WGA

# TECHNICAL MEMORANDUM

**PROJECT NO.: WGA211239**

**DATE: 4 JULY 2023**

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| **COMPANY NAME** | West Coast Regional Council |
| **ATTENTION** | Tony Ridge |
| **SUBJECT** | Review of TiGa resource consent application – Barrytown Mine |

## 1. INTRODUCTION

The West Coast Regional Council (WCRC) has received an application by TiGa Minerals and Metals Limited for resource consents authorising the development of a mineral sands mining operation at Barrytown. A range of technical documents have been lodged with the WCRC in support of the application.

The WCRC has commissioned Wallbridge Gilbert Aztec (WGA) to review the technical documents lodged in support of the application. The review by WGA covers the hydrological and hydrogeological aspects of the application. Ecological, geotechnical, water quality and other aspects of the application are considered only in regard to identifying aspects of the site and surrounding area that may be impacted by changes in the hydrological system.

This technical memorandum documents the outcomes from an initial review of the documents listed below. The objective of this review is to determine if there are any gaps in information and two provide requests for information under Section 92 of the Resource Management Act.

## 2. REPORTS REVIEWED

The following documents have been considered during this review of the hydrological and hydrogeological aspects of the resource consent application for the Barrytown mineral sands mine.

- Tai Poutini 2023a. Application for Resource Consent to Grey District Council and West Coast Regional Council - Mineral Sand Mining Activities at Barrytown. Report produced by Tai Poutini Professional Services Ltd for Tiga Mineral & Metals Ltd.
- Tai Poutini 2023b. Site Plan produced 22 March 2023. Copy attached as Appendix A to this memorandum.
- RDCL 2023. Geotechnical Assessment, Tailings Operations and Storage, Barrytown Mineral Sands Tailings. Report produced by Resource Development Consultants Ltd for Tiga Mineral & Metals Ltd. Report #: R-220986A-01. Dated 13 April 2023.
- Kōmanawa 2023a. Barrytown Mineral Sands Mine Hydrological Impact Assessment. Report produced by Kōmanawa Solutions Ltd for TiGa Minerals & Metals Pty Ltd. Report #: Z22004_1-Rev3.
- Kōmanawa 2023b. Barrytown Mineral Sand Operation, Water Management, Monitoring and Mitigation Plan, REV 2. Report produced by Kōmanawa Solutions Ltd for TiGa Minerals & Metals Pty Ltd. Report #: Z22004_2. Dated 17/04/2023
- Ridley 2023. Barrytown Mineral Sand Operation Erosion and Sediment Control Plan. Report produced by Ridley Dunphy Environmental Limited for TiGa Minerals & Metals Pty Ltd. Final Draft - Version C. Dated 31/03/2023.
- EcoLogical Solutions 2023. Wetland Construction and Riparian Planting Plan. Report produced by EcoLogical Solutions Limited for TiGa Minerals & Metals Pty Ltd. Draft v3. Dated 17/04/2023.

- TiGa 2023. Rehabilitation Management Plan. Report produced by Tiga Mineral & Metals Ltd. Rev 0. Dated 13/04/2023.

The following sections summarise our review of the technical documents, in the order that the documents are listed above.

Requests for clarification or further information are provided in numbered bullet points throughout the following sections.

## 3. PROPOSED MINING OPERATION

The general description of the mining process is consistent between the various reports. The key aspects of the proposed mining operation with respect to mine water management and hydrological impacts are summarised here to avoid repetition later.

- The active mine void will cover 3 ha in a 300 m long x 100 m wide strip, which advances as the ore is progressively extracted and processed.
- "*The active sand extraction zone would progress generally from west to east in strips that would generally progress from south to north*" (Kōmanawa 2023a Section 3.1).
- The mineral sands are to be processed at the point of mining to remove any oversize and slimes (undersize) components. This would presumably be done through processing of an ore slurry, with the reject materials returned directly to the tailings deposition area.
- The mineralized component of the ore is transported to the processing plant is a slurry and the processed wastes (tailings) are returned to the open pit as a slurry.
- A processing plant, where the "*mineral fraction [will be] separated by gravity using no chemical additives*".
- Mining will be undertaken during daylight hours only, with a sand extraction rate of approximately 350 tonnes per hour. Ore processing will be undertaken 24 hours per day at a rate of approximately 165 tonnes of sand per hour. The rate of mining is approximately double the rate of processing to enable the stockpiling of excess ore at the processing plant and therefore provide a 24 hour feed to the processing plant. The geotechnical report states that "*Tailings will be pumped to the mining void at night*".
- The tailings will be dewatered and discharged to the mine void by cyclone. The processed tailings will be allowed to naturally beach out, with the cyclone moved "*as required to distribute the tailings as necessary*". The deposited tailings will then be "pushed out by bulldozer within the pit" to provide a contoured surface ready for final capping, landscaping and rehabilitation. "One hectare of the mining void will be actively receiving tailings pumped from the processing plant".
- The final landform will be formed as the mine advances through "*overburden placed to cap the tailings*" followed by "*top soiled and returned to farming*".

It is not clear from the reports reviewed what the maximum depth of excavation is to be. The AEE (Tai Poutini 2023a) indicates "the maximum mining depth will be 9 m." The Water Management Plan (Kōmanawa 2023b) also indicates the proposal is for "*sand extraction to a depth of approximately 9 m below grade*". However, the hydrological report also refers to the depth limit for economic mineral sand extraction of "*between 9 and 12 m below ground level*". The geotechnical report (RDCL 2023) indicates "*mining will be by open pit to ~14m below current ground level*" and the ground stability models in that report reflect this expectation.

1. **Please provide a map with contours of the projected cumulative pit floor and confirm the maximum depth of mining below ground level.**

## 4. HYDROLOGICAL REPORT (KŌMANAWA 2023A) REVIEW

The main body of the hydro logical report is reviewed in Section 4.1 below. The appendices to the hydrological report reviewed separately in Sections 4.2 and 4.3 below.

### 4.1 Main report

Section 1 and Sections 2.1 to 2.4 of the Hydrological Assessment (Kōmanawa 2023a) provide general background information on the site. No concerns are raised with respect to the information presented in these sections.

Sections 2.5.1 to 2.5.3 of the report describe the background hydrological setting of the site. No concerns are raised with respect to the information presented in these sections.

Section 2.5.4 of the report describes hydrological studies from monitoring undertaken at the site. Two flow monitoring sites were established on Collins Creek, upstream and downstream from the site. Four flow gaugings were carried out on Collins Creek during the period 4 May to 8 November 2022. These gaugings were used to convert the recorded water levels into a flow record for each site.

The $MALF_{7d}$ for Collins Creek as provided in Table 6 is 16 L/s. The continuous monitoring period documented in the report was from May to November 2022, which excludes a summer period. The lowest recorded flow during this period at the upstream monitoring site was 25 L/s. The documented $MALF_{7d}$ for Collins Creek, which is not based on flow monitoring in Collins Creek, appears reasonable.

2. Although both of these flow monitoring locations are described in Table 7 in the report, **it would be useful to have a map identifying the locations of both of these two sites, for avoidance of possible confusion.**

3. **For completeness, please provide the flow gauging records and the flow rating curves developed for each of the stream flow monitoring sites.**

4. The derived flow records for Collins Creek as shown in Figures 13 and 14 suggest base flows in the creek are lower at the downstream monitoring site that at the upstream monitoring site, implying the creek reach between the two sites is overall a losing reach. **Please provide a chart showing the difference in calculated creek flows between the two monitoring sites through the duration of the recorded period**.

Sections 2.6.1 to 2.6.3 of the report summarise background hydrogeological information from nearby sites that are useful for comparison purposes to site-specific investigations. **No requests for further information arise with respect to the information presented in these sections**.

Section 2.6.4 documents site groundwater investigations undertaken during 2022 and 2023.

A total of 26 piezometers have been installed at the site, with continuous recorders installed in six of these piezometers. These piezometers are scattered across the site, providing very good coverage for monitoring groundwater levels. Continuous groundwater level records are provided four six piezometers for the period from May to November 2022. A clear and reasonable rationale for the placement of the piezometers is provided in Section 2.6.4.2.

Four of the piezometers show rapid responses to rainfall events. The two easternmost piezometers show more attenuated responses to rainfall events. The observed range of groundwater levels was greater in the two easternmost piezometers than in the other four piezometers. Groundwater level responses in each of the piezometers appear to exceed changes in Collins Creek levels for corresponding rainfall events. The report indicates that incipient rainfall is likely to be the main driver for observed groundwater fluctuations within the investigated area.

Tidal influence (Figure 24 in the hydrology report) was observed in the form of groundwater level fluctuations in two of the coastal piezometers (PX05 and PZ07), with the maximum fluctuations being approximately 50 mm in scale. No water level record is available for the adjacent coastal lagoons and the report indicates it is not clear if they are tidally influenced or effectively static. However, conceptually there are only two general scenarios available:

1. The lagoons are connected to the underlying and adjacent groundwater systems and the lagoons are tidally influenced; or

2. The lagoons are not connected to the underlying groundwater system and the tidal influence is propagated from the aquifer connection to the ocean at the coastline.

The most likely of the two scenarios is the first one, especially in light of the water quality data considered later in this review. However, both scenarios are considered in further review of the hydrology report. The report states "*the effect of tide on the groundwater system is minor and does not tangibly extend any further than 300 m from the landward edge of the coastal lagoons*". This conclusion is reasonable and has been accepted in this review. **No requests for further information arise with respect to the information presented in Section 2.6.4**.

Section 2.6.5 of the report documents hydraulic tests performed at the site during 2022. One Production Bore(PB-1) and two Observation Bores were installed near the centre of the site to perform and monitor a pumping test. A second Production Bore (PB-2) was incompletely installed toward the southwestern side of the site, with the well screen unable to be installed. Full pumping tests were only able to be performed on PB-01. Documentation for the test is provided in Appendix A to the report. In general, the hydrogeological characteristics off the sedimentary materials described in Table 14 are accepted. Notes with respect to the information presented in Appendix 1, which described the derivation of these hydrogeological characteristics, are provided later in this review.

Also in Section 2.6.5 is a short description of two injection tests performed on bores PB-1 and PB-2. Injection to PB-1 of 4.2 L/s was achieved compared to the maximum pumping rate of 4.5 L/s achieved during the stepped rate test and 4.0 L/s applied for the constant rate test on the same bore. This injection rate validates the concept that injection bores can be used to recharge the basal gravel aquifer. No Observation Bore data has been presented to indicate monitoring during the injection test on PB-1.

5. Later in the report the groundwater level observations in PB-1 from the injection test performed on PB-1 were used to validate the statement that the change in head in an injection bore would be the same as the drawdown in that bore if the injection and abstraction flows are the same. Supporting data is not presented in Section 2.6.2. **Please provide the PB-1 test water level curved for both the abstraction test and the injection test.**

6. **Were water levels in the Observation Bores TB-1, TB-2 and TAC-157 monitored during the injection test performed on PB-1? If they were, please provide the groundwater up-coning response curves for these bores and an indication of the extent and magnitude of up-coning achieved during the test.**

Section 2.6.6 of the report describes the process whereby the lateral distribution of hydraulic conductivity values for the sedimentary deposits at the site have been evaluated. Although the process described is conceptually reasonable, it's applicability in terms of deriving hydraulic conductivity values for the areas to the east of the proposed mine pit are questionable. This uncertainty arises because the analysis of average hydraulic conductivity for the materials to the east of the pit tends to be dominated by shallower gravel deposits. This issue was recognised in the report. It is accentuated because the groundwater table in the area to the east of the pit may be predominantly below the shallow surficial gravels. i.e. The shallow gravels do not have a significant bearing on groundwater flow patterns in the saturated zone. However, this is not a critical issue as the key outcome from this assessment is the indication that the permeability of the ore and overburden materials does not vary greatly within the proposed pit footprint. **No requests for further information arise with respect to the information presented in this section**.

Section 2.6.7 describe the derivation of a groundwater level contour map for the side and presents the resulting groundwater contour map in Figure 32. The methodology used to generate the map is reasonable and defensible. The groundwater gradients indicate seepage flows across the site discharge to Collins Creek and the Canoe Creek lagoon. This supports the interpretation that the shallow groundwater system under the site is directly hydraulically linked to these two surface water bodies. The piezometric map presented in Figure 32 does appear to show a sharp increase in hydraulic gradient across one section of the site. However, there are no piezometers located in this particular area of the site and the interpreted change in hydraulic gradient may be incorrect.

7. The piezometric contours presented in Figure 32 appear to have been hand drawn with experienced artistic licence applied. **Please provide a reviewed version of the interpreted piezometric map. The aspect of primary interest is what proportion of the groundwater currently flowing across the planned mine pit area is reporting to either the Northern Boundary Drain or Rusty Lagoon.**

The groundwater profiles provided in Section 2.6.7.1 are consistent with the groundwater level observations and the surface topography. The report describes these profiles as supporting the interpretation that the groundwater recharge is principally occurring across the eastern half of the site and this recharge includes losses from Collins Creek to the underlying groundwater. This interpretation is reasonable and accepted.

Section 2.6.7.2 presents calculations of groundwater volumetric flow rates and velocities under the proposed mine site. The calculations presented use commonly accepted equations and the results are accepted. However, the calculation ignores the groundwater flows in the gravel bed underlying the mineral sand deposit. This gravel bed is hydraulically linked to the mineral sands, as demonstrated by the pumping test on PB-1. Any operation to dewater the mineral sands during mining will automatically result in partial depressurisation of the underlying gravel bed, with water discharging from this bed into the overlying pit.

8. **Please provide a calculation of groundwater through-flow within the basal gravel bed underlying the site, taking into account the transmissivity values derived from the pumping test.**

9. **Please reassess the relative combined groundwater flow estimates compared to the surface water flows, as documented in the final paragraph of Section 2.6.7.2.**

Section 2.7 deals with groundwater and surface water quality. The groundwater analysis results are fully documented in Appendices 2, 3 and 4 to the Hydrology report. In this section of the report groundwater sampling analysis results that exceed the ANZG for the protection of 95% of aquatic species are summarised in Table 17.

Only one of the analysis results listed in Table 17 as exceeding an ANZG species protection value was from water sampled during the PB-1 pumping test. The remainder appear to represent pore water in the mineral sands. This is important as it linked to the question regarding the larges source of water to the mining operation and the potential contaminant mass loads that may need to be managed. If inflows to the pit from the underlying gravels are the largest component of the water requiring management, then the quality of water from the PB-1 test may play a controlling role in mine water quality.

Dissolved iron has not been included in Table 17 or Table 18, probably because there is no ANZG value for dissolved iron. However, dissolved iron should still be considered in mine water management and mine closure planning. The elevated concentrations of dissolved iron detected on occasion in water samples from Collins Creek Lagoon and the Northern Boundary Drain, together with the apparent state of water in Rusty Lagoon, clearly indicates that dissolved iron cannot be discounted in mine closure planning.

The dissolved iron concentrations detected in analysis of water from the slimes and processed tailings wastes tests (Appendix 6) were below the 0.4 g/m$^3$ laboratory detection limit, which is lower than in the in-situ groundwater. However, these relatively low concentrations may reflect a low dissolution rate of iron from the processed wastes.

**No requests for further information arise with respect to the information presented in Section 2.7 as the water quality analysis data has been documented in the report appendices and the interpretation of this information with respect to mine water quality management is considered later in the report.**

Section 3 documents the proposed sand extraction activities. The summary of the proposed activities presented in Section 3.1, when considered in conjunction with the various maps provided in the report, is clear. However, three items of importance to the hydrogeological assessment for the effects arising out of the proposed activity are missing from this section and are not provided elsewhere in the report.

10. **Please provide a contour map of the interface between the base of the mineral sand deposits into the top of the basal gravel deposits.**

11. **Please provide a contour map of the thickness of mineral sands left in place between the base of the pit shell (as per Request 1 above) and the top of the basal gravels underlying the pit.**

The generic image of the indicative mining sequence provided in Figure 5 of the AEE indicates the full thickness mineral sand will be extracted, at least in some areas. This implies the underlying basal gravel aquifer will be exposed in the floor of the pit, at least on occasion. The above items are important to confirm this understanding. More importantly, the above requested information is important enable a good understanding of the likely interaction between the proposed opencast pit and the groundwater flowing within the basal gravel aquifer during the ore extraction operations.

Section 3.2.1 provides a generic description of the proposed in-pit water management operation. mine dewatering is to be performed through pumping mine water from a sump located at the lowest point in the operational pit.

12. **Please advise whether the sump is described above is also to collect water extruded from the accumulating tailings backfill.**

No further requests for information arise from review of Section 3.

Section 4 of the report evaluates the effects of the proposed mine on water quality. This assessment is based on information presented earlier in the report in Section 2.7.

The report recognises that mining operations are likely to result in increased suspended sediment and turbidity in the mine water. It notes that a water treatment train described in the ESCP is to be implemented to minimise the effects of increased suspended sediment and/or turbidity in the discharged minewater. This aspect of the mining operation is reviewed later in this memorandum.

The assessment of the effects of dissolved metals and metalloids on receiving water concentrations is summarised in Section 4.2. The report states "*Discharge of influent groundwater from the mine pit to surface water has the potential to result in concentrations of aluminium, arsenic, chromium, copper, nickel and zinc to exceed the ANZG 95% species protection values.*" This statement is simply based on the results from analysis of groundwater samples obtained from monitoring world screened in the mineral sands. No assessment of potential contaminant loads arising from groundwater inflows and receiving water concentrations is provided in the report. It should also be noted that significant groundwater inflows will potentially arise from the underlying basal gravel aquifer. A detailed assessment of the potential effects of these contaminants has been left to the ecological effects assessment report (EcoLogical Solutions 2023).

The assessment of the mining operation on receiving water quality undertaken by EcoLogical Solutions (2023) has been based on discharging water containing median concentrations of the observed groundwater quality values as listed in Appendix 2. These values appear to have been taken as representative of "treated clean process water". The relative contaminant mass load contributions from different sources to the discharge flow stream have not been taken into account. These relative contributions should logically come out of the Hydrology report (Kōmanawa 2023a), but they are not documented in this report.

13. **Please provide an estimate of mine discharge water quality based on estimates of relative mass load contributions from the various contaminant sources to the mine water management system. In lieu of a calculated discharge based on contributing mass loads, please provide an indication of the 'worst case' contaminant concentrations in the mine discharge water and the reasoning behind the values provided.**

Section 4.3 considers the risk of saline water intrusion arising from the proposed mining operation. The concepts applied in assessing the effects of mine dewatering are widely accepted and applied. However, in applying these concepts to assessing the risk of saline water intrusion it has been assumed that the geology under the site is homogenous down to the interface with the "*silty sandstone Blue Bottom Formation, which for the purposes of assessing short term saline up-coning is effectively impermeable*". This is the only mention of the Blue Bottom Formation in the entire report. It is not clear at what depth this formation is present beneath the site. However, the model does state in Section 5.3.2 that "*The main model and TMR model both simulate a 15 m thickness of Layer 2 basal gravel layer from -5 m to -20 MSL.*"

14. **Please provide an indication of the thickness of the basal gravel unit underlying the mineral sands. Please also advise what underlies the gravel unit and at what depth the Blue Bottom Formation may be found beneath the site.**

15. **If the direction of groundwater flow within the basal gravel aquifer between the mine and the coastline is at least locally reversed due to drawdown linked to mining operations, what implications will this have for saline water intrusion risks?**

Section 5 documents the assessment of the effects of the mining operation on groundwater quantity. Section 5.1 provides background information on the modelling package and supporting software. **No requests for further information arise with respect to the information presented in this section**.

Section 5.2 relates to the calibration of a past model in steady state mode. However, this model does not take into account the recent investigations and groundwater monitoring undertaken on site. Therefore, little weight has been accorded the information in this section of the report. It has been considered as background material only. **No requests for further information arise with respect to the information presented in this section**.

Section 5.3 documents a refinement of the groundwater model described in Section 5.2, in which the mining area is simulated at higher resolution within the broader model using a Telescopic Mesh Refinement facility of the software. The refinement of mesh within a larger model is common practice and widely accepted.

The refined area of the model, focused on the proposed mine, retains a two-layer configuration as set up in the original model. However, it is not clear from the documentation what these layers now represent or their geometry within the refined area.

Table 20 from Section 5.2 of the report is replicated below. The two layers of the model are described in this table, as representing the wider Barrytown hydrogeological environment. Based on the descriptive text provided in Section 5.3.2 of the report, it becomes clear that Layer 1 represents the mineralized sand deposits within the proposed mine area and Layer 2 represents the basal gravels. Layer one is further subdivided into different zones, depending on the nature of the surficial geology. There is no indication in Section 5.3 of the report that the model layer geometry has been adjusted in any way, beyond simple refinement of the model mesh. This conceptual layout is accepted as reasonable.

| Formation / Strata | Coffey Partners' Hydraulic Conductivity (m/d) | Final Optimised Model Hydraulic Conductivity (m/d) | Initial LSR (mm/yr) | Optimised Model LSR (mm/yr) |
|---|---|---|---|---|
| Transgressive Beach (Shallow, Layer1) | 3 | 6.01* | | |
| Transgressive Beach (Deep, Layer 2) | 1.7 | 0.13* | | |
| Alluvial Fan | 3 | 3.44 | | |
| Recent Foredune | 6 | 0.72 | | |
| Land Surface Recharge | | | 460 | 40 |

**Note:** * the combined transmissivity of Layer 1 and Layer 2 available to convey groundwater is 122 $m^2/d$, allowing for layer thicknesses at the modelled hydraulic conductivities for each layer.

In terms of hydraulic boundary conditions, the area of refined mesh representing the mine site and its immediate surrounds has effectively been isolated from the wider model by defined boundary conditions. These boundary conditions are presented visually in Figure 43 of the report and described in Section 5.3.1. It is not clear from figure 43 where is the river and drain sections of the boundaries representing Collins Creek and the northern boundary drain have been applied. It is also not clear where Mahers Wetland Lagoon, which is represented as a river boundary condition, is located.

16. **Please present a modified version of Figure 43 clearly showing all the boundary conditions described in the text with appropriate labels.**

17. The application of very high conductance values to boundary conditions can lead to the model generating anomalously high values for flows in and out of the defined boundary conditions and discrepancies in model water balances. **Please provide the water balance results and the boundary inflow / outflow results for the refined model to support the model documentation.**

Section 5.3.2 documents the model optimisation (calibration) process. The groundwater model was run on a steady state basis and the calibration results presented in Figure 44 are reasonable. The model overpredicts groundwater levels by about 0.7 m but this is not necessarily a critical issue with the overall performance of the model. The calibrated hydraulic conductivity values for the mineral sands and the underlying basal gravels are 2.86 m/day and 75 m/day, respectively. The latter value is consistent with the outcomes from the pumping test performed on PB-1. The former value relating to the mineral sands is at the lower end of the range indicated from earlier sections in this report.

18. Section 5 does not provide any documentation regarding the set-up of the model used to simulate the predictive effects. This model will clearly be based on the calibrated model documented in the report but the means of simulating the progressing opencast pit are not documented. **Please provide model set-up documentation for the predictive model that was used to generate the flow results documented in Section 6.1, including detail on the progression of the simulated opencast pit across the site.**

19. **Please provide the layout of the parameter zones listed in Table 22 within the refined model mesh area.**

Section 6 considers the management of effects of mining on the groundwater system. Section 6.1 discusses the primary effects of in-pit pumping. This section is expected to document the potential effects of the mining operation if no management measures are put in place to minimise the effects. The unmanaged effects presented in the report are the groundwater pumping rates through the five-year operational period of the mine (Figured 45). However, the documentation of the projected effects that would arise unless management measures are implemented is limited to three bullet points did identify key controlling factors.

There is insufficient information provided in Section 6.1 to understand the extent and magnitude of the unmanaged effects of the proposed mining operation. Therefore, it is unclear what potential effects actually need to be managed, although a generic list of potential effects is provided in Section 3.2.3 and a short discussion of water management requirements as presented in Section 6.2.

20. **Please provide a chart showing the flow rates into the simulated opencast pit for Layer 1 and Layer 2 separately. How much water is entering the pit from the basal gravels compared to the mineral sands? What component of this water is direct recharge water to the pit footprint?**

21. **Please provide indicative groundwater drawdown maps showing the extent of drawdown when ore extraction is operational in Panel 8 and separately when Panel 9 is operational. Please present the drawdown maps for Layer 1 and Layer 2, together with an overlay of surface water bodies, wetland areas and known springs.**

22. **Please provide model outputs for water losses from adjacent surface water bodies to the mine and compare these to inflow and outflow rates for the surface water bodies in the calibration model.**

23. **Please provide a vector map of groundwater flow directions in Layer 2 in the area between the mine and the coastline.**

The objectives of the proposed water management system for the mine are described and prioritised in Section 6.3. A summary of the mine water management measures that are proposed to enable TiGa to achieve the water management objectives is presented in Section 6.4, together with a systematic flow chart of the proposed water management measures (Figure 46) and a conceptual layout for these measures (Figure 47). Water flow and quality monitoring that would be required to support the water management system operations is summarised in Section 6.4.

The key questions with respect to water drawdown management and therefore indirect management of the potential effects on adjacent surface water bodies are:

1. Can the perimeter system of infiltration trenches function as intended end minimise depletion effects from the adjacent surface water bodies? The perimeter infiltration trenches are described generically in Section 6.5.1.1. The potential performance of the infiltration trenches is considered in Section 6.7.

2. Can the proposed recharge wells limit drawdown of the deeper groundwater system and thereby minimise the potential effects of the proposed mine on wetlands and springs that are further from the mine footprint? The proposed injection wells are described generically in Section 6.5.1.2. The potential performance of the recharge wells is considered in Section 6.7.

Secondary questions relate to:

1. The potential performance of the proposed , which is to function as a back-up discharge system for excess treated minewater. This question is considered in Section 6.5.2.

2. The potential performance of the proposed , which is intended to provide additional water to the site water management system in the event of a water balance shortfall. This question is considered in Section 6.5.3.

An estimate for the performance of the infiltration trenches is presented in Appendix 5 to the report. It indicates a trench would have an acceptance capacity of approximately 30 L/s for a 900 m length of trench. It is clear that this calculation does not take into account the mining induced drawdown that would also be occurring in the area of the recharge trench. The infiltration rate calculation methodology would therefore lead to an underestimation of the potential acceptance rate.

24. **The acceptance capacity calculation incorporates a hydraulic conductivity of 25 m/day, which is above the range for the mineral sands. Please clarify the source of this value. Also, please provide the calculation used to determine the radius of influence for the mounded generated by the recharge.**

The recharge wells are described in Section 6.5.1.2 as being able to accept flows of between 1.5 L/s and 15 L/s, depending on the nature of the receiving aquifer sediments. In comparison, the recharge rate to PB-1, which is screened in the basal gravel, was about 4 L/s.

25. **Please provide the calculations that generated the estimates for potential flow rates to the recharge wells as listed in Section 6.5.1.2.**

The descriptions of the proposed Canoe Creek Infiltration Basin and the Canoe Creek Bank Infiltration Gallery presented in Sections 6.5.2 and 6.5.3 are accepted as reasonable for the purposes of this review. The general techniques for water management provided for under these sections are widely used and well understood. Site specific investigations prior to construction may result in modifications to the designs of these features. However, they are both considered to be back-up measures to the primary water management system at the site. **No requests for further information arise with respect to the information presented in this section**.

Section 6.6 describes in general terms the expected operations of the water management system. **No requests for further information arise with respect to the information presented in this section**.

Section 6.7 describe the results of simulating the groundwater recharge system that is intended to be used to minimise the offsite effects of the mining operation on groundwater and linked surface water systems. Although the modelling appears to indicate the proposed management measures are suitable to minimise the effects of the mining operation on flows in offsite water bodies and groundwater levels under adjacent sites, it is difficult to review this information without maps showing the extent of the effects of the proposed groundwater recharge system.

26. **Figure 56 appears to show the combined injection rates to the four proposed recharge bores located along the northern side of the mine. Please confirm this understanding is correct.**

27. **Figure 58 appears to show the combined injection rates to the proposed recharge bores located along the southern side of the mine. Please confirm this understanding is correct.**

28. **Please provide the MODFLOW model outputs for water losses from adjacent surface water bodies to the mine with the recharge systems in place and operating. Compare these depletion rates for the adjacent water bodies to inflow and outflow rates for the surface water bodies in the calibration model, and similarly to the model with no management measures in place.**

29. **Please provide a map showing the extent and magnitude of groundwater mounding in Layer 2 that would arise from the simulated recharge bore operation at the <u>northern</u> side of the mine. The mounding should be representative of a date late in the mining period with a high simulated rate of recharge. Please also provide a piezometric map for Layer 2 for the same date.**

30. **Please provide a map showing the extent and magnitude of groundwater mounding in Layer 2 that would arise from the simulated recharge bore operation at the <u>southern</u> side of the mine. The mounding should be representative of a date early in the mining period with a high simulated rate of recharge. Please also provide a piezometric map for Layer 2 for the same date.**

31. The report states "*Figure 55 shows that an additional ~60 L/s (~5000 m³/d) of water may need to be discharged directly to Collins Creek to maintain flows in the creek and/or stage Canoe Creek Lagoon during the peak period of depletion*." It is unclear how this value of 60 L/s is arrived at, especially given the average pre-mining upstream flow for Collins Creek is calculated to be 60 L/s. **Please provide the calculations to support the estimation of a 60 L/s depletion rate from Collins Creek**.

Section 6.8 summarises the key findings of the assessment with respect to water quantity effects. **No additional questions or requests for information arise out of the information presented in Section 6.8**.

Section 6.9 documents the water quality effects assessment. There are a number of factors to be taken into account in assessing receiving water quality. The only factor considered under section 6.9 is the receiving water dilution ratios as set out in Table 25. The calculations for the dilution ratios for Canoe Creek and the Northern Boundary Drain are clear. However, the calculations to estimate dilution ratios for Collins Creek and Canoe Creek Lagoon are not clearly set out in this section. This lack of clarity may be addressed by responses to information requests listed above.

Questions regarding the calculation of contaminant mass loads in discharge water from the site have been raised earlier in this review. They will not be repeated here.

32. **Please provide simple water balance calculations for the mine site as a whole showing inflows to the site and outflows from the site under normal operating conditions with no augmentation from the Canoe Creek gallery. Please provide similar water balance calculations taking into account the maximum augmentation flow from the Canoe Creek Gallery. Please show how the dilution rations for Collins Creek and the Canoe Creek Lagoon may be derived from these water balance calculations. It would help if these calculations are supported by a flow schematic showing the key flow paths at the time.**

Section 7 summarises the proposed rehabilitation concept for the site. Details for the rehabilitation concept are provided in the Water Management Monitoring and Mitigation Plan and the Rehabilitation Management Plan as discussed below. **No additional questions or requests for information arise out of the information presented in Section 7**.

Section 8 presents the key conclusions from the hydrological assessment. **No additional questions or requests for information arise out of the information presented in Section 8**.

## 4.2 Appendix 1 – Memorandum from Kōmanawa to John Berry, TiGa.

The memorandum provided in this Appendix documents the hydraulic tests performed on bores at the site. In summary:

- Stepped rate and constant rate pumping tests were performed on a Production Bore PB-1 and the interference drawdown monitored in three Observations Bores at distances up to 16.6 m from PB-1 (Sections 2.3 and 2.4 of Appendix 1). The data was analysed to derive the hydraulic characteristics of the sediments underlying the site.
- Two falling head tests were performed on a second Production Bore PB-2, Is construction difficulties on the board prevented it from being structured in a manner suitable for a longer duration test.
- The tests on PB-1 were performed appropriately. Monitoring was undertaken manually and using pressure transducers. The tests were of sufficient duration to enable drawdowns in response to the pumping to be measured in the Observation Bores. The drawdown responses in the Observation Bores enabled appropriate analysis to determine the aquifer characteristics. The documentation provided for the test is appropriate for the intended purpose.
- The analysis of the pumping test data from PB-1 was done using a widely accepted software package. The methodologies applied to the analysis of each of the drawdown curves are widely accepted and used.
- For analysis of the data, the aquifer targeted by PB-1 has been conceptualised as a leaky confined sandy gravel aquifer, with Observation Bores TB-1 and TAC-157 screened in the same aquifer. Observation Bore TB-2 is conceptualised as being screened in a shallower aquifer layer, separated from the deeper aquifer layer in which PB-1 is screened by a less permeable layer. The lower permeability layer is not considered to be an aquitard (leaky confining layer) in this memorandum.
- There is no indication from the test analyses that surface water in the nearby drain has acted as a hydraulic boundary condition, influencing the analysis results.
- The analysis results for Observation Bores TB-1 and TAC-157, summarised in Table 4 of the appendix generated reasonable and defensible results that are accepted (290 to 388 m/day) for the sandy gravels underlying the ore mineral sands.
- The analysis of the data from Observation Bore TB-2 appears reasonable. However, it is not clear how the vertical flow component between the conceptualised upper and lower aquifer layers has been addressed in the analysis. Although "*stratification and the vertical flow resistance that this would impart is not included in the final MODFLOW model*" documented in the main report (Section 5.3.3 in the main report), the question on how the vertical flow associated with the pumping test has been addressed leaves uncertainty regarding the hydraulic conductivity result for the ore sands derived from this test (about 17 m/day).
- The analysis of falling head tests performed on PB-2 (Section 2.5) to evaluate the hydraulic characteristics of the mineral sand ore material is subject to uncertainty due to the change in the recovery curves form part way through the test. Both tests performed showed similar changes in recovery curve slope. The actual analysis presented does not provide a match to either the early-stage data (prior to 2 minutes) or the late-stage data (after 2 minutes). This leaves some uncertainty as to the hydraulic conductivity for the ore sand indicated from this test (about 3 m/day).

- A check has been performed using the grain size distribution (GSD) from a bulk mineral sand sample. Such estimates tend to be less reliable than the analysis results from in-situ hydraulic tests. More importantly, only a single sample GSD was chosen for analysis. The geotechnical report (RDCL 2023) indicates at least 12 samples were taken during field investigation program and GSD data for each are documented in that report. The sample analysed to produce a hydraulic conductivity value represents "high grade ROM ore", is the most well-sorted of the samples analysed for GSD and has the lowest fines fraction from the documented samples. This implies that analysis of the GSD for the other samples is likely to return lower hydraulic conductivity values that that from the single sample considered (11 m/day).
- The main uncertainty arising out of the analysis of hydraulic parameters in Appendix 1 relates to the hydraulic conductivity of the mineral sands. Each of the three analyses discussed above have associated issues. However, the results are consistent between the analyses. Therefore, the range of hydraulic conductivity values for the mineral sands is accepted.

**No requests for further information arise with respect to the information presented in Appendix 1, Sections 1 to 3.**

Section 4 of the Appendix 1 memorandum relates to the quality of water discharged during the pumping test on PB-1. This information is considered separately in the following section of this review memorandum.

### 4.3 Appendices 1 (Section 4), 2, 3 and 4 – Water Quality Analysis Results.

This review is not intended to provide a detailed consideration of the likely quality of water at the mine site during mining operations and following closure. The following notes provide some guidance with respect to possible water quality factors that may influence water management during the operational period of mine and the design for the mine closure layout.

The groundwater sample taken from PB-1 during the pumping test and analysed was characteristic of a low-oxygen geochemical environment. The combined nitrate and nitrite nitrogen concentration was below the laboratory detection limit, with ammoniacal nitrogen being the dominant form detected in the sample. Additionally, dissolved iron and manganese were both elevated in the analysis results. These aspects of the groundwater quality have been highlighted in the Appendix 1 memorandum. The water quality data from the PB-1 pumping test are likely to be most representative of groundwater inflows to the planned mine.

## 5. GEOTECHNICAL REPORT (RDCL 2023) REVIEW

The geotechnical report is an important component of this review because a key factor in water management for the proposed development is the defined setback of the pit rim from nearby surface water bodies. Any failure of the pit wall needs to be contained within this setback. Furthermore, any failure of the pit wall should not lead to enhanced seepage from the adjacent surface water bodies and therefore exacerbated failure risks for the remaining pit wall.

The first three sections of the geotechnical report are introductory and set the background for the report.

Section 4 of the report describes the geological setting in generic terms, which is acceptable for the purposes of the geotechnical report. In Section 4.2 it is stated that "*groundwater levels are assumed 1 to 2m below current ground level.*" Depths to groundwater vary across the site and in response to weather patterns.

33. **Please clarify if there may be any impacts of a shallower groundwater table on the proposed 20 m offset (considered further below) and what the potential impacts are.** The concern is whether a shallower groundwater table would change the cut slope stability characteristics to the extent that a 20 m offset is insufficient to accommodate any potential slope failures.

Section 5 of the report provides a high-level summary of the mining method and Section 6 summarises the tailings management process.

In Section 6.1, the report states that the tailings "are 'clean' with no toxic potential", supporting a subsequent statement that "liners for containment are not required". The source of this information is not provided. However, this statement is not necessarily consistent with the water quality information presented in the Hydrology report. No request for further information is presented with regards to these statements as guidance on water quality is more appropriately provided by the authors of the Hydrology report.

34. In Section 6.1 of the report it states "*Freeboard always > 3m to ground level from final tailings surface as ~30% of the material is extracted as ore.*" **Please clarify if the freeboard referred to is measured from the original ground level or the final proposed ground level.**

Section 7 of the report summarises the geotechnical assessment of the mining operation. Review of the geotechnical components of the mine is outside the scope of this memorandum and is outside the reviewer's area of expertise. The groundwater component of work has been considered in this review.

The hydraulic conductivity values presented in Table 2 (Section 7.2 of the report) are not fully consistent with those derived from on-site testing and documented in the hydrology report. The mineral sand hydraulic conductivity is consistent between the two reports. However, the gravel underlying the mineral sand is characterised by a hydraulic conductivity of $1 \times 10^{-7}$ m/s in the geotechnical report compared to approximately $1 \times 10^{-3}$ m/s in the hydrology report. The implied 'underdrainage' of the mineral sands in the pit wall during the mining operation would suggest potentially high inflow rates around the toe of the pit wall. It is not clear that this feature of the groundwater system during the mining operation has been taken into account in the slope stability assessment.

35. **Please confirm that the hydraulic conductivity values presented in Table 2 have been applied in the slope stability analyses documented in Appendix B of the same report**.

36. **If groundwater flows are simulated in the pit wall stability modelling, does this change the model outcomes with respect to the area potentially affected by ground failure?**

Section 8 of the report focuses on pit wall stability and tailings management at the site.

Section 8.2.2 documents the assessment of the inferred permeability of the deposited tailings. The anticipated range in hydraulic conductivity is from $1 \times 10^{-4}$ to $1 \times 10^{-7}$ m/s. The assessment took into account the grain size distribution for the ore sands, a methodology for hydraulic conductivity analysis based on grain size distributions and the expected mixing of waste streams during deposition in the operational pit. The outcomes from this analysis and the expected hydraulic behaviour of the deposited wastes are reasonable. The outcomes are subject to a degree of uncertainty, due to uncertainty regarding the mixing of deposited tailings with fines separated during the initial ore processing stage. The key impacts of this uncertainty in terms of geotechnical behaviour of the stored tailings relate to drainage times and material workability. These are principally operational matters that may impact site rehabilitation procedures rather than environmental effects. Therefore, the uncertainty regarding the permeability and consolidation behaviour of the stored wastes as described in this report is acceptable at this stage of the project. Adjustments to mining and waste storage processes can reasonably be addressed through the Water Management Plan (Kōmanawa 2023b).

Section 8.4 of the report addresses pit wall stability. Earlier in the report, in Section 8.1, the report states: "*The proposed initial pit slope will be excavated at 50° - 65° to a depth up to 14 m below original ground surface*." The pit wall is expected to be left unbuttressed by the placement of tailings for periods of days to weeks, which is a reasonable expectation given the proposed mining methodology. In Section 8.4.1 the report states "*The open pit is expected to be stable for the proposed configuration with no substantial ground displacement due to instability expected > 5m from the pit crest based on this study*." This conclusion is important in that it presumably supports the designation of the 20 m offset between the pit rim and any sensitive surface water features.

37. **Please also confirm the aquifer parameters applied to the units simulated in the stability analysis. If the hydraulic conductivity applied to the basal gravel unit is not in accordance with the values provided in the Hydrology report, please adjust the value applied in the geotechnical model accordingly.**

38. The slope stability models documented in Appendix B indicate mineral sand extraction will extend to the top of the basal gravel layer. The basal gravel layer constitutes a more permeable aquifer that the overlying mineral sands, according to the Hydrology report. Additionally, it is not clear from either the Hydrology report or the Geotechnical report whether mineral sand extraction is to extend to the top of the basal gravel layer. **Please confirm the slope stability models correctly represent the layout of the pit walls according to the current mine plan. If the model layout does not provide an appropriate conceptual representation of a pit wall under the current mine plan, please adjust the models to more accurately represent the of the pit shell layout with respect to the geological units simulated.**

39. The slope stability models documented in Appendix B to the report appear to support the above statements with respect to the pit slope stability. However, these models also appear to have been run with static groundwater levels applied, without groundwater flows being simulated. The concern is that a setback of 20 m may not be sufficient to ensure adjacent streams and drains are not impacted by ground settlement, with associated potential development of preferred seepage paths into the planned opencast pit and possible piping along any seepage paths. **Please clarify if groundwater seepage flows have been taken into account in the slope stability analysis. If groundwater flows have not been taken into account, please run the models with seepage flows simulated to confirm the above statement regarding the limit of expected ground stability.**

40. The slope stability models do not take into account the proposed reinjection of water pumped from the operational pit into the same aquifer to manage potential impacts on Collins Creek and the Northern Boundary Drain, as described in the Hydrological report (Kōmanawa 2023a). The Water Management Plan indicates reinjection bores are to be installed between the open pit and the adjacent surface water bodies. This reinjection may require injection heads and the development of groundwater heads around the injection bores that exceed ground level. **Please run the slope stability models with the groundwater pressure effects of these reinjection bores taken into account and provide the model outcomes to confirm the stability of the proposed cut slopes and the appropriateness of the proposed setback.**

The report indicates that the slope stability model incorporating the backfilled tailings has tailings placed to a level of 3 m BGL. However, the model images provided in Appendix B of the report suggest tailings placement to a level approximately 7 m BGL. This discrepancy is **advisory only** as the lower level of tailings placement is unlikely to improve the modelled stability of the pit wall.

Section 8.4.2 of the report addresses coastal interaction. In this section of the report there is a statement "*The rehabilitated ground will be made up of hydraulically and mechanically placed tailings overlain by a clay cap placed and compacted by machines including oversize, finished to pasture for dairy use.*" There is no mention of an engineered clay cap as part of the site rehabilitation process in either the Rehabilitation Management Plan (TiGa 2023), the Water Management Plan (Kōmanawa 2023b) or any of the other documents reviewed.

41. **Please clarify if an engineered clay cap to the rehabilitated tailings is planned. If such a cap is planned, please clarify its intended purpose and verify that such a cap can be practically installed on a foundation of tailings backfill.**

Section 9 of the report provides a risk assessment for the tailings storage. This risk assessment appears to have been principally undertaken on the basis that the storage area may be considered as a storage dam. Risks and failure modes have been evaluated on the basis of a potential dam failure. An assessment of this aspect of the project is outside the scope of this review. However, it is noted that the top of the stored tailings is to be at least 3 m BGL. No embankment above the level of the surrounding ground is proposed. Furthermore, mining is to be undertaken in a dewatered pit. Therefore, it seems unlikely that any geotechnical failure in the proposed tailings storage could potentially lead to mine water or tailings being discharged from the operational pit area to the surrounding environment. **No concerns are raised through this review with respect to the contents of Section 9.**

## 6. REHABILITATION MANAGEMENT PLAN (TIGA 2023)

The rehabilitation management plan has not been reviewed in detail, as it is recently expected that this plan will be adjusted as mining operations progress. Overall, the plan provides appropriately for site rehabilitation in terms of the aspects affecting water management at the site following closure. However, two aspects of the rehabilitation management plan raise implications for the overall review of the hydrological aspects of the proposed mining operation.

The water treatment ponds at the northwestern corner of the mine footprint (Ponds 3 and 4) are shown as having been backfilled and rehabilitated as pasture in Figure 7 of the rehabilitation management plan. The closing and backfilling of these ponds as part of the site rehabilitation was not mentioned in the rehabilitation report.

42. **Please confirm that the planned water treatment ponds are to be backfilled and rehabilitated as pasture following the completion of ore extraction operations. If this is not the case, please clarify the proposed rehabilitation for this area of the site.**

The cross sections showing the current and post mining profiles for the site, as presented in Figures 8, 9 and 10, appear to indicate that the rehabilitated ground surface will be predominantly above the current ground surface. It is not clear if this understanding is correct or an artefact of the alignment of the cross sections presented in these figures. Although the final landform topography is presented in Figure 7, this figure is difficult to understand as contour elevations have not been provided.

43. **Please provide a version of Figure 7 with contours labelled and proposed farm drains identified, to enable a better understanding of the expected final landform.**

44. **Please confirm the bulking factor applied to the mine backfill and verify that there will be sufficient material available at the close of mining operations to refill and rehabilitate the final mine void and the water treatment ponds.**

Section 7 in the Hydrology report (Kōmanawa 2023a) states "*Material from above the water table to the east of the proposed excavation area, where the seasonal high water table is between 1 m and > 3 m deep, will be excavated and transferred to the mined area to replace the heavy mineral concentrate material removed from the site*." This clarifies the situation with respect to availability of material for site rehabilitation. However, the above requests for information have been left in place to ensure there is no uncertainty regarding material availability for site rehabilitation.

## 7. EROSION AND SEDIMENT CONTROL PLAN (RIDLEY 2023)

The erosion and sediment control plan (ESCP) has been reviewed to confirm that management measures incorporated in the plan are in line with those described in the Hydrology report (Kōmanawa 2023a).

Overall, the ESCP is appropriate for the nature of the proposed mining operation. Management measures with respect to various disturbed surfaces have been presented and are considered appropriate. The treatment of water from disturbed areas is to be addressed through a multi-stage process, with Pond 4 being the ultimate treatment stage for mine water.

Prioritised options for the discharge of treated mine water from pond 4 I described in section 4.3.1 of the ESCP. The first priority is to use treated mine water for groundwater recharge around the mine boundaries. If the available water exceeds the capacity of the recharge systems, and the treated water quality is acceptable for direct discharge to Canoe Creek Lagoon, this will be the next option applied. If the water quality is not sufficiently good for direct discharge to the lagoon, the treated water will be pumped to infiltration basin adjacent to canoe Creek or will be returned to the opencast pit in extreme situations.

The plan provides for appropriate turbidity and sediment monitoring in the mine water to support the real-time management of mine water quality through the proposed disposal options.

**No concerns are raised through this review with respect to the ESCP.**

## 8. BARRYTOWN MINERAL SAND MINE ECOLOGICAL EFFECTS ASSESSMENT (ECOLOGICAL SOLUTIONS 2023)

My detailed review of this document is outside the scope of this memorandum. However, there are a number of aspects of the ecological effects assessment report that rely on information provided in the hydrology report (Kōmanawa 2023a). Given the requests for information raised with respect to the Hydrology report,

Dilution ratios presented in Section 9.9.4 of the Ecological Assessment report have been taken form the Hydrology report. A request has been made for information to support these dilution ratios. If the ratios change in response to this request, then the receiving water contaminant concentrations may need to be revisited.

The report states in Section 9.9.4 with respect to the assessment of receiving water quality that "*Modelling inputs were based on the median of estimated treated clean process water*". This text refers to median contaminant concentrations. However, it appears that these medians have been calculated directly from groundwater sampling analysis data with no consideration of the proportional contributions of groundwater from the mineral sands, the underlying gravels and the mine waste backfill have to the mine water discharges. Normally, mass load calculations would be used to calculate these relative contributions and the expected discharge water quality. Questions have been raised in the review of the Hydrology report with respect to this aspect of the assessment. If the responses to these questions indicate the contaminant concentrations in the mine discharge water are higher than indicated in the Ecological Assessment, then the assessment of receiving water quality may need to be revisited.

## 9. CONCLUSION

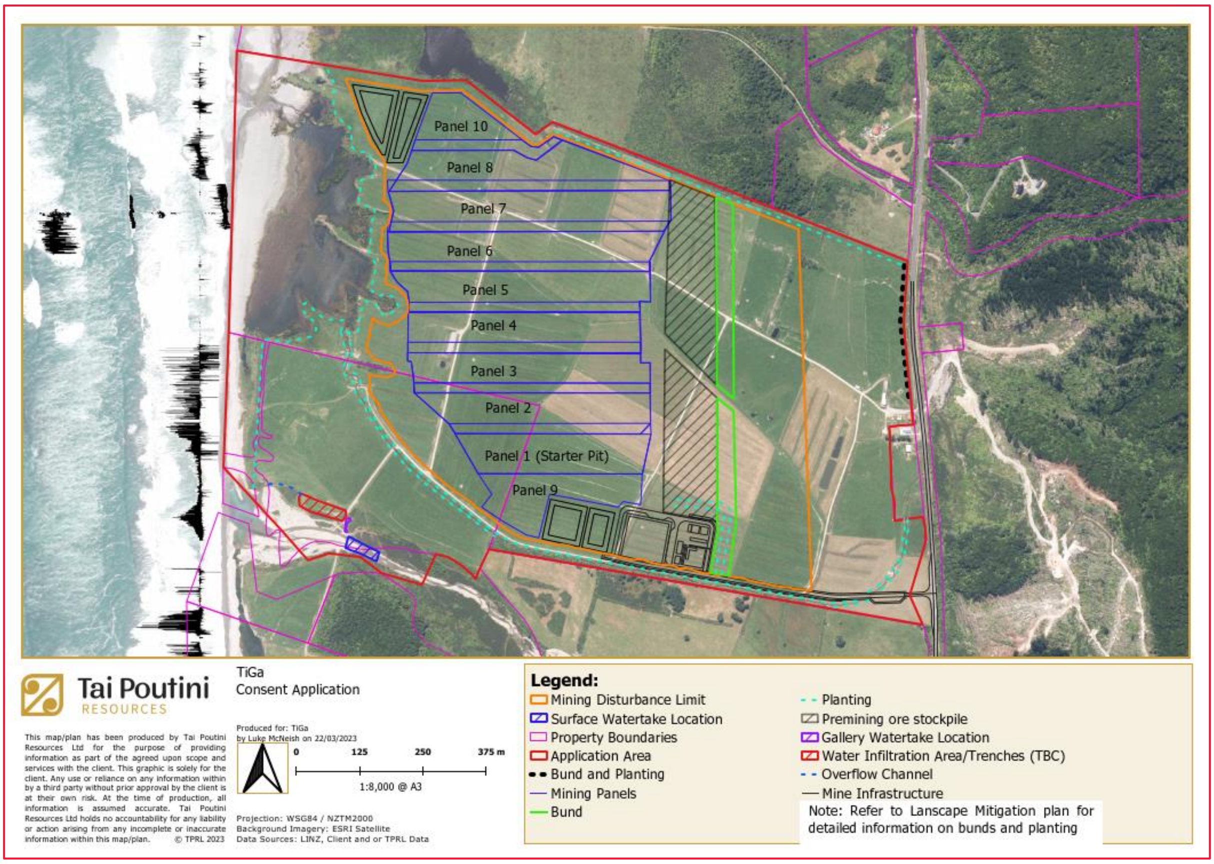
A substantial amount of work has been put into the hydrological assessment of the proposed mine and the design of water management systems. The work undertaken generally appears technically reasonable and defensible. The requests for further information mainly relate to gaps in documentation rather than gaps in assessment work undertaken.

Yours Sincerely

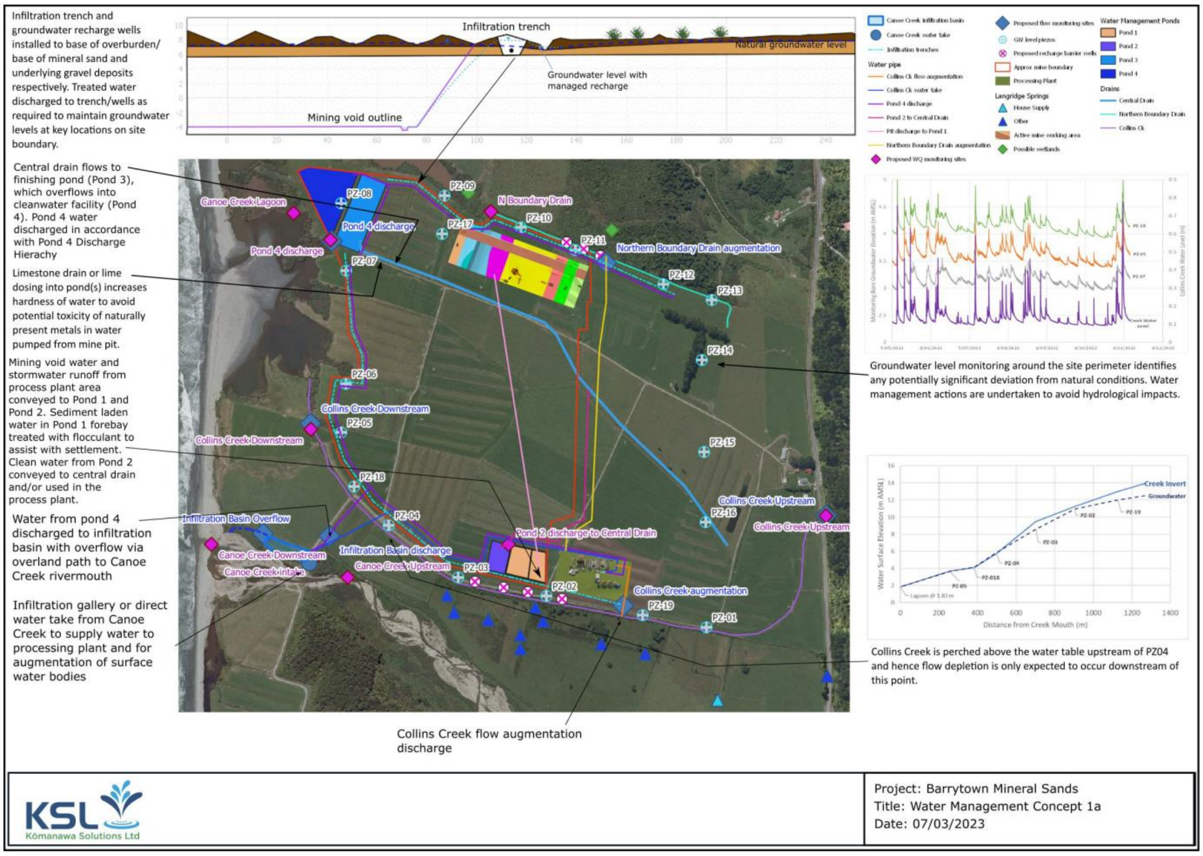
Brett Sinclair
Senior Principal Hydrogeologist
**WALLBRIDGE GILBERT AZTEC**

**APPENDIX A** SITE PLANS

# APPENDIX A
## SITE PLANS



Panel 10
Panel 8
Panel 7
Panel 6
Panel 5
Panel 4
Panel 3
Panel 2
Panel 1 (Starter Pit)
Panel 9
Tai Poutini RESOURCES
TiGa
Consent Application
This map/plan has been produced by Tai Poutini Resources Ltd for the purpose of providing information as part of the agreed upon scope and services with the client. This graphic is solely for the client. Any use or reliance on any information within by a third party without prior approval by the client is at their own risk. At the time of production, all information is assumed accurate. Tai Poutini Resources Ltd holds no accountability for any liability or action arising from any incomplete or inaccurate information within this map/plan. © TPRL 2023
Produced for: TiGa
by Luke McNeish on 22/03/2023
0 125 250 375 m
1:8,000 @ A3
Projection: WSG84 / NZTM2000
Background Imagery: ESRI Satellite
Data Sources: LINZ, Client and or TPRL Data
Legend:
Mining Disturbance Limit
Surface Watertake Location
Property Boundaries
Application Area
Bund and Planting
Mining Panels
Bund
Planting
Premining ore stockpile
Gallery Watertake Location
Water Infiltration Area/Trenches (TBC)
Overflow Channel
Mine Infrastructure
Note: Refer to Lanscape Mitigation plan for detailed information on bunds and planting

Infiltration trench and groundwater recharge wells installed to base of overburden/ base of mineral sand and underlying gravel deposits respectively. Treated water discharged to trench/wells as required to maintain groundwater levels at key locations on site boundary.
Infiltration trench
Natural groundwater level
Groundwater level with managed recharge
Mining void outline
Central drain flows to finishing pond (Pond 3), which overflows into cleanwater facility (Pond 4). Pond 4 water discharged in accordance with Pond 4 Discharge Hierachy
Limestone drain or lime dosing into pond(s) increases hardness of water to avoid potential toxicity of naturally present metals in water pumped from mine pit.
Mining void water and stormwater runoff from process plant area conveyed to Pond 1 and Pond 2. Sediment laden water in Pond 1 forebay treated with flocculant to assist with settlement. Clean water from Pond 2 conveyed to central drain and/or used in the process plant.
Water from pond 4 discharged to infiltration basin with overflow via overland path to Canoe Creek rivermouth
Infiltration gallery or direct water take from Canoe Creek to supply water to processing plant and for augmentation of surface water bodies
Canoe Creek Lagoon
Pond 4 discharge
N Boundary Drain
Northern Boundary Drain augmentation
Collins Creek Downstream
Collins Creek Upstream
Infiltration Basin Overflow
Infiltration Basin discharge
Canoe Creek Downstream
Canoe Creek intake
Canoe Creek Upstream
Pond 2 discharge to Central Drain
Collins Creek augmentation
PZ-01
PZ-02
PZ-03
PZ-04
PZ-05
PZ-06
PZ-07
PZ-08
PZ-09
PZ-10
PZ-11
PZ-12
PZ-13
PZ-14
PZ-15
PZ-16
PZ-17
PZ-18
PZ-19
Water Management Ponds
Pond 1
Pond 2
Pond 3
Pond 4
Drains
Central Drain
Northern Boundary Drain
Collins Ck
Groundwater level monitoring around the site perimeter identifies any potentially significant deviation from natural conditions. Water management actions are undertaken to avoid hydrological impacts.
Creek Invert
Groundwater
Distance from Creek Mouth (m)
Collins Creek is perched above the water table upstream of PZ04 and hence flow depletion is only expected to occur downstream of this point.
Collins Creek flow augmentation discharge
KSL Kōmanawa Solutions Ltd
Project: Barrytown Mineral Sands
Title: Water Management Concept 1a
Date: 07/03/2023