with this level of effects, it is reasonable to expect further work to have been completed to conceptualise the site, including continuous water level monitoring in groundwater monitoring bores around the site and in close proximity to Waikaka Stream.

Connectivity between groundwater and surface water has not been investigated. The assessment assumes that Waikaka Stream is a sink for groundwater, however it is more likely to be both gaining and losing throughout the affected reaches. There is currently an upward vertical hydraulic gradient. It is unclear what the effects of reversing this gradient and depressurising the confined aquifers will be.

Minimal groundwater quality data for a very limited range of parameters has been provided without any discussion of sampling protocols, locations, depths, times and no measurement of field parameters. It is therefore very difficult to determine whether this data is representative of current groundwater and stream water quality.

In general, the groundwater report seems to have been completed without checking for consistency with the finalised mining methodology, geotechnical report or Acid Mine drainage report.

Without seeing the proposed rehabilitation plan within the application, and without improved site conceptualisation, it is difficult to assess what the long-term effects on Waikaka Stream will be. The entire 3 layer aquifer system will be homogenised by the works to the base of the pit, which will result in no areas of greater transmissivity through the profile.

The AEE by Town Planning group states that the Waikaka Stream diversion will not be lined in order to replicate the natural conditions of shallow groundwater losses,

however these have not been investigated at all. Given that groundwater will be pumped away from the stream during works, lining may reduce losses and maintain flows in the stream.

2.2 Acid and Metalliferous Drainage (AMD)

Mine Waste Management Ltd (MWM) have thoroughly described the site's potential for formation of acid and metalliferous drainage. The presence of pyrite and marcasite in the wash and Gore Lignite Measures (GLM) meets the classification of potential acid formatting – Low capacity. To establish the potential contaminants from the wash/GLM, MWM undertook a column leach test which identified that heavy metals were the main contaminants of concern. However, MWM state that "Such elevated contaminant concentrations are unlikely at the project given the PAF materials (process residues, silt pond slimes, GLM) represent (15%) of the materials that will be mined and that overall the project materials are non-acid forming with an excess of acid-neutralising materials (MWM, 2022).

MWM made several recommendations, including engineering solutions and methods for managing the material so that the risk from AMD remains low. MWM recommended that "an environmental / AMD management plan be developed for the project, which should be supported by performance monitoring and adaptive management processes. It is recommended this management plan be developed prior to mining activities commencing. The management plan needs to address the following activities:

- Materials characterisation (validation testing)
- Performance monitoring of key project risks
- Compliance monitoring
- Closure"

In addition to that MWM also suggested that further work be undertaken to understand effects to water quality "based on the conceptual site model and flow rates from various materials and mine domains. The data indicates the identified contaminants (from the column leaching tests) should be analysed as part of any monitoring programme including baseline studies and future potential project effects."

Waikaka Gold have incorporated MWMs findings into the mine plan methodology such as "Any potentially acid forming materials will be directed to the backfill and encapsulated below the restored water table with the expectation that any oxidation

will cease once fully saturated with low oxygen groundwaters. The plan states that "any drainage from stockpiles and backfill while the pit void remains open will be monitored and directed to the settling ponds for treatment where necessary before discharge to the environment.

3 Audit Questions

3.1 Groundwater

Based on our review of the available groundwater information, we have the following comments and questions:

1. Given that the groundwater abstracted will be primarily returned to the Waikaka Stream, with significant delay and a significant distance from the take, and that at least 10% of water will be lost in processing, can you please demonstrate why the take should be considered non-consumptive?

2. The naming of observation wells, pump test sites and pumping test data is difficult to follow and doesn't appear to be consistent (or exclusive) and there are no clear maps of the pumping test setups, or clear tables that summarise each pumping test. There are no summaries of the bores present, their screen depths, and the lithology they are targeting. Can you please provide a clear summary of all of the available data, and their corresponding appendices? The two bore logs provided for those called 'Main bores' have a maximum depth of 22 m.b.g, and none of the monitoring piezometer logs seem to be any deeper than this. Given that the maximum depth of excavation is to be 50 m, this data is not adequate to conceptualise the site. The data provided in the Aquafirma report is also poorly documented.

3. Dewatering calculations are presented for an initial mine pit of 100 m x 50 m pit. This is not consistent with the Mining Methodology report (Attachment H) that anticipates a much larger pit (170 x 100 m) at the pit base. Can you please update calculations accordingly?

4. Calculation of peak dewatering rates seems to be based on an equivalent radius of the established pit (Table 4.2). However, the entire length of the pit will need to be dewatered (500 m). Can you please explain how this calculation allows for dewatering of the entire pit, or alternatively update the calculations to ensure dewatering of the entire pit?

5. The mining methodology assumes that stormwater will be diverted into the mining pit from across the site. Can you please confirm whether pumping and discharge rates account for this?

6. Please provide continuous water level logging data for nested piezometers targeting the different aquifer levels within 50 m of the stream in conjunction with Waikaka Stream water level monitoring to assess the relationship with the stream, at both ends and central to the proposed works. Please also review the water level data that has been collected by Waikaka Gold from their existing monitoring sites and update the assessment accordingly.

7. Please provide measures of streambed conductance of Waikaka Stream to improve the understanding of the hydrogeological connection between Waikaka Stream and the aquifers.

8. Please provide actual pumping data from the L&M operations if available and assess the significance of this information relative to the actual mining operations that occurred.

9. The geological model provided by T & T (2022) in their geotechnical assessment (Attachment J) is very different to that provided within the groundwater report. Please reconcile the data provided.

10. When confined layers are depressurised, storage comes from gravity drainage, how will this alter flows into the pit?

11. Stream depletion calculations were completed assuming that the mine pit would be at least 50 m from the stream, however the mining methodology states that the buffer will be 30 m. The assessment states that the physical site data shows that the stream connection is poor, however this has not been justified with the data, and also is at odds with the rehabilitation strategy suggested (which states that the new channel will be incomplete connection with sediments). The assessment is also based on a pumping rate of 8.1 L/s. It is unclear whether this assessment accounts for the full dimensions of the mine pit at the surface (which will be much larger than the pit base due to the required battering slopes). After stream diversions have occurred and stream lengths have been reinstated, it is expected that streambed conductance will be

greatly altered, but mining will still continue. What effect will this have on stream depletion?

12. Please provide adequate assessment of groundwater quality in terms of water quality sampling of each of the aquifers including documentation of sampling protocols, locations, depths, times and measurement of field parameters. Please assess groundwater quality for the full range of contaminants that may be expected in this environment (MWM have identified Al, As, Cd, Cr, Co, Cu, Pb, Mn, Ni, Se, and Zn as contaminants of concern).

3.2 Contaminated/Acidic Site Drainage

MWM made multiple recommendations for required future works. Please confirm what if any of these recommendations were undertaken by Waikaka Gold e.g. baseline water testing for dissolved metals, and/or whether some recommendations will be undertaken once commissioned.

The Waikaka Gold mining methodology incorporates advice from MWM on how best to manage the potential for contaminated site drainage. The methodology lists the required site management plans, including "4. Acid mine drainage management plan". It would be useful for this plan to be reviewed in conjunction with the EMP as per proposed condition 5, confirming the proposed performance monitoring conditions and that the future work recommendations made by MWM were adopted by Waikaka Gold.

The ongoing, long-term stability of the PAF materials requires oxygen ingress to be eliminated, primarily by placing the PAF materials below the water table. However, the method of backfilling the PAF materials back into the pit means that they will be oxidised for a significant period of time during operations while the water table is drawn down. How will Waikaka Gold validate "that any oxidation will cease once fully saturated with low oxygen groundwaters" post-closure. Is Waikaka Gold proposing to continue monitoring groundwater post-closure to determine groundwater quality impacts?

4 Proposed Conditions

The monitoring conditions proposed in Attachment I are more extensive than those proposed in Attachment K, however further work is required to ensure that monitoring of both groundwater levels and quality is adequate to assess effects.

There is no Erosion and Sediment Control Plan (ESCP) mentioned with respect to the waterway diversions. A ESCP condition is added as a requirement to help minimise sediment mobilisation.

Condition 2. The consent term shall be for 20 years. The information supplied suggests the earthworks will be undertaken over 8 years. Further explanation of why a 20 year term is sought would be beneficial to the application.

Condition 38 requires the establishment of a network of monitoring wells for detecting drawdown in neighbouring wells. This network should also be for the purposes of monitoring stream depletion, and water quality effects within the different aquifers.

Condition 50 should require monitoring for the full range of contaminants expected possible within the discharge and include measurement of field parameters.

All monitoring conditions should require the collection of baseline data prior to the commencement of works.

Further conditions need to be added to account for the recommendations of the AMD report.