# Appendix N Hydrogeology Assessment (Groundwater Effects)

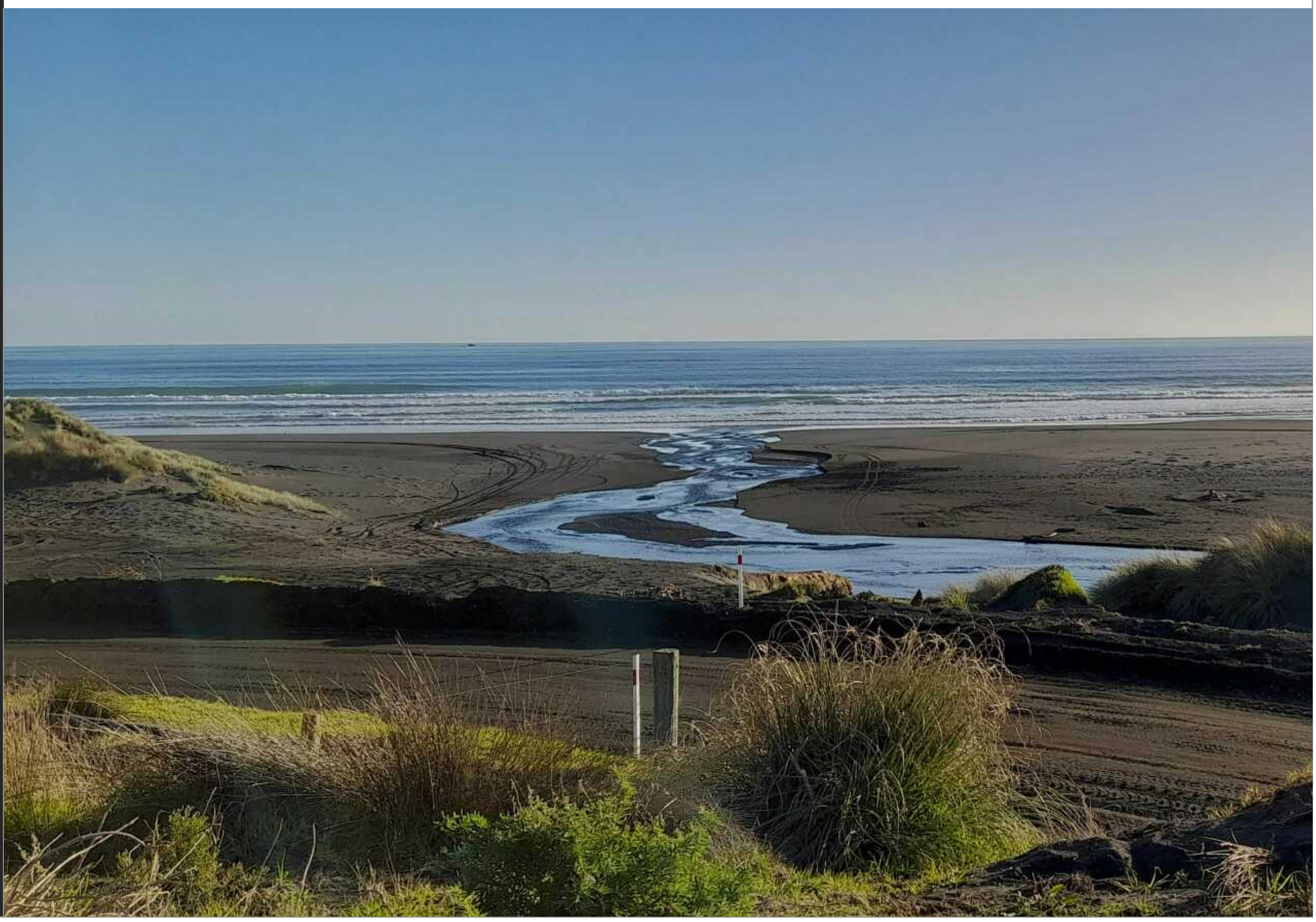
# Taharoa Mine Expansion

# Assessment of Groundwater Effects

TAHAROA IRONSAND LIMITED

WWLA1303 | Rev. 6

17 September 2025



## Assessment of Groundwater Effects

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|---|---|
| Project no: | WWLA1303 |
| Revision: | 6 |
| Date: | 17 September 2025 |
| Client name: | Taharoa Ironsand Limited (TIL) |
| Project manager: | Jon Williamson |
| Author(s): | Asanka Thilakerathne, Jake Scherberg |
| File name: | G:\Shared drives\Projects\Taharoa Ironsands Limited\WWLA1303_Taharoa Hydrogeological Modelling\Deliverables\Reports\Groundwater AEE\WWLA Rep_Taharoa Gw AEE_Final_170925 .docx |

Williamson Water & Land Advisory

Auckland | Whangārei | Tauranga
New Zealand
www.wwla.kiwi

### Document history and status

| Rev | Date | Description | By | Review | Approved |
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| 1 | 30 June 2025 | Draft for internal review | Asanka Thilakerathne | Jake Scherberg | Jake Scherberg |
| 2 | 4 July 2025 | Draft for client review | Asanka Thilakerathne & Jake Scherberg | Jon Williamson | Jon Williamson |
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| | | | | | |

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## Executive Summary

| | |
|---|---|
| **Project Objectives** | This report has been prepared for Taharoa Ironsands Limited (TIL) in respect of its application for all approvals under the Fast-track Approvals Act 2024 for the Central and Southern Blocks of the Taharoa Ironsand Mine. The Panel appointed to consider the application for the Central and Southern Blocks Mining Project may rely on this report for the purpose of making its decision under the Fast-track Approvals Act 2024.<br>This report has been prepared in accordance with the Environment Court's Code of Conduct for expert witnesses, contained in the Environment Court's Practice Note 2023. The authors of this report agree to comply with the Code of Conduct, and confirm that unless otherwise stated, the issues addressed in this report are within the area of expertise of the authors. No material facts have been omitted that might alter or detract from the opinions expressed in this report.<br>Williamson Water & Land Advisory (WWLA) were commissioned by TIL in January 2025 to undertake hydrogeological investigations, groundwater monitoring and to develop a groundwater model to simulate the proposed mining in the Central and Southern Blocks of the Taharoa Ironsand Mine.<br>In support of the Fast-track Approvals process, this document provides an Assessment of Environmental Effects (AEE) related to groundwater effects from the proposed mining activities in the Central and Southern Blocks.<br>WWLA has developed a 3D numerical groundwater model to provide a quantitative representation of the groundwater conditions within the proposed TIL mining areas and the surrounding catchments, and to ultimately inform the AEE. Specifically, the model was used to anticipate the effects of proposed mining on environmental conditions both during mining and after the mine area is restored to approximate the original topography after mining is complete.<br>The groundwater effects assessment quantifies the effects of excavating mine pits on the local groundwater system. This analysis comprised:<br>• Evaluation of the depth and extent of drawdown resulting from pit excavations;<br>• Assessment of neighbouring bore interference effects;<br>• Assessment of potential impacts on stream baseflow;<br>• Assessment of potential impacts on wetlands due to groundwater drawdown;<br>• Assessment of saline intrusion;<br>• Estimation of the rate and volume of groundwater seepage into excavation areas (i.e. pit dewatering); and<br>• Long term changes in the hydrogeological regime following mining and land reclamation. |
| **Methods** | The indicative mine plan for the Central and Southern pits, as provided by TIL was adapted into the model and through a 44 year transient simulation driven by historic climate conditions. A mining scenario and a baseline scenario with no mining were used as a reference to predict the effects that may occur from the proposed mining operation. |
| **Summary of Results** | The maximum extent of groundwater drawdown is primarily confined to within the Central and Southern Block, but extends approximately 1 km east of the C Block boundary at the peak of excavation in the Southern Pit. The only infrastructure within the area that is subject to groundwater drawdown is the domestic bore ID 142329 which has a maximum of 1.65 m of drawdown predicted during the peak of the excavation in the Southern Block. It can be assumed that this level of drawdown would still allow sufficient pump submergence for normal bore operation, hence the effects of drawdown are considered to be less than minor.<br>As the mine excavation intersects the water table, groundwater will drain into the mine pit resulting in dewatering. Based on WWLA's modelling, the maximum groundwater drainage into the Central and Southern mine pits are 83.1 and 131.8 L/s, respectively.<br>The maximum base flow reduction for the Mitiwai Stream is anticipated to be 4.4 L/s, which equates to approximately a 10% of 7-day mean annual low flow (MALF). A trigger level set at 28 L/s, equal to 90% of the $Q_5$ (the default minimum flow requirement set in the Waikato Regional Plan) is recommended. If flow in the Mitiwai Stream were to fall below this level, contingency measures to be implemented may include direct flow augmentation, and/or partial or full cessation of pit dewatering adjacent to the affected stream. These measures are further considered by the project freshwater ecologist. |

| | |
|---|---|
| | For the Wainui Stream no change in overall flow is anticipated if an environmental flow of 34 L/s flow is maintained below the invert of the v-notch weir, equating to the combined rate required for downstream residual flow and fish passage flow (WWLA 2025). This flow is currently maintained by TIL's existing consents and we have recommended that this is continued, through consent requirements (as recommended in the hydrology assessment associated with this application). From a groundwater perspective, some reduction in baseflow can be anticipated during the peak of the excavation in the South Pit, but given that a minimum flow will be sustained by management of the lake outlet and augmentation if needed (as specified proposed consent conditions), the total streamflow during low-flow events will not be affected.<br>There are 88 wetlands that have been identified within the model area (encompassing the entire Mitiwai Stream Catchment, the Wainui Catchment below Lake Taharoa and the portion of the Wainui Catchment that lies north of the lake), with over half found to be either groundwater fed or potentially groundwater fed. Some wetlands are within the proposed excavation area, and others near Lake Taharoa and the Wainui Stream are within the Central and Southern Block and may be vulnerable due to drawdown. Detailed investigation determined that the retained wetlands within the drawdown area were primarily surface water fed, based on their topographic position and water levels being above the regional groundwater level measured in the nearby monitoring piezometer (S101).<br>The retained wetlands within the drawdown area were classified into four groups based on their location and topographic position. The first group is comprised of one wetland near the Mitiwai Stream and is currently monitored by the piezometer C103. The second group comprised of riparian features and will be supported via the management of flow conditions in the Wainui Stream. The third wetland group is near the edge of Lake Taharoa, with Wetland 72 being both the largest and closest to the excavation. The fourth group are to the south of the Southern Pit. They are predominantly surface water fed and negligible effects from mining are anticipated with the exception of Wetland 80 which is within the drawdown area and may have a partial connection to groundwater.<br>WWLA recommends that new monitoring sites be established within Wetland #72 and Wetland #80 to monitor potential drawdown effects and alert TIL when management steps may be required in relation to Wetland groups Three or Four, respectively. In summary, the retained wetlands within the area where groundwater drawdown is expected are all primarily surface water fed, with groundwater connection only likely to occur during high water events if at all, though it is prudent to take conservative measures to assure wetland protection during mining.<br>Consistent with WWLA's recommendation, a monitoring and management package is being proposed by the project ecologists to address the potential effects on wetlands which are proposed to be mined as part of this project and which are potentially affected by drawdown.<br>Following mining, the land will be restored to approximately the original topography with tailing material emplaced except for a void in the area of the final stage of the excavation. Groundwater and stream baseflow conditions will rebound to their original state within a timeframe of approximately 2 years.<br>During the peak of the excavation, particularly in the Southern Block, the natural groundwater flow between the ocean and the shallow aquifer is predicted to temporarily reverse in a localised area for a brief period because of changes in hydraulic pressure resulting from the depth of the excavation. Although this could theoretically allow seawater to move inland, it is unlikely that this results in saline intrusion because the movement of saline water is anticipated to be very slow, the duration of this reversal is expected to be brief (so there is not enough time for significant migration to occur). If saline intrusion did occur, the effects would be confined to the active pit area, which is uninhabited and not used for water supply. |
| **Key Conclusions** | With consideration for all mitigation and compensation packages that are included as part of this application, all potential effects related to the proposal for the mining of the Central Pit and Southern Pit are less than minor. |

## Contents

# 1. Introduction

This report has been prepared for Taharoa Ironsands Limited (TIL) in respect of its application for all approvals under the Fast-track Approvals Act 2024 for the Central and Southern Blocks of the Taharoa Ironsand Mine. The Panel appointed to consider the application for the Central and Southern Blocks Mining Project may rely on this report for the purpose of making its decision under the Fast-track Approvals Act 2024.

This report has been prepared in accordance with the Environment Court's Code of Conduct for expert witnesses, contained in the Environment Court's Practice Note 2023. The authors of this report agree to comply with the Code of Conduct, and confirm that unless otherwise stated, the issues addressed in this report are within the area of expertise of the authors. No material facts have been omitted that might alter or detract from the opinions expressed in this report.

Williamson Water & Land Advisory (WWLA) was commissioned by TIL in January 2025 to undertake hydrogeological investigations, groundwater monitoring and to develop a groundwater model to simulate the proposed mining in the Central and Southern Blocks of the Taharoa Ironsand Mine.

This document provides an Assessment of Environmental Effects (AEE) related to groundwater effects from the proposed mining activities in the Central and Southern Blocks to inform TIL's application for approvals.

The assessments undertaken in this report are based on quantitative analysis of 3D numerical model outputs of the proposed mining process relative to baseline (current) conditions in the surrounding environment, including groundwater levels, stream baseflows, wetland water levels and the saline interface. The model was also used to estimate mine dewatering requirements for mine operational purposes.

The model developed is referred to as the Taharoa Ironsands Groundwater Model (TIGM). Specifically, the TIGM was utilised to assess the proposed mining excavation in terms of the following considerations:

- Evaluation of the depth and extent of groundwater drawdown resulting from pit excavations;
- Assessment of neighbouring bore interference effects;
- Assessment of potential impacts on stream flow;
- Assessment of potential effects on wetlands within and adjacent to the proposed mining area;
- Assessment of potential saline intrusion;
- Estimation of groundwater dewatering requirements from the mine pit at various stages in the excavation process; and
- Long term changes in the hydrogeological regime following mining and land rehabilitation.

This document provides an assessment of groundwater effects intended for a general reading audience. It has been assumed that technical experts supporting the Fast-track Approvals Panel are familiar with the project context, so this report provides a high-level summary of that background. A document providing the more detailed technical details underpinning the numerical model development and related analysis and conclusions is provided as **Appendix A**.

## 1.1 Report Structure

The report comprises:

- **Section 2** – a description of the proposed activity;
- **Section 3** – a description of environmental conditions including climate, surface water features, and hydrogeological conditions;
- **Section 4** – a description of the mining areas, mining methodology, and details of the mine plan;
- **Section 5** – an overview of the groundwater model setup;
- **Section 6** – Model scenario results and an assessment of environmental effects; and

- **Section 7** – Mine Dewatering Analysis – Estimated dewatering requirement through the mining process.
- **Section 8** – Conclusions.

# 2. Description of Proposed Activity

## 2.1 Location

The Taharoa Ironsand Mine is located approximately 88 km south-west of Hamilton, in the Waikato Region. The project area consists of Northern, Central and Southern Blocks, with the northern and central blocks separated by the Mitiwai Stream, and the central and southern blocks separated by the Wainui Stream. The overall mine site (legally described as the Taharoa C Block) is approximately 1,300 ha. The study area for this assessment is shown in **Figure 1**.

**Figure 1**, is defined by the catchments of the Mitiwai Stream and the western portion of Wainui Stream, including the western shore of Lake Taharoa.

Currently, mining is underway in the Central Pit (located within the Central Block) while mining in the Southern Block has occurred previously, but is not currently active. The proposed mine plan includes mining both the Central and Southern Blocks. The excavation will include mining above and below the water table. It is assumed that mining in the Northern Block will be undertaken at a later time and is not part of this assessment.

## 2.2 Mine Development and Methodology

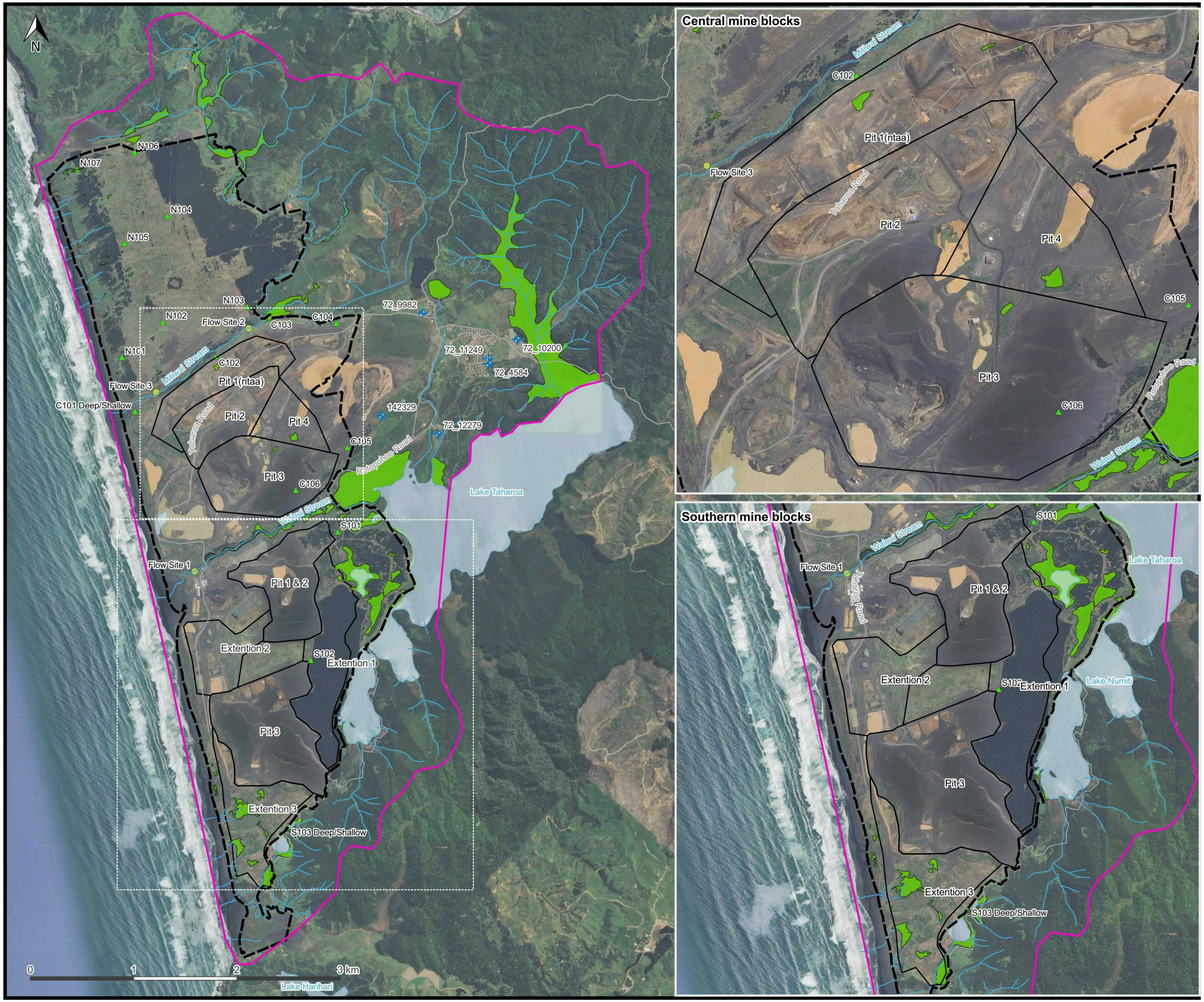
An indicative mine plan was provided by TIL detailing plans for excavations proceeding through the Central and Southern Blocks (**Appendix B**, **Appendix C**). The extent and depth of the excavation areas that were the basis for this assessment are detailed in **Section 4** of this report.

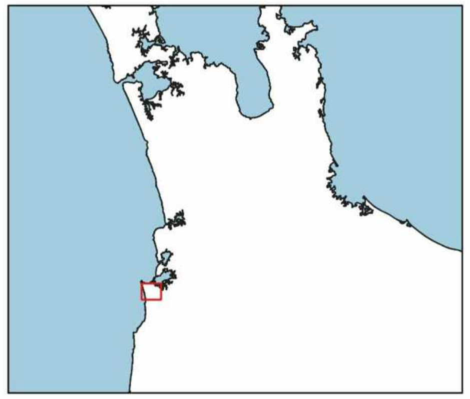
A modelling analysis has been undertaken to simulate the excavation process using a numerical groundwater model in a manner that follows the indications in the mine plan. Details about how the model was set up, calibrated, and the model scenarios were implemented into the numerical groundwater model are detailed in a separate modelling report (**Appendix A**).

Map Title:
**Location map with mine development phases**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



Legend
- Stream flow monitoring sites
- Piezometers
- Known Bores
- Roads
- Streams
- Lakes
- Wetlands
- Study area
- TIL Property Boundary
- Southern mine blocks
- Central mine blocks

Data Provenance
Land information New Zealand

Drawn by: Asanka Thilakerathne
22/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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Figure 1

# 3. Description of the Receiving Environment

The environmental conditions across the Taharoa C Block and surrounding area, collectively referred to as the 'Study Area' in this report, are described in this section and shown in **Figure 1**. These include:

- climate;
- topography;
- surface water drainage;
- soils; and
- geological and hydrogeological characteristics.

Collectively, this information is synthesised into a conceptual model of hydrological conditions across the site, which specifically inform the sub-soil drainage, groundwater recharge, and hydrogeological environment operating through the study area.

The conceptual model derived from this information is translated into a quantitative assessment using these physical characteristics with a Soil Moisture Water Balance Model (SMWBM), which is a daily catchment water balance accounting tool. The SMWBM was used to calculate the partitioning of rainfall into key catchment water balance components including interception loss, surface runoff, soil evaporation and groundwater recharge.

## 3.1 Climate

Rainfall data was primarily sourced from Port Taharoa AWS through the NIWA Cliflo database (1982 to 2025). Data gaps were filled using data from the Fire and Emergency NZ (FENZ) rain gauge about 3 km east of Lake Taharoa (2018 to 2025). In a few cases no data was available from either station, therefore monthly median rainfall was used as an alternative. These stations provided most reliable data for the period of 1982-2025. There were some data gaps which was filled by each other station or monthly median average.

Potential evapotranspiration (PET) data was obtained from the Te Kuiti station for the period of 2003 through 2024. No data was available in reasonable proximity to the study area prior to 2003.

A statistical summary of monthly rainfall data is presented in a box-whisker plot in **Figure 2**, showing monthly rainfall and PET data from the above stations. The boxes represent the $25^{th}$ to $50^{th}$, and $50^{th}$ to $75^{th}$ percentile ranges and the whiskers represent the most extreme years.

Mean annual rainfall for the data period was 1,162 mm. June was the wettest month, with rainfall ranging from 97 mm to 148 mm and a median of 126.6 mm. The lowest average rainfall was found to be in January, ranging from 19 to 82 mm, with a median total of 59 mm, while February had similarly dry conditions. Maximum PET occurs in summer, as would be expected, averaging over 120 mm in December and January while minimum PET is typically below 20 mm through June and July.

**Figure 3** shows 7-day cumulative rainfall which reflects the frequency and intensity of high rainfall events. The peak 7-day cumulative rainfall occurred during the period was 306 mm. 7-day rainfall exceeding 200 mm occurs, on average, only once every 10 years. Such events have occurred in 1983, 1992, 1993, and 2022.

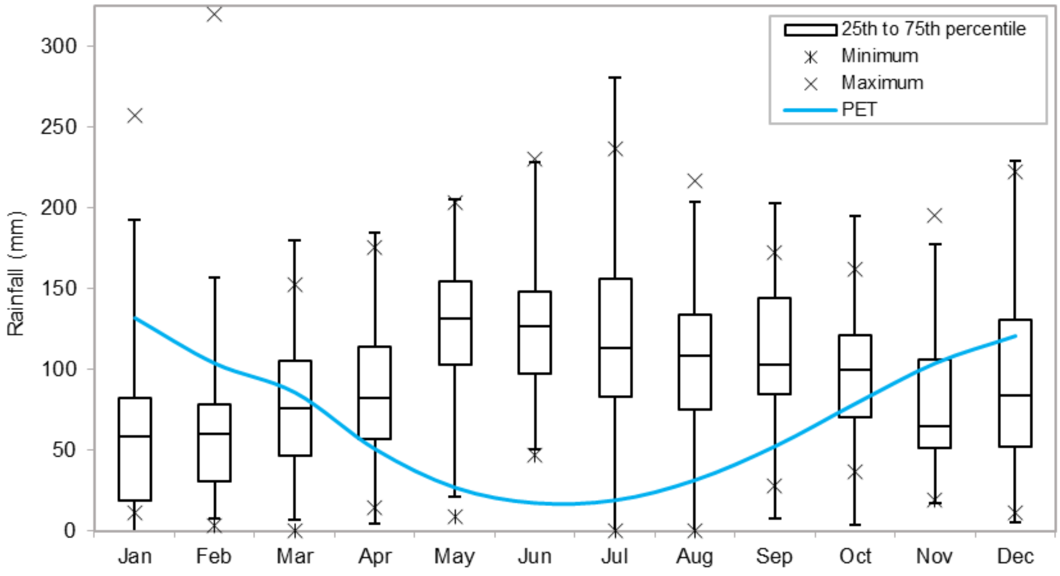



Figure 2. Box and whisker plot of monthly rainfall and PET (2003 – 2024).

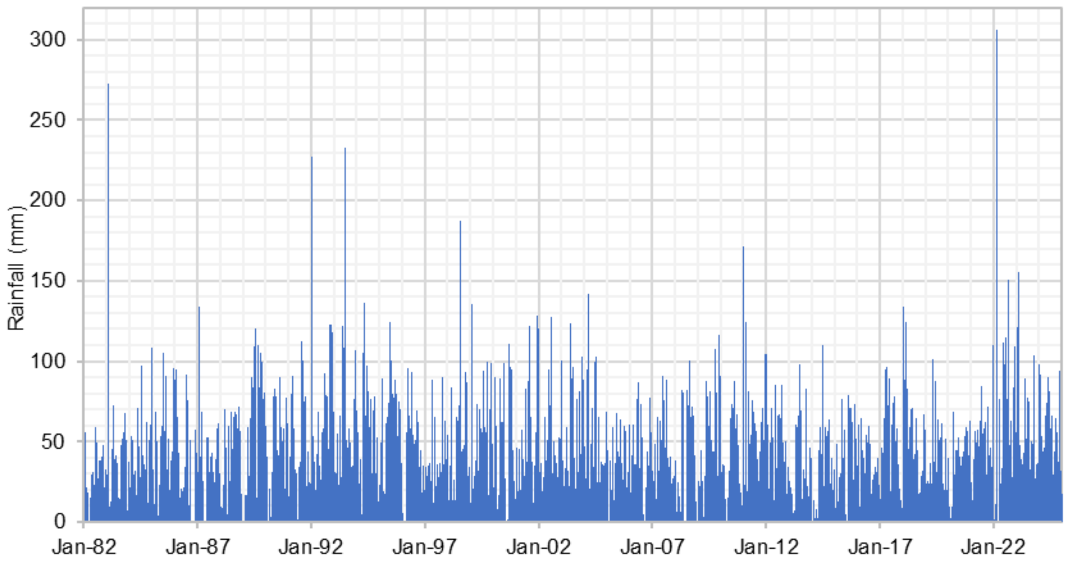



Figure 3. 7-day cumulative rainfall recorded at Port Taharoa AWS and FENZ Taharao (1982 to 2025)

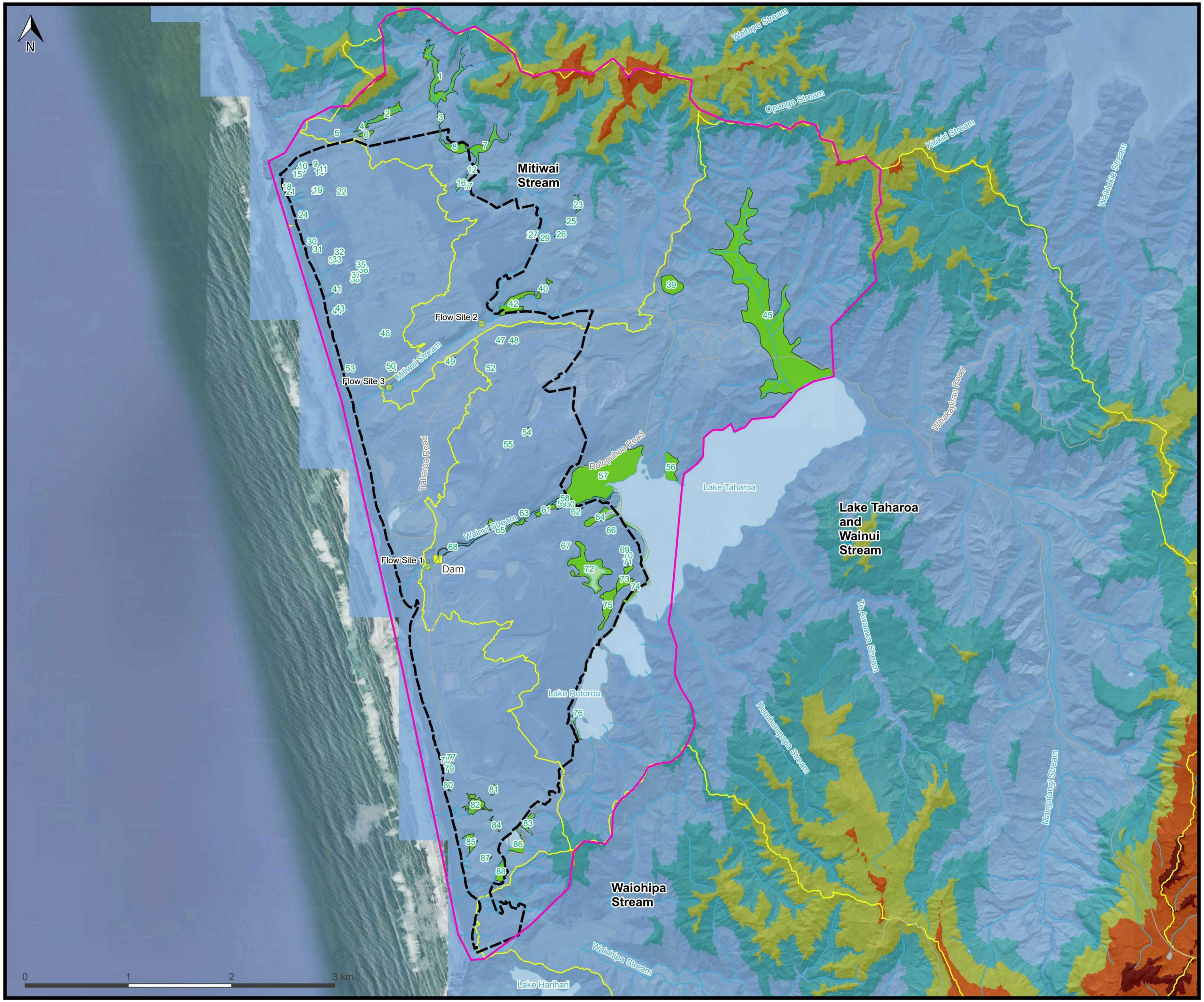
## 3.2 Topography and Drainage

The study area is primarily defined by catchment boundaries and the coast, with the major streams and lakes within and around the study area shown **Figure 4**. It should be noted that all elevations in this document are relative to New Zealand Vertical Datum.

The Mitiwai Stream catchment covers the 7.5 $km^2$ northern portion of the study area. The Wainui Stream catchment covers a total of 13.8 $km^2$, covering 46% of the study area for this analysis. Lake Taharoa covers an area of 2.2 $km^2$ along the eastern portion of the study area. The lake's water level is in part controlled by TIL as part of its water management operations.

The TIL mine site comprises undulated topography with sand dunes and a modified landscape. The Northern Block is generally higher in elevation, ranging from 3 to 105 m above mean sea level (mAMSL). Rugged hilly terrain surrounds the TIL mine site to the north and east, comprises steeper terrain and reaches significantly higher elevation toward the eastern edge of the Mitiwai Stream catchment where the Orangiwhao Peak comprises the highest elevation within the study area at 298 mAMSL. Around the village of Taharoa the terrain flattens into a low-relief that is subject to flooding during periods of heavy rainfall.

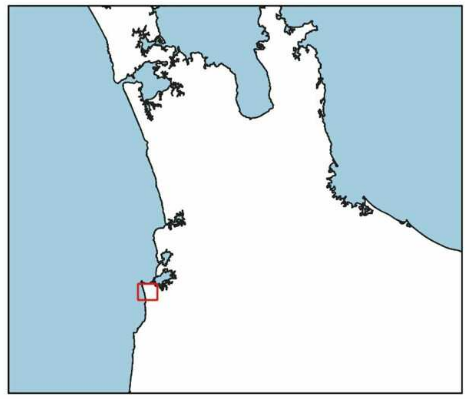
Over most of the current and proposed mining area, surface water runoff (albeit minimal, other than the stream catchments, due to high infiltration) and groundwater flows occur directly to the ocean.




Map Title:
**Topography and drainage overview**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- **Stream flow monitoring sites**
- **Dam Structure**
- **Roads**
- **Study area**
- **TIL Property Boundary**

Surface water features

- **Streams**
- **Lakes**
- **Surface water catchments**
- **Wetlands**

Elevation Categorise
**mAMSL**

- **<= 57**
- **57 - 116**
- **116 - 175**
- **175 - 234**
- **234 - 293**
- **> 293**

Data Provenance
Land information New Zealand

Drawn by: Asanka Thilakerathne
25/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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**Figure 4**

## 3.3 Wetlands

Wetlands within and around the study area were identified by data available through NZLINZ, and site specific surveys undertaken by 4Sight Consulting during the summer of 2021-2022 (Central and Southern Blocks) and more recently by Boffa Miskell (Northern Block) (email communication). In total, there are 88 wetlands within the study area, which are shown in both **Figure 1** and **Figure 4**. 10 of these are at least partially within the TIL Central Block mine site and an additional 28 a least partially within the TIL Southern Block mine site. Summary information (i.e. reference ID, area, and data provenance) for surveyed wetlands is provided in **Table 1**.

An assessment was undertaken by WWLA to estimate the hydrological functionality of wetlands in Southern and Central Blocks (WWLA, 2024a). Of particular interest was whether the wetlands are likely to be reliant on groundwater or surface water inputs, or in some cases a combination of the two. The groundwater model was used to assess the degree of connection (or disconnection) between the various wetlands and groundwater and is discussed in detail in **Section 6.3**.

The information from this assessment is useful in determining which wetlands may be vulnerable to mine dewatering effects. Groundwater connected wetlands are more vulnerable if they are located within the area where groundwater drawdown is expected.

Table 1. Summary of the wetlands

| ID | Area ($m^2$) | Description / Survey Name | Data source |
|---|---|---|---|
| 1 | 58,893 | Natural | Boffa-Miskell |
| 2 | 19,565 | Natural | Boffa-Miskell |
| 3 | 5,989 | Natural | Boffa-Miskell |
| 4 | 5,843 | Natural | Boffa-Miskell |
| 5 | 486 | Natural | Boffa-Miskell |
| 6 | 6,401 | Natural | Boffa-Miskell |
| 7 | 30,292 | Natural | Boffa-Miskell |
| 8 | 18,433 | Wetland 2 | Boffa-Miskell |
| 9 | 107 | Constructed pond | Boffa-Miskell |
| 10 | 2,228 | Wetland 7a, 7b and 7c | Boffa-Miskell |
| 11 | 519 | Wetland 6a | Boffa-Miskell |
| 12 | 1,380 | Wetland 2 | Boffa-Miskell |
| 13 | 135 | Wetland 7d | Boffa-Miskell |
| 14 | 86 | Wetland 6b | Boffa-Miskell |
| 15 | 86 | Wetland 6b | Boffa-Miskell |
| 16 | 3,696 | Wetland 1 and 3 | 4Sight Consulting |
| 17 | 2,103 | Wetland 4 | Boffa-Miskell |
| 18 | 501 | Seepage | Boffa-Miskell |
| 19 | 45 | Wetland 9 | Boffa-Miskell |
| 20 | 42 | Constructed pond | Boffa-Miskell |
| 21 | 320 | Seepages | Boffa-Miskell |
| 22 | 702 | Wetland 10 | Boffa-Miskell |
| 23 | 3,890 | Natural | Boffa-Miskell |
| 24 | 271 | Seepage | Boffa-Miskell |
| 25 | 1,294 | Natural | Boffa-Miskell |

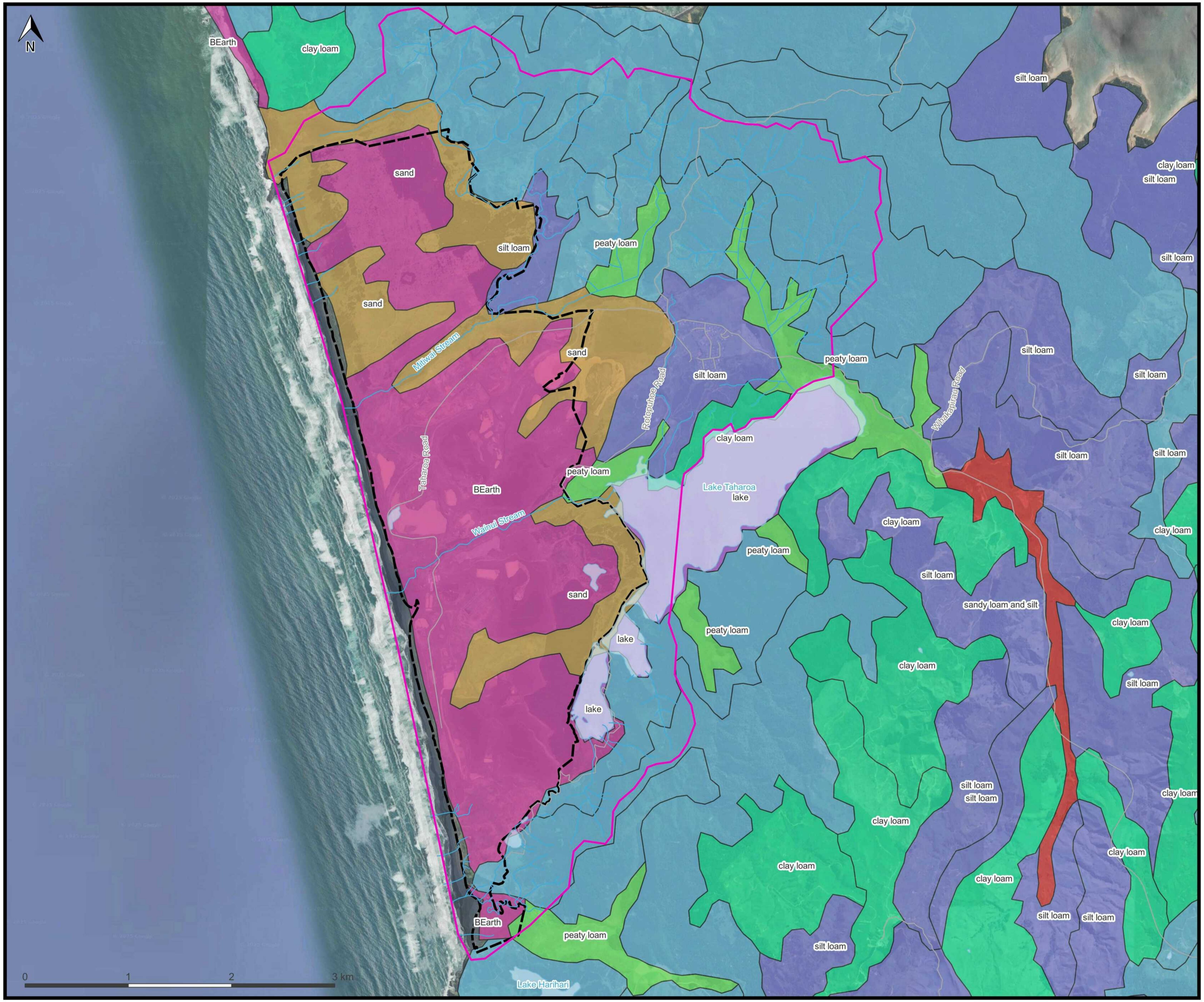
| ID | Area ($m^2$) | Description / Survey Name | Data source |
|---|---|---|---|
| 26 | 1,620 | Natural | Boffa-Miskell |
| 27 | 46 | Wetland 5 | Boffa-Miskell |
| 28 | 100 | Wetland 4 | Boffa-Miskell |
| 29 | 599 | Natural | Boffa-Miskell |
| 30 | 406 | Seepage | Boffa-Miskell |
| 31 | 236 | Seepage | Boffa-Miskell |
| 32 | 555 | Wetland 19 | Boffa-Miskell |
| 33 | 315 | Wetland 18 | Boffa-Miskell |
| 34 | 197 | Wetland 18 | Boffa-Miskell |
| 35 | 590 | Wetland 11 | Boffa-Miskell |
| 36 | 585 | Wetland 12 | Boffa-Miskell |
| 37 | 67 | Wetland 14 | Boffa-Miskell |
| 38 | 214 | Wetland 13 | Boffa-Miskell |
| 39 | 29,508 | S2 | LENZ |
| 40 | 5,460 | Natural | Boffa-Miskell |
| 41 | 212 | Seepage | Boffa-Miskell |
| 42 | 29,919 | Natural | Boffa-Miskell |
| 43 | 384 | Wetland 16a | Boffa-Miskell |
| 44 | 470 | Wetland 15 | Boffa-Miskell |
| 45 | 502,423 | S4 | LENZ |
| 46 | 470 | Wetland 15 | Boffa-Miskell |
| 47 | 504 | Site 26 | 4Sight Consulting |
| 48 | 247 | Site 28 | 4Sight Consulting |
| 49 | 2,695 | Site 29 | 4Sight Consulting |
| 50 | 61 | Wetland 20a | Boffa-Miskell |
| 51 | 338 | Wetland 20b | Boffa-Miskell |
| 52 | 203 | Site 1 | 4Sight Consulting |
| 53 | 121 | Wetland 17 | Boffa-Miskell |
| 54 | 4,118 | Site 4 | 4Sight Consulting |
| 55 | 1,097 | Site 3 | 4Sight Consulting |
| 56 | 26,719 | S3 | LENZ |
| 57 | 208,673 | Lake Shore | 4Sight Consulting |
| 58 | 276 | Wainui Stream Wetlands | 4Sight Consulting |
| 59 | 4,987 | Wetland 14 | 4Sight Consulting |
| 60 | 723 | Wetland 13 | 4Sight Consulting |
| 61 | 7,392 | Wainui Stream Wetlands | 4Sight Consulting |
| 62 | 2,371 | Wetland 12 | 4Sight Consulting |
| 63 | 10,610 | Wainui Stream Wetlands | 4Sight Consulting |
| 64 | 21,671 | Wetland 22 | 4Sight Consulting |
| 65 | 10,828 | Wainui Stream Wetlands | 4Sight Consulting |

| ID | Area ($m^2$) | Description / Survey Name | Data source |
|---|---|---|---|
| 66 | 326 | Wetland 16 | 4Sight Consulting |
| 67 | 758 | Wetland 9 | 4Sight Consulting |
| 68 | 2,303 | Wainui Stream Wetlands | 4Sight Consulting |
| 69 | 1,487 | Wetland 10 | 4Sight Consulting |
| 70 | 262 | Wetland 11 | 4Sight Consulting |
| 71 | 42,150 | Lake Shore | 4Sight Consulting |
| 72 | 77,566 | Site 27 | 4Sight Consulting |
| 73 | 19,018 | Wetland 21 | 4Sight Consulting |
| 74 | 1,318 | Wetland 8 | 4Sight Consulting |
| 75 | 29,047 | Wetland 21 | 4Sight Consulting |
| 76 | 6,620 | Lake Edge | Boffa-Miskell |
| 77 | 337 | Wetland 23 | 4Sight Consulting |
| 78 | 235 | Site 24 | 4Sight Consulting |
| 79 | 914 | Wetland 25 | 4Sight Consulting |
| 80 | 1,985 | Wetland 15 | 4Sight Consulting |
| 81 | 3,670 | Wetland 6 | 4Sight Consulting |
| 82 | 21,776 | Wetland 5 | 4Sight Consulting |
| 83 | 8,020 | Lake Piopio | 4Sight Consulting |
| 84 | 1,732 | Wetland 20 | 4Sight Consulting |
| 85 | 10,765 | Wetland 7 | 4Sight Consulting |
| 86 | 11,851 | Wetland 19 | 4Sight Consulting |
| 87 | 3,314 | Wetland 17 | 4Sight Consulting |
| 88 | 14,533 | S1 | LENZ |

## 3.4 Soils

Soils over the study area were assessed based on information from the Fundamental Soils Layer developed by Manaaki Whenua Landcare Research (1999). The TIL mine area is completely covered with sand and bare earth. An assortment of clay loam soils predominate outside the area, with silt loams along some of the stream channels (**Figure 5**).

Areas where sand soils prevail have generally high infiltration rates, whereas clay dominated soils have low infiltration, and therefore lower groundwater recharge.




Map Title:
**Main soil types in the model area**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**

**Legend**

- Roads
- Streams
- TIL Property Boundary
- Study area
- Lakes

Soil types

- bare earth
- clay loam
- lake
- peaty loam
- sand
- sandy loam and silt
- silt loam
- unnamed

Data Provenance
Land information New Zealand

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**Figure 5**

## 3.5 Land Cover

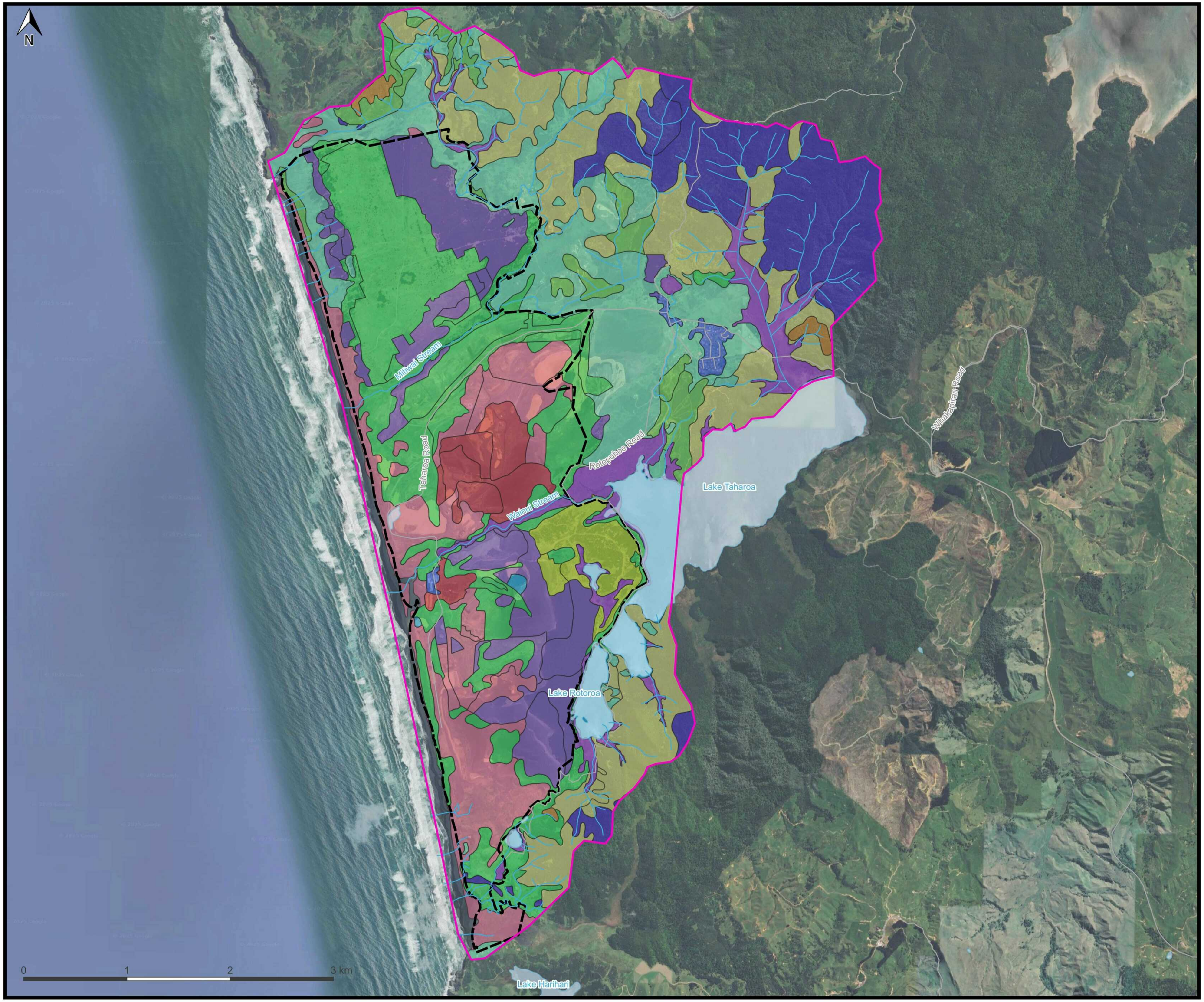
According to the New Zealand Land Cover Data Base (LCDB)[1], land cover over the study area can be categorised into 13 sub-categories as shown in **Figure 6**. **Table 2** provides further information regarding the area of various land covers over the study area as a while and within the mining area specifically.

The main land cover in Taharoa C Block is low productive grassland, which covers 37% of the area with an additional 23% covered with exotic forest and 22% identified as sand or gravel (likely sand in this case). Notably, 7% of the area is shown as a surface mine, reflecting the historic land use at the site.

Table 2. Land cover within the study area (left) and proposed mining area (right).

| Land cover | Study Area | | | Mining Area (Taharoa C Block) | | |
|---|---|---|---|---|---|---|
| | Area ($m^2$) | Area (ha) | Percentage | Area ($m^2$) | Area (ha) | Percentage |
| Gorse and/or Broom | 917,526 | 91.75 | 3.2 | 42,726 | 4.27 | 0.3 |
| Exotic Forest | 97,923 | 9.79 | 0.3 | 2,924,756 | 292.48 | 22.6 |
| Low Producing Grassland | 795,354 | 79.54 | 2.8 | 4,756,410 | 475.64 | 36.8 |
| Indigenous Forest | 2,936,520 | 293.65 | 10.3 | 14,406 | 1.44 | 0.1 |
| High Producing Exotic Grassland | 3,853,477 | 385.35 | 13.5 | 482,446 | 48.24 | 3.7 |
| Sand or Gravel | 247,069 | 24.71 | 0.9 | 2,831,574 | 283.16 | 21.9 |
| Manuka and/or Kanuka | 4,361,506 | 436.15 | 15.3 | 11,072 | 1.11 | 0.1 |
| Lake or Pond | 957,381 | 95.74 | 3.4 | 52,817 | 5.28 | 0.4 |
| Herbaceous Freshwater Vegetation | 1,147,213 | 114.72 | 4.0 | 234,255 | 23.43 | 1.8 |
| Broadleaved Indigenous Hardwoods | 137,614 | 13.76 | 0.5 | Not Applicable | | |
| Surface Mine | Not Applicable | | | 913,820 | 91.38 | 7.1 |
| Forest - Harvested | 14,343 | 1.43 | 0.1 | 632,829 | 63.28 | 4.9 |
| Built-up Area (settlement) | 152,767 | 15.28 | 0.5 | 24,761 | 2.48 | 0.2 |
| Mining Area (refer Figure 6 inset) | 12,921,873 | 1,292.19 | 45.3 | Not Applicable | | |
| Total | 28,540,567 | 2,854 | 100 | 12,921,873 | 1,292.19 | 100 |

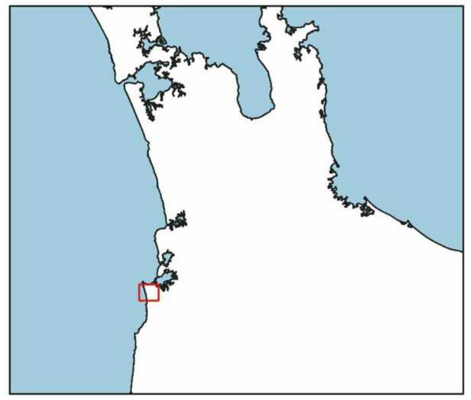
[1] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/




Map Title:
**Landcover of the model area**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Roads
- Streams
- Study area
- TIL Property Boundary
- Lakes

LCDB cover of the study area

- Broadleaved Indigenous Hardwoods
- Built-up Area (settlement)
- Exotic Forest
- Forest - Harvested
- Gorse and/or Broom
- Herbaceous Freshwater Vegetation
- High Producing Exotic Grassland
- Indigenous Forest
- Lake or Pond
- Low Producing Grassland
- Manuka and/or Kanuka
- Sand or Gravel
- Surface Mine or Dump

Data Provenance
Land information New Zealand

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Figure 6

## 3.6 Geology

The geology in and around the mining area is described by Pain (1976), Edbrooke (2005) and the geological model of the Taharoa Ironsand Mining Area updated in 2014 (Geotechnics, 2014). The following geological information from these documents is summarised here.

### 3.6.1 Geological Setting

The geology of the area comprises two major stratigraphic units (**Table 3**) that are discussed in chronological order from youngest to oldest; Holocene to Pliocene age coastal sand dunes associated with marine and alluvial sediments of the Tauranga Group (Waihu Formation (Te Ake Ake Sand) and Mitiwai Formation (Paparoa and Nukimiti Sand)) and Awhitu Sand, overlaying Mesozoic age Greywacke, which form the basement in the area. These formations are described in general below, with further detail provided in the following section.

**Paparoa and Nukimiti Sand (Mitiwai Formation)**; Aeolian sand with basal subaqueous sediments are predominant in this unit. Subaqueous sediments (alluvium, lake sediments and estuarine sediments) form the base of the current streams.

Mitiwai Formation dune sand consists of grey to black, fine grained sand and silty sand. These aeoline deposits fill the paleo channels and form the vast area overlying the Te Ake Ake Sand. Localised lenses of peat and silt area present within the dunes.

**Te Ake Ake Sand (Waiau Formation)**; This lithological unit is composed of mixed of estuarine, riverine and aeoline (dune) sediments. Estuarine muds and muddy sands comprise the lower base unit of the layer, with overlain by Tauranga Group Alluvium. River channel alluvium is mainly composed of low grade ironsand and peat with occasional wood particles. Fine to medium grade silty to clean black and yellowish-brown beach sand layers is also observed within this unit. Ferromagnesian rich beach sand and dune sand layers are recorded within this unit (Geotechnics, 2014), which comprises the ironsand resource targeted by TIL mining activities. Te Ake Ake sand can be subcategorised into three layers:

- Magnetic-enriched fine grained silty sand and sand,
- Lower grade fine grained sand and silty sand,
- Weathered dune sand and soils.

Upper paleosol clay rich layer deposits occur within the upper layers of the unit.

**Alluvium (Tauranga Group)**; Primarily comprised of undifferentiated alluvium, pumicesous sands and silts. The alluvium is rich with peat, quartzofeldspathic sand or low grade ferromagnesian sand. Pumicesous sands and silts are mainly found in southern portion of the study area and in the south-western corner of northern area (Geotechnics, 2014).

**Awhitu Sand**; Older dune sands mainly composed with Quartzofeldspathic sand. These deposits generally occur below sea level near the coast.

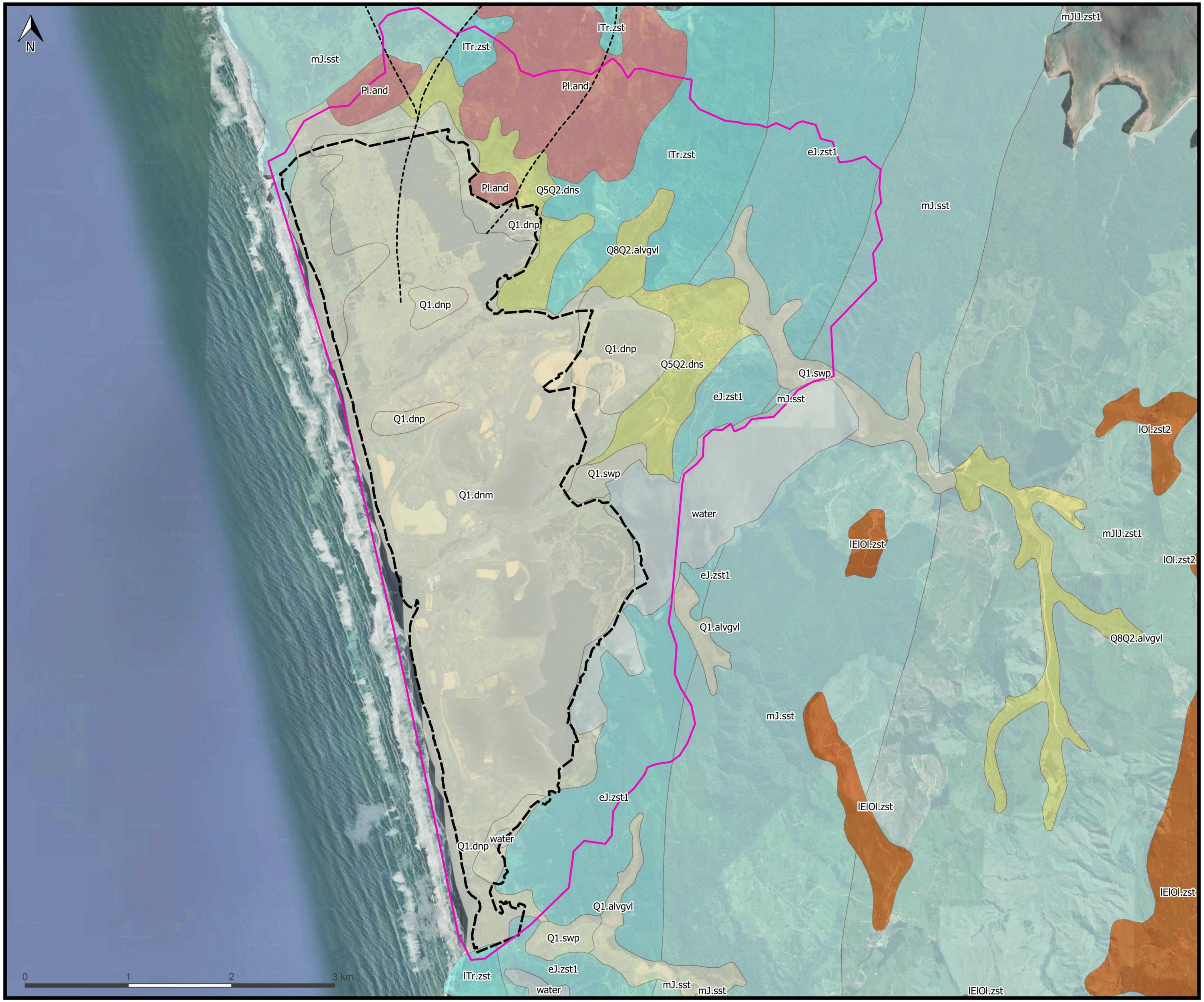
**Greywacke**; Weathered residual soils and greywacke with outcropping along inland side of the project area giving rise to mountainous topography (**Figure 7**).

The above two units are considered to be the resource basement as they do not contain economic or accessible iron content, which is the resource of this mine.

In addition to the native materials described above, tailings and overburden produced as a byproduct of mining operations overlie areas where mine operations have been active.

Table 3. Regional geology of Taharoa mining area (Geotechnics,2014)

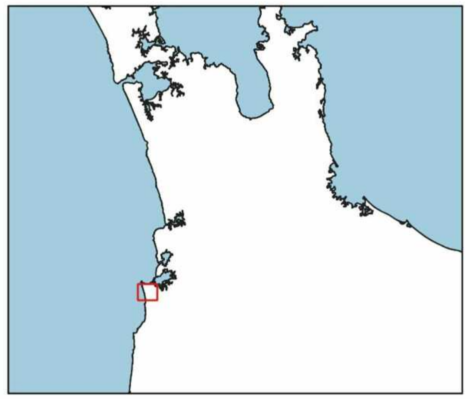
| Age (Ma) | Tauranga Group Subaqueous deposits | | Kaihu Group Subaerial deposits | | Description |
|---|---|---|---|---|---|
| Pliocene to Holocene (5.33 to 0.011 Ma) | | Titano-magnetite dominated facies sand | Mitiwai Formation | Paparoa and Nukimiti Sand | Tailings and fill in upper layer, free flowing grey to black sands, localised thin layers of silt and sandy silt and peat at the bottom layer. ***Reserve Basement*** |
| | (Upper) Tauranga Group | | | | Clay rich layer (Clay rich alluvium, lacustrine mud, sandy mud with shell) |
| | | | Waiau Formation | Te Ake Ake Sand | Silt, sandy silt and clay rich layers in upper sequence. Fine to medium sand with variable content of magnetic sands (mags). Peat layers are also present. ***Resource Basement*** |
| | (Lower) Tauranga Group | | | | Silt and sand with low mags. Incompetent mud with shell. Alluvial deposits, pumiceous and siliceous sand. |
| | | | Awhitu Sand | | Silty quartzofeldspathic sand. |
| Mesozoic (252 to 66 Ma) | Greywacke basement | | | | Greywacke basement |




Map Title:
**Geological map of the Taharoa mining area and surrounding region**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- **TIL Property Boundary**
- **Study area**

Geology

- **Faults**

Geological units

- **Pl.and (andesite)**
- **[Otauanui Intrusive Formation]**
- **Q1.alvgvl(mud)**
- **Q1.dnm(sand)**
- **[Karioitahi Group]**
- **Q1.dnp(sand)**
- **[Karioitahi Group]**
- **Q1.swp(peat)**
- **[Piako Subgroup]**
- **Q5Q2.dns(sand)**
- **[Karioitahi Group]**
- **Q8Q2.alvgvl(clay)**
- **[Tauranga Group]**
- **eJ.zst1(siltstone)**
- **[Newcastle Group]**
- **lElOl.zst(siltstone)**
- **[Lower Te Kuiti Subgroup]**
- **lOl.zst2(siltstone)**
- **[Whaingaroa Formation]**
- **lTr.zst(siltstone)**
- **[Newcastle Group]**
- **mJ.sst(sandstone)**
- **[Kirikiri Group]**
- **mJlJ.zst1(siltstone)**
- **[Kirikiri Group]**
- **water**

Data Provenance
Land information New Zealand

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**Figure 7**

### 3.6.2 Faults

Two north-east to south-west trending faults are mapped in QMAP[2] database of the 1:250 000 geology map of Waikato area as shown in **Figure 7**.

These features are not likely to have implications for groundwater flow, since the fault is not continuous across the project area and does not significantly intersect the Southern Block and Central Block mining areas that are the focus of this analysis.

## 3.7 Hydrogeology and Groundwater

### 3.7.1 Groundwater Monitoring

In April 2025, 18 groundwater monitoring piezometers were installed within Taharoa C Block to provide information to support this study.

Each piezometer has been equipped with a data logger for continuous water level monitoring, which is ongoing at the time of writing. Two of the monitoring sites are also measuring electrical conductivity as a proxy for salinity, which provides a means of recognising any changes that may signal saline intrusion. The monitoring locations are shown in **Figure 8**, with construction details provided in **Table 4**. A barometric pressure data logger has also been installed at the TIL office to facilitate barometric correction for all of the data being collected.

Of the eighteen piezometers, C101 and S103 are nested piezometers with multiple depths being monitored to show vertical hydraulic gradient at these locations. The other stations provide data that reflects local water table conditions at a single depth. All of these sites were used in this study to inform the assessment of groundwater conditions detailed in **Section 6** of this report.

At the time of writing this report, the natural fluctuation of the groundwater levels has been limited due to the short monitoring period to date (**Figure 9**). The fluctuations observed on 6-7 May 2025 were a result of the hydraulic testing being conducted as detailed in **Section 3.7.4.1**.

Initial observations show that the depth to groundwater has a strong correlation to borehole depth (**Figure 10**). These findings both confirm the moderately low permeability of hydrogeological materials and limited vertical pressure gradients. To date, the groundwater level has been below the base of the shallow S103 piezometer, and hence monitoring data is not available at this time for that particular site.

### 3.7.2 Water Table Assessment

In general, the regional water table follows with topography, although a more localised complex distribution of groundwater pressures can be expected where there is influence from barriers such as natural clay lenses and tailings from previous mine activity mentioned in **Section 3.6.1**.

Groundwater levels across the study area were estimated from water level measurements from the piezometer network in combination with gaining streams and springs where groundwater discharges at the land surface. The estimated water table contours derived from this information are shown in **Figure 8**.

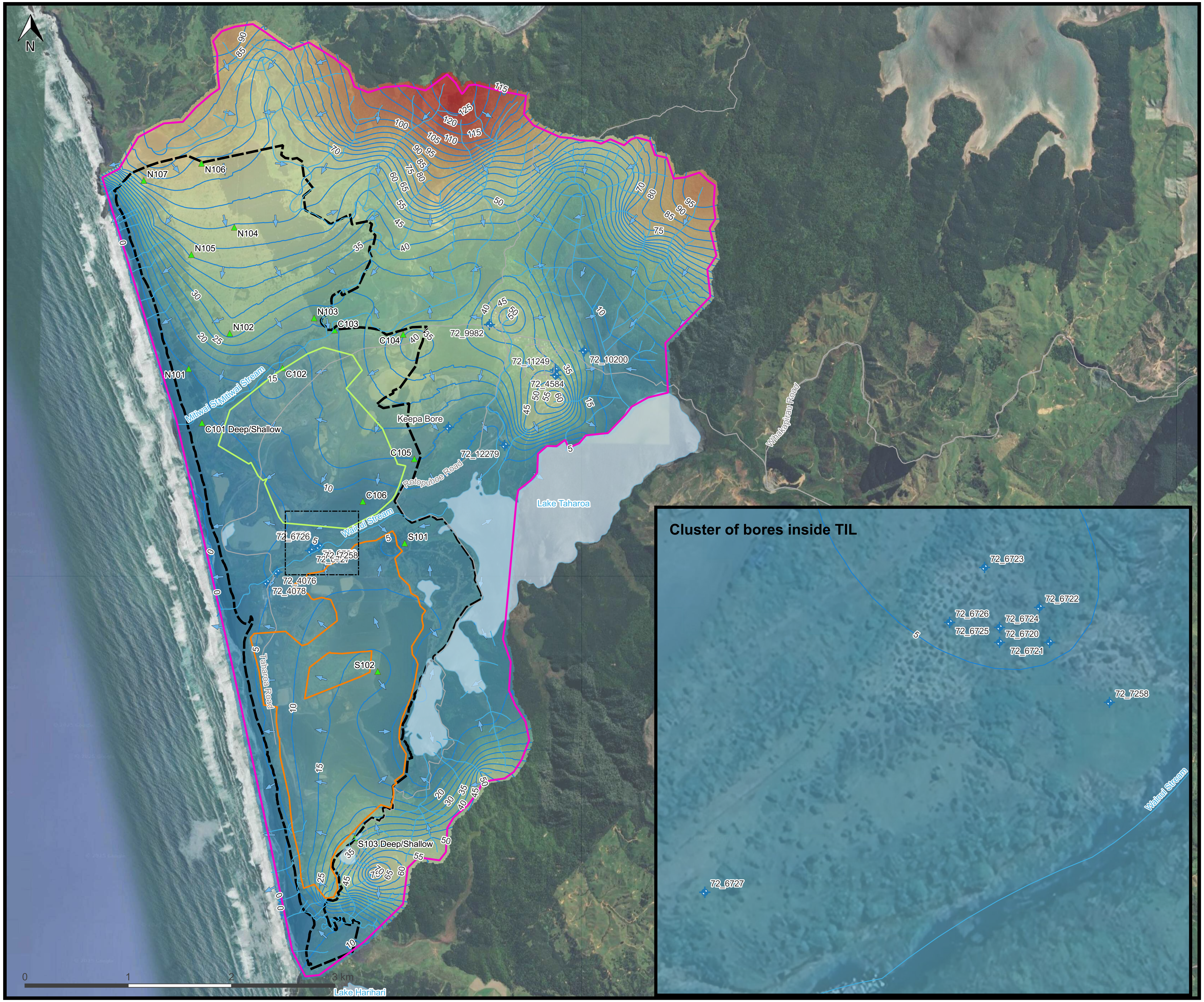
The overall trend is that groundwater flow in the study area originates from the higher altitudes in the north, east and south and generally flows westwards towards the ocean, with localised convergence into stream channels. Steeper gradients occur where there is steeper terrain and low-permeability materials such as within greywacke outcropping areas, while the water table profile is significantly flatter in the plains where the mine is located.

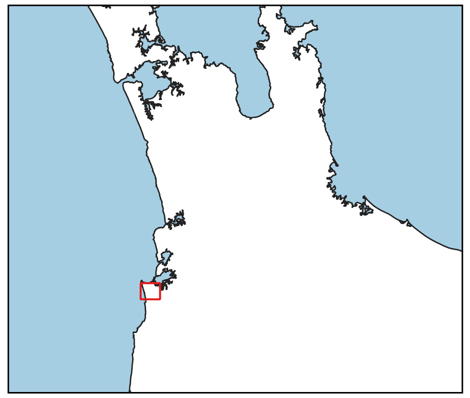
[2] GNS Science. (2012). 1:250 000 Geological Map of New Zealand [Data set]. GNS Science.

Map Title:
**Groundwater monitoring and flow direction map**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Groundwater monitoring sites
- Known bores
- Groundwater elevation contours (mAMSL)
- Study Area
- TIL Property Boundary
- Streams
- Road
- Lakes
- Water table elevation (mAMSL)
  - 130
  - 0

Data Provenance
GIS Layers

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07/08/2025

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Figure 8

Table 4. Summary of water level data from monitoring piezometers.

| Piezometer | Easting (NZTM) | Northing (NZTM) | Elevation at surface (mAMSL) | Total Depth (m) | Water table elevation (mAMSL) | | | Measurements days |
|---|---|---|---|---|---|---|---|---|
| | | | | | Maximum | Minimum | Range (m) | |
| N101 | 1748853 | 5775763 | 22.3 | 32 | 4.7 | 4.8 | 0.2 | 44 |
| N102 | 1749250 | 5776104 | 68.6 | 82.7 | 33.4 | 34.7 | 1.2 | 44 |
| N103 | 1750067 | 5776253 | 52.8 | 68 | 20.1 | 20.2 | 0.1 | 21 |
| N104 | 1749294 | 5777131 | 78.9 | 69 | 54.6 | 55.0 | 0.4 | 44 |
| N105 | 1748879 | 5776866 | 68.6 | 53 | 45.7 | 46.1 | 0.4 | 44 |
| N106 | 1748977 | 5777749 | 83.1 | 53 | 67.0 | 67.5 | 0.5 | 44 |
| N107 | 1748418 | 5777584 | 69 | 53 | 63.9 | 66.8 | 2.9 | 44 |
| C101_Deep | 1748981 | 5775237 | 8.27 | 23 | 0.1 | 0.6 | 0.5 | 31 |
| C101_Shallow | 1748981 | 5775238 | 8.27 | 14 | 0.2 | 0.2 | 0.1 | 23 |
| C102 | 1749761 | 5775770 | 61.66 | 58 | 19.9 | 20.1 | 0.3 | 21 |
| C103 | 1750264 | 5776136 | 20.38 | 1.5 | 19.63 | | | 1 |
| C104 | 1750929 | 5776094 | 58.35 | 41 | 41.4 | 41.5 | 0.1 | 20 |
| C105 | 1751037 | 5774890 | 78.17 | 77 | 15.3 | 15.9 | 0.6 | 43 |
| C106 | 1750538 | 5774478 | 68.61 | 74 | 5.9 | 6.7 | 0.8 | 43 |
| S101 | 1750943 | 5774074 | 18.86 | 34 | 3.2 | 3.7 | 0.5 | 43 |
| S102 | 1750682 | 5772833 | 36.59 | 44 | 17.4 | 17.9 | 0.6 | 43 |
| S103_Deep | 1750460 | 5771223 | 33.07 | 29 | 29.6 | 31.1 | 1.5 | 30 |
| S103_Shallow | 1750460 | 5771222 | 33.07 | 3 | Dry | | | |

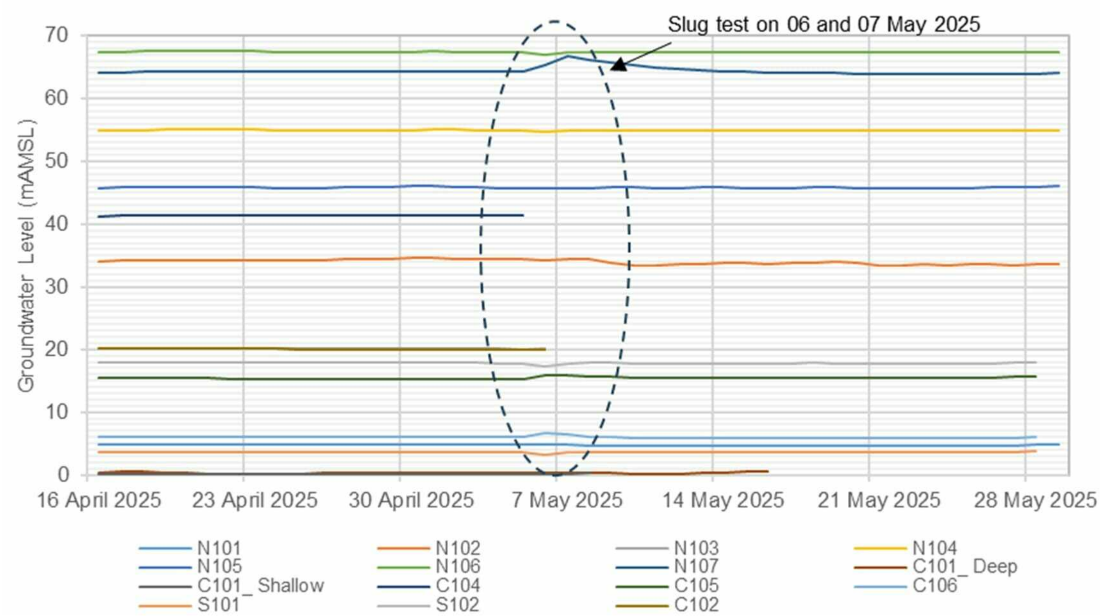



Figure 9. Groundwater levels measured at monitoring piezometers.

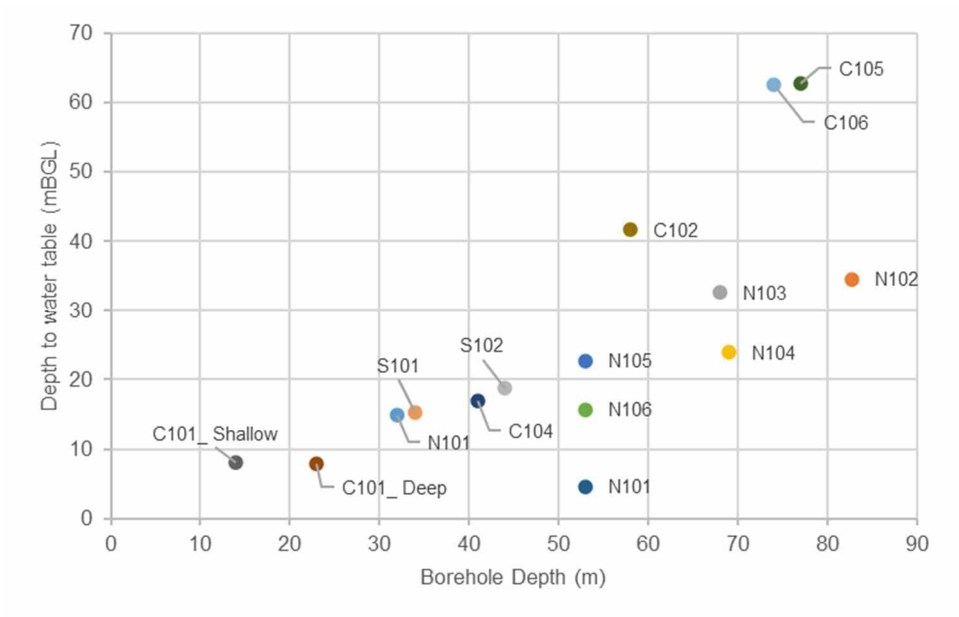



Figure 10. Depth to water relative to borehole depth.

### 3.7.3 Neighbouring Bores

A review of bores within the study area showed that there are numerous geological exploration bores on the Taharoa C Block and within the study area.

The Wellsnz[3] Database indicated 17 bores within the study area, which are shown in **Figure 8** with additional details provided in **Table 5**. Out of these 17 bores one bore has been decommissioned (Bore ID. 72_4584) and two bores are replaced by new bores. Bores which are less than 5 m in depth could be monitoring bores. Out of 17 bores 12 are located inside the TIL property boundary. Effects on neighbouring bores are assessed in

[3] https://wellsnz.teurukahika.nz/

**Section 6.1.2** with the TIL owned and administered Taharoa community water supply bores being a primary focus for potential effects.

Table 5. Bores within study area.

| Bore ID | Easting | Northing | Depth (mBGL)** | Comment |
|---|---|---|---|---|
| 72_10200 | 1752680 | 5775934 | N/A | Community Drinking Water Supply |
| 72_11249 | 1752402 | 5775749 | 180 | Community Drinking Water Supply |
| 72_12279 | 1751911 | 5775021 | 103.5 | |
| 72_4076* | 1749708 | 5773794 | 3.75 | Monitoring bore |
| 142329 | 1751368 | 5775195 | 90 | Domestic bore with 19.2 m available drawdown (based on 45 m casing depth and static water level at 25.8 mBGL). |
| 72_4077* | 1749608 | 5773694 | 4.25 | Monitoring bore |
| 72_4078* | 1749608 | 5773694 | 4.5 | Monitoring bore (Assumed, replacement bore of 72_4077 |
| 72_4584 | 1752405 | 5775698 | 96 | Decommissioned |
| 72_6720* | 1750091 | 5774051 | 22.8 | |
| 72_6721* | 1750101 | 5774051 | 35 | |
| 72_6722* | 1750099 | 5774058 | 31 | |
| 72_6723* | 1750088 | 5774066 | 28 | |
| 72_6724* | 1750091 | 5774054 | 30 | |
| 72_6725* | 1750081 | 5774055 | 29 | |
| 72_6726* | 1750081 | 5774055 | 49 | Assumed, replacement bore of 72_6725 |
| 72_6727* | 1750032 | 5774001 | N/A | |
| 72_7258* | 1750113 | 5774039 | 20 | |
| 72_9982 | 1751763 | 5776189 | 45.4 | |

*Bores inside Taharoa mine site

**meters below ground level

### 3.7.4 Hydrogeological Field Testing

Estimates of the hydraulic conductivity (k) of subsurface materials at Taharoa mine were derived through in situ field testing, applying the slug testing method described in the following sections and further detailed in (WWLA 2025b).

#### 3.7.4.1 Slug Testing

Slug testing was undertaken in seventeen piezometers to provide a measure of the bulk permeability of subsurface materials while the S103 shallow piezometer could not be tested.

Slug testing was conducted by adding a 20 L ‘slug’ of water into the piezometers, or removing 2.15 L of water from a piezometer to induce a rise or fall in water level. The water level recession was monitored with both a pressure transducer measuring at 2 second intervals and confirmed by manual measurements as it returned to its original level. The maximum change in water level from the testing was a 10.2 m rise within the 50 mm casing diameter.

The data was then analysed using WWLA’s Slug Test Analysis software[4] which applies the Hvorslev slug recovery test method (1951). The results of this analysis are summarised in **Table 6**. Test results showed conductivity ranging from $6.49 \times 10^{-10}$ m/s to $1.01 \times 10^{-04}$, with an average of $9.64 \times 10^{-06}$ m/s, and median of $1.37 \times 10^{-7}$ m/s. The values derived at the higher end of the range (>$5 \times 10^{-6}$ m/s) are considered to be consistent.

[4] https://software.wwla.kiwi/wiki/index.php/WWLA_Software#STA_-_Slug_Test_Analysis

The native ironsand interbedded with clay layers would normally be expected to have permeability in the range $10^{-6}$ to $10^{-7}$ m/s. The conductivity values of less than $10^{-8}$ m/s (or two orders of magnitude lower) are considered unrealistically low, which may indicate testing errors or the skin effect (i.e. a compact layer of smeared clay) on the bore wall induced during drilling, hence these values were ignored.

The conductivity values derived from this analysis were used as the baseline for establishing hydraulic conductivity in the numerical modelling analysis, as detailed in the Technical Report (**Appendix A**).

Table 6. Summary of slug test results.

| Well ID | Hydraulic Conductivity (m/s) | Remarks |
|---|---|---|
| N101 | $4.05x\ 10^{-08}$ | |
| N102 | $3.02x10^{-08}$ | |
| N103 | $8.85x10^{-07}$ | |
| N104 | $3.82x10^{-07}$ | |
| N105 | $1.62x10^{-07}$ | |
| N106 | $5.87x10^{-07}$ | |
| N107 | $6.49x10^{-10}$ | Probably erroneous |
| C101_Deep | $1.01x10^{-04}$ | |
| C101_Shallow | $5.87x10^{-05}$ | |
| C102 | $1.67x10^{-08}$ | |
| C103 | $1.37x10^{-07}$ | |
| C104 | $4.99x10^{-08}$ | |
| C105 | $8.65x10^{-09}$ | Potentially erroneous |
| C106 | $9.40x10^{-09}$ | Potentially erroneous |
| S101 | $7.18x10^{-07}$ | |
| S102 | $1.13x10^{-06}$ | |
| S103_Deep | $2.09x10^{-08}$ | |
| S103_Shallow | - | Static water level is below the bottom of the piezometer. |

# 4. Mining Areas

This section describes historic, current and proposed mining areas.

## 4.1 Taharoa Mine

The mine site covers an area of 1,300 ha, effectively divided by the Mitiwai Stream and Wainui Stream into three separate blocks (North, Central and South Blocks). The mine originally commenced operations in early 1970's, with the Central and Southern Blocks having been altered by earth works and tailings storage over previous 50+ years of mining. Mine operations initially started on the Southern Block, and in 2001 shifted to the Central Block. In the Central Block, recent and ongoing mine operations have resulted in several historic pits that are now ponds. The Southern Block has largely been revegetated with grass and native plantings.

To date, no mine operations have been undertaken in the Northern Block, and the area remains covered with grasslands and native plants. This assessment of effects relates to the hydrogeological effects of mining the Central and Southern Block only.

Lake Taharoa is the main water supply source for the mining operations.

## 4.2 Summary of Mine Operations

The indicative mine excavation plans for this project includes mining operations in both Central and Southern Blocks.

Mining includes excavation and other associated activities above and below the water table. Mining below the water table involves a floating dredging machine. All excavated material is transported to a concentration plant where the resource is separated by particle size and ore concentration. The concentrated slurry is then pumped to a stockpile and thereafter transferred into a ship via an ocean floor pipeline. Tailings are disposed of in mined land and then recontoured.

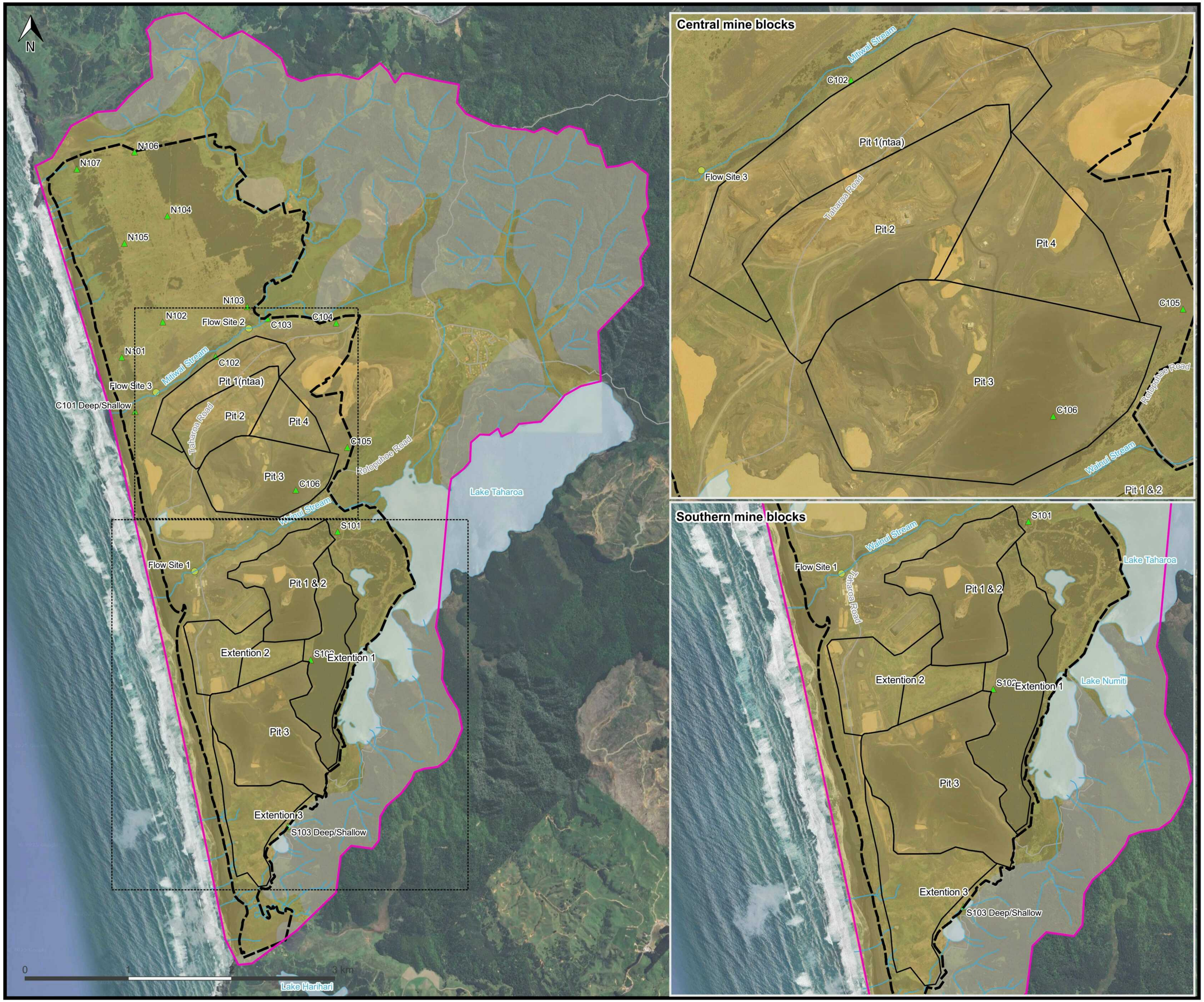
### 4.2.1 Mining

Mining above the groundwater table involves a combination of large bulldozers and excavators to remove the sands and transport to collector stations for processing.

Mining below the groundwater water table occurs once mining has reached a depth whereby the standing water in the pit can support a floating barge. The barge is equipped with a 14 m long dredge ladder that enables mining to proceed beneath the groundwater table, as dewatering occurs.

Once a given area is excavated it will be left open as the excavation proceeds to the adjacent area, and is subsequently backfilled with engineered land fill (ELF) as the excavation proceeds. The final area to be excavated in both the Central and Southern Pits was left open.

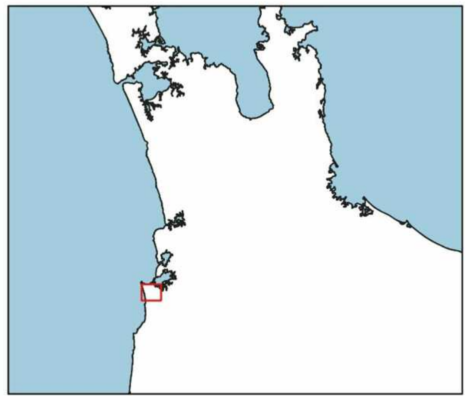
Indicative mine excavation plans for the Central and Southern Blocks, as provided by TIL, are provided in **Appendix B** and **Appendix C**, respectively, and are summarised in the following sections. **Figure 11** shows the sub-divided excavation areas based on the mine excavation plan.




Map Title:
**Mine development phases**

Project:
**Taharoa Iron Sand Groundwater Effect Assessment**

Client:
**Taharoa Iron Sand Limited**



**Legend**
- Stream flow monitoring sites
- Piezometers
- Roads
- Streams
- Lakes
- Study area
- TIL property boundary
- Greywacke
- Ironsand
- Central mine blocks
- Southern mine blocks

Data Provenance
Land information New Zealand

Drawn by: Asanka Thilakerathne
25/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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Figure 11

#### 4.2.1.1 Central Block

The indicative Central Block mine excavation plan extends from 2024 through 2036 with the area sub-divided into four mine pits as shown in **Figure 11**, with further detail included in **Table 7**.

Table 7. Summary of Central Block mine excavation plan

| Pit Name | Proposed begin date | Proposed ending date | Time period (years) | Area ($m^2$) (assumes no pit overlap) | Mean excavation depth (m) | Volume ($m^3$) | Rate ($m^3$/day) |
|---|---|---|---|---|---|---|---|
| NTAA | 28/08/2024* | 12/03/2029 | 4.54 | 454,202 | 56 | 25,598,165 | 15,449 |
| Pit 2 | 12/03/2029 | 20/05/2031 | 2.19 | 462,619 | 60 | 27,892,407 | 34,909 |
| Pit 3 | 20/05/2031 | 3/12/2033 | 2.54 | 783,272 | 58 | 45,324,335 | 48,841 |
| Pit 4 | 3/12/2033 | 29/06/2036 | 2.57 | 274,491 | 52 | 14,158,175 | 15,078 |
| **Total** | | | **11.84** | **1,974,584** | **Average** | | **28,569** |

*Mining on NTAA pit is ongoing, for the modelling purpose it was proposed 28/08/2024, which is the last modified date of the LiDAR image used for the surface elevation of the model

#### 4.2.1.2 Southern Block

TIL provided base elevation and extent of Southern mine pits which are hereby referred to as Southern Pit 1 & 2, and Southern Pit 3. In addition, three additional areas were included as potential mining areas to be included in the substantive Fast-track application. These are known as Extension 1, Extension 2, and Extension 3. All sub-divisions of the Southern Block are shown in **Figure 11**.

The mine design included in the groundwater assessment incorporated a timeline developed for the Southern Block excavation by assuming an excavation rate equivalent to the Central Block's average of 28,569 m³/day. Based on this, the Southern Block excavation, including its three extension areas, is projected to take 8.65 years in terms of active mining, although in practice it is anticipated that operations will take significantly longer allowing time for equipment transport and earthworks/roading activities associated with mining. It should be noted that the magnitude of effects that are simulated in the numerical modelling analysis in this report will remain consistent if a longer mining period was applied, assuming that mined areas are backfilled when mining is competed in a given area.

Table 8. Summary of South Block mine excavation plan

| Pit Name | Time period (years) | Area ($m^2$) (no pit overlap) | Subdivisions |
|---|---|---|---|
| Pit 1 & 2 | 1.83 | 613,888 | 1 to 15 |
| Pit 3 | 3.52 | 930,144 | 22 to 30 |
| Extension 1 | 0.98 | 627,346 | 19 to 21 |
| Extension 2 | 1.08 | 380,428 | 16 to 18 |
| Extension 3 | 1.24 | 539,264 | 31 to 33 |
| **Total** | **8.65** | **3,091,070** | |

# 5. Groundwater Model Overview

The TIGM was developed for the purpose of this analysis. The model is broadly based on the conceptual groundwater model presented in the technical report included as **Appendix A** of this document. The adaptation of the conceptual model to the numerical model, and the model calibration methodology is also presented in **Appendix A**. The numerical model grid is shown in **Figure 12**.

## 5.1 Model Scenario Descriptions

As previously mentioned, the overall objectives of this assignment were to quantify the effects of the proposed mine excavations in the TIL mine site on the local groundwater system and connected surface water features and to provide an estimate of dewatering requirements for operational planning. To facilitate this, the model was used to simulate the full mining period and subsequent recovery after the end of mine operations. A transient model was setup with a 44 year simulation period spanning from 2003 through 2046. This setup required two cycles of the climate/groundwater recharge data set to be combined back-to-back. The initial condition of the model scenario was representative of the legal "existing environment" where mining under the existing consents has ceased and all rehabilitation required under the consents has been completed.

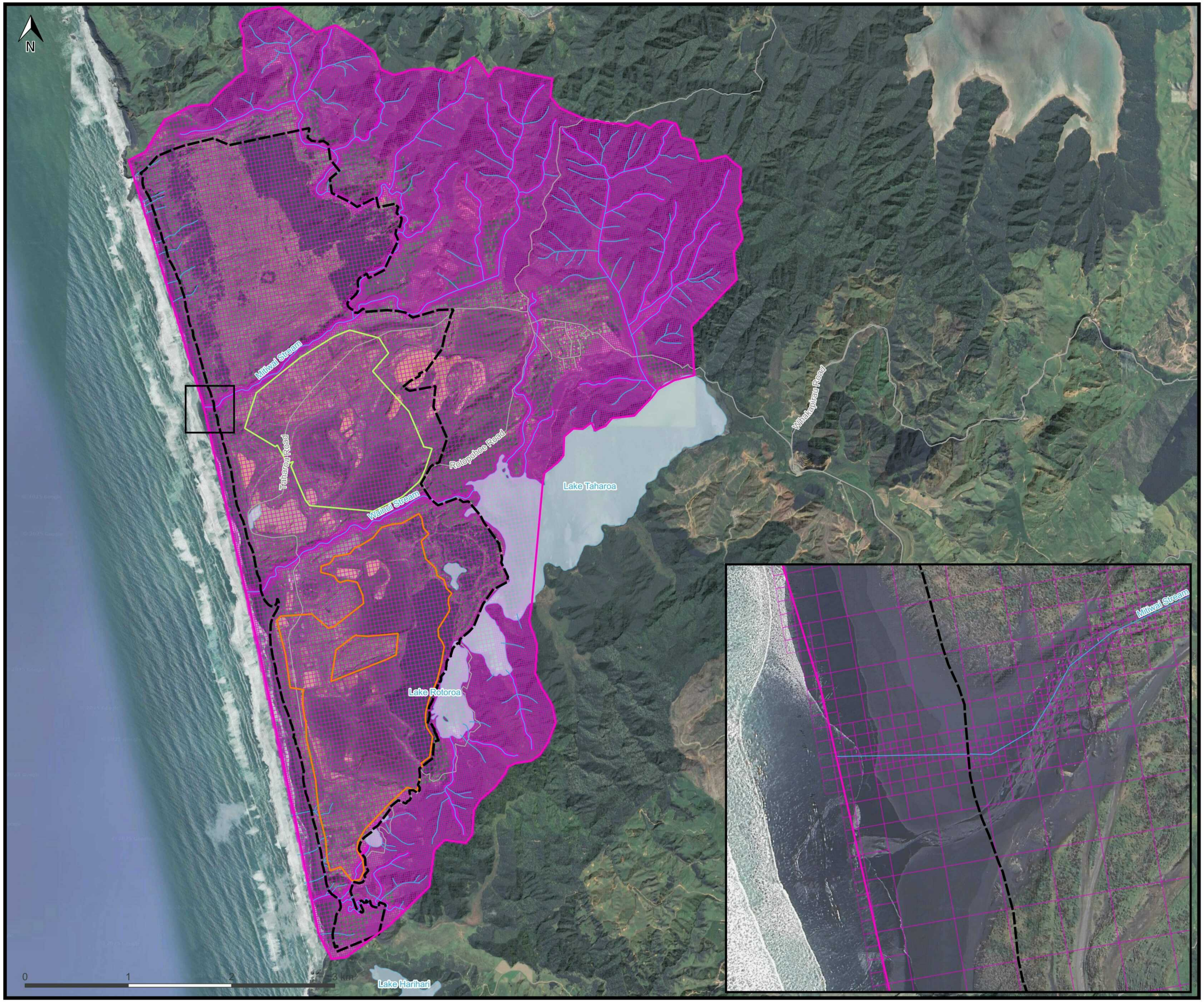
For all mine pits it was assumed that once the excavation was complete in a given area, it remained open as the adjacent area was excavated, and then backfilled with engineered land fill (ELF).

## 5.2 Modelled Scenarios

A pair of model scenarios were developed to test the long-term impact of the proposed mining on regional groundwater. The scenarios are described as follows:

***Baseline:*** The model is run with groundwater recharge corresponding to the 22-year historic climate data record repeated twice to allow for a 44 year model run.

***Mining:*** The continuous 20-year mine excavation process proceeds according to the indicative mine plans provided by TIL as detailed in **Section 2.2**. Approximately, the first 12 years of mining occur in the Central Pit and the following 8.5 years occur are in the Southern Pit. The groundwater recharge conditions are equal to the Baseline scenario.




Map Title:
**Groundwater model grid**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**

**Legend**
- Road
- Streams
- Lakes
- Study Area
- Model grid
- TIL Property Boundary
- Central mine block outline
- Southern mine block outline

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
25/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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Figure 12

# 6. Assessment of Environmental Effects

In this section, the TIGM is broadly summarised to provide context for the analysis derived from its application. A full description of its development and calibration, and relevant background information is provided in **Appendix A**.

## 6.1 Groundwater Drawdown

### 6.1.1 Overview of the anticipated drawdown

**Central Block**

The greatest drawdown predicted in the Central Block occurs when the excavation is in Pit 3, with the groundwater level drawdown approximately 17 m lower than in the corresponding time of the Baseline simulation. The model indicates that drawdown will primarily be within the mining area, although about a 1 m of drawdown can be anticipated to extend outside the boundary of the Central Block towards east and south-west, primarily affecting the area currently known as the Eastern Block of the Taharoa Mine. Reduced groundwater levels are also anticipated along the southeastern edge of the mine area during excavation in Pit 3, although the drawdown contour only extends a few hundred meters beyond the TIL mine site. It is therefore anticipated to affect the adjacent Pihopa property to a small extent, as shown in **Figure 13** below.

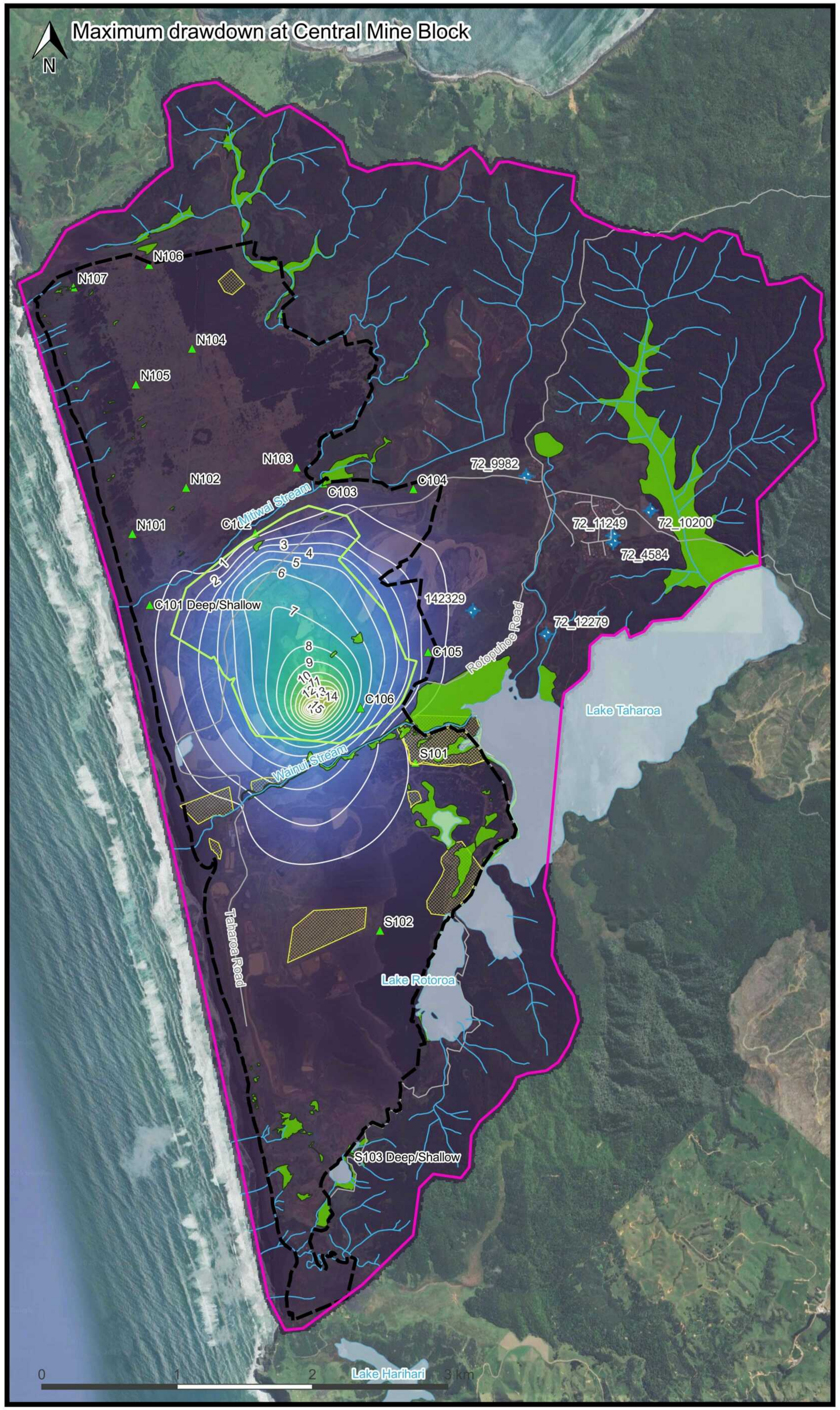
**Southern Block**

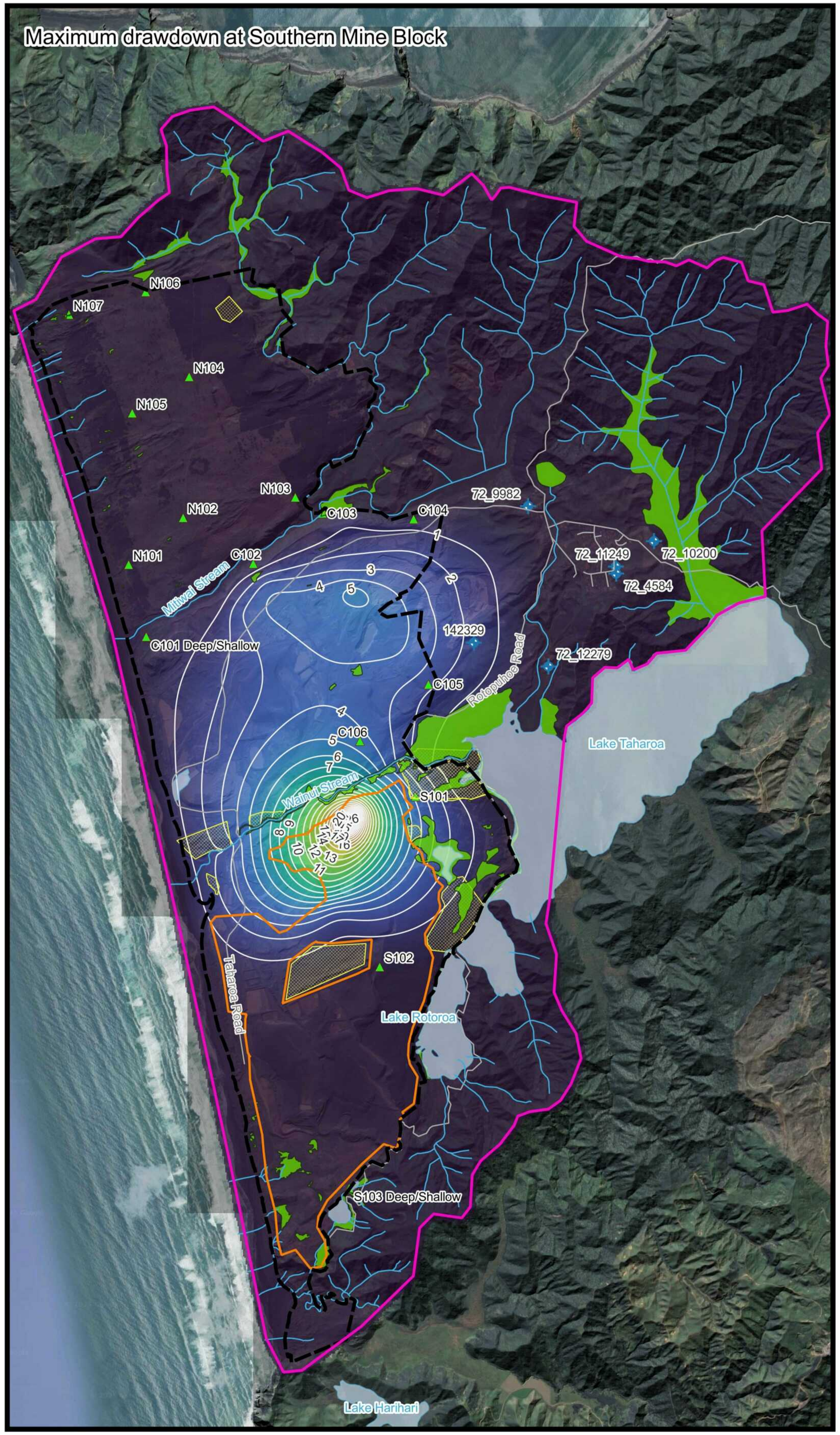
For the Southern Block, maximum drawdown of 29 m is predicted to occur in the northern portion of Pits 1 & 2, corresponding to where the deepest excavation is proposed. Predicted drawdown extends towards the north-east within the mining area and up to approximately 1 km beyond the property boundary, primarily affecting the Eastern Block, Te Mania Extension and Pihopa property, as shown in Figure 13 below. The extent of peak drawdown in the Southern Block is compounded by residual dewatering effects from the Central Block at a prior stage of the excavation i.e. groundwater levels had not fully recovered during excavation in Pits 1 & 2 in the Southern Block.

We have considered the potential effects of this drawdown below. In particular as stated in the introduction, this analysis comprises a quantitative assessment of:

- Potential effects of lowered groundwater levels on neighbouring bores;
- Potential impacts on surface water systems, including the stream baseflow and wetlands within and adjacent to the proposed Central and Southern Blocks which are hydraulically connected to the groundwater system;
- Potential for saline intrusion in groundwater as a result of reduced pressure during mining; and
- Potential long term changes in the hydrogeological regime following mining and land reclamation.

Due to the nature of the proposed mining activity, there will be no significant or sustained groundwater drawdown so the risk of land subsidence has not been considered.

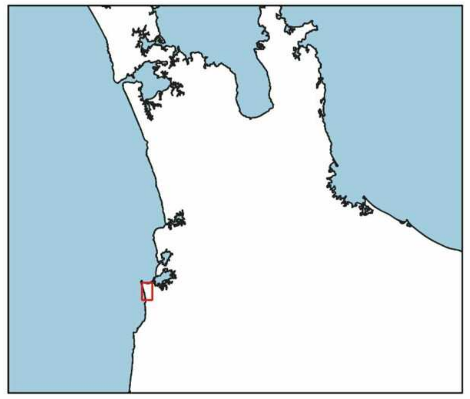



Map Title:
**Groundwater drawdown at time of maximum mine extent**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Groundwater monitoring sites
- Known bores (Outside Taharoa Mine)
- Road
- Streams
- Study Area
- Lakes
- Wetlands
- Cultural reserves
- TIL Property Boundary
- Central mine block
- Southern mine block

Groundwater drawdown (m)

25

0

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
22/08/2025

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Figure 13

### 6.1.2 Neighbouring Bore Interference Effects

If nearby properties rely on shallow bores for drinking water, stock water, or irrigation, groundwater drawdown could reduce water availability or increase pumping requirements. The magnitude of groundwater drawdown at registered bores within the model area is shown in **Figure 13** of which there are 6 bores located outside the mine area. Bores within the Taharoa mine area are excluded from this analysis because these bores are owned by TIL and are utilised for monitoring purposes.

Peak predicted drawdown at neighbouring bores from both the Central and Southern Block excavations is shown in **Table 9**. The greatest drawdown at a bore outside of the mining area was 1.65 m at Bore ID 142329, which a domestic bore on a neighbouring property. The bore log provided for this bore indicates that casing extends to 45 mBGL with the bore open below that depth and static water level is 25.8 mBGL. Assuming the pump 1 m above the bottom of the casing, there would be 18.2 m of water above the pump. Accounting for the maximum drawdown that may occur during the excavation would reduce the pump submergence to 16.55 m, which would allow for approximately 14.5 m drawdown while still leave 2m of pump submergence which is acceptable for normal bore operation. These findings indicate that the drawdown effect from the excavation on neighbouring bores is less than minor.

Table 9. Drawdown at registered bores outside Taharoa mine

| Bore ID | Status | Distance from Southern peak drawdown pit (m) | Distance from Central peak drawdown pit | Predicted drawdown (m) Central Pit | Predicted drawdown (m) Southern Pit |
|---|---|---|---|---|---|
| 72_4584 | Decommissioned | 2,676 | 2,542 | 0.007 | 0.033 |
| 72_12279 | Active | 1,860 | 1,871 | 0.001 | 0.005 |
| 72_11249 | Active | 2,710 | 2,565 | 0.007 | 0.032 |
| 142329 | Active | 1,618 | 1,380 | 0.58 | 1.65 |
| 72_10200 | Active | 3,039 | 2,898 | 0.001 | 0.006 |
| 72_9982 | Active | 2,664 | 2,338 | 0.012 | 0.046 |

## 6.2 Stream Baseflow

Streams, wetlands, and springs that are hydraulically connected to the groundwater system can potentially experience reduced baseflow as a result of groundwater drawdown. The transient model was used to evaluate stream baseflow of Mitiwai and Wainui Streams over the mine area by comparing flow with and without mining over the course of the simulation period.

It should be noted that both these simulations included the presence of the dam structure on the Wainui Stream and therefore raised water levels in Lake Taharoa. The effects on these two streams of mining from the Central and Southern Blocks were analysed separately.

The excavation resulted in reduced baseflow during the mining period, as would be expected, however after the land form was stabilised and backfilled with ELF once mining finished, the baseflow returned to its initial level in both streams.

### 6.2.1 Mitiwai Stream

For the Mitiwai Stream, the maximum base flow reduction from mining in the Central Block was predicted to be 4.4 L/s, which would occur during the excavation of proposed Pit 3, which is located approximately 1.3 km from the stream channel. This potential effect amounts to a 5% reduction in total stream flow (under summer low-flow conditions when groundwater baseflow accounts for most of the total stream flow). This illustrated in **Figure 15**, which shows reduction in both total streamflow and baseflow alone, with the relative effect represented by the purple trace in the low plot.

Once the landscape is restored following mining in Pit 3 of the Central Block, the stream baseflow returns to 97% of the rate in the Baseline Scenario within 15 months and continues toward full recovery thereafter (**Figure 15**). These findings support the conclusion that seasonal and year to year variation in stream baseflow will far exceed any lasting effects related to mining.

Model results were evaluated to show where the stream will have gaining conditions (i.e. groundwater discharging into the stream, thereby increasing total stream flow) under both Baseline and Mining model scenarios at the time corresponding to the peak excavation. **Figure 14** shows where flow reduction could potentially occur if gaining conditions are reduced due to a declining water table, with the red shading representing the potential decline in baseflow along the stream channel when the excavation is closest to the stream (i.e. peak stream depletion).

To provide assurance that the flow regime in the Mitiwai Stream is not adversely affected by mining, it is recommended that the existing flow monitoring stations that are downstream from the potentially vulnerable area indicated in **Figure 14** be used to confirm flow maintenance. A monitoring program should be implemented along with a three-tier trigger level (TL) system to set criteria for management and contingency measures.

An analysis of flow data from the two gauges on the Mitiwai Stream shown in (**Figure 4**) is presented in **Appendix D**. The data was used to develop and calibrate a Soil Moisture Water Balance Model (SMWBM) to quantify and flow regime of the Mitiwai Stream. The flow statistics presented below are derived from that analysis and a were used to determine the trigger levels presented in **Table 10**.

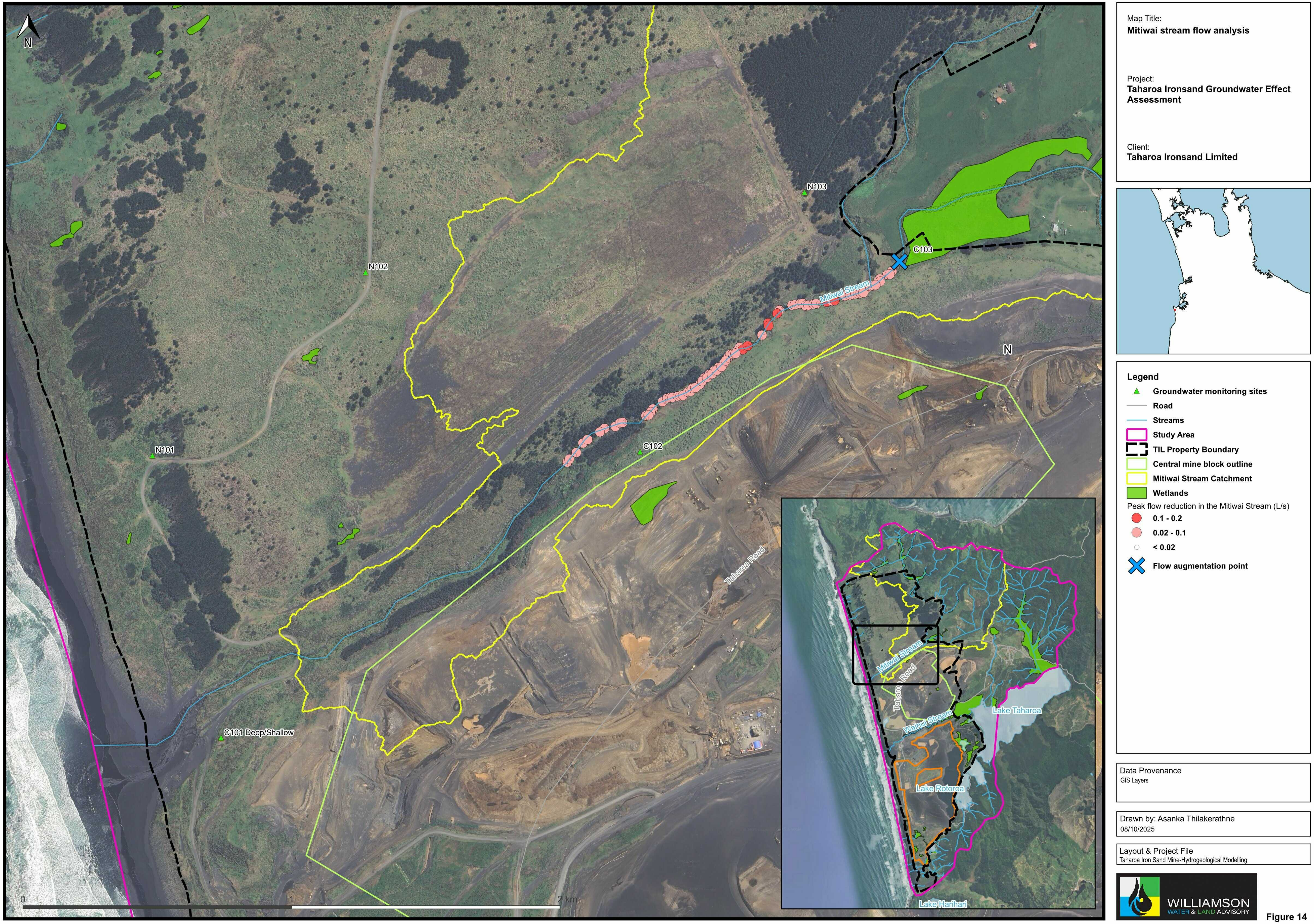
The first level, TL1 would be set at the 7-day mean annual low flow (MALF) and serve as an early warning that low stream flows were occurring. The second level, TL2, would be set at the 7-day low-flow with a 1 in 5 year recurrence interval ($Q_5$) and initiate a review of catchment wide water use, recent climate and mining, and planning for supplemental water sources. The third level, TL3, would be set at 90% of the $Q_5$, which is the default minimum flow requirement set in the Waikato Regional Plan[5], and would require contingency measures to be implemented that may include direct flow augmentation to be discharged into the Mitiwai Steam, and/or partial or full cessation of pit dewatering adjacent to the affected stream.

If flow augmentation was to be implemented as part of a mitigation package the ideal place to discharge water into the stream would be at the upstream extent of the shaded portion of the stream bed indicated by the blue X in **Figure 14**.

Table 10. Proposed trigger level criteria for Mitiwai Stream.

| Trigger level | Metric | Flow (L/s) | Management Response |
|---|---|---|---|
| TL1 | 7-day MALF | 45 | Early warning |
| TL2 | $Q_5$ | 31 | Water use review |
| TL3 | 90% $Q_5$ | 28 | Flow augmentation |

[5] https://www.waikatoregion.govt.nz/assets/WRC/Council/Policy-and-Plans/Rules-and-regulation/WRP/Chapter-3-Water-Module-Operative-WRP.pdf




Map Title:
**Mitiwai stream flow analysis**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
08/10/2025

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**Figure 14**

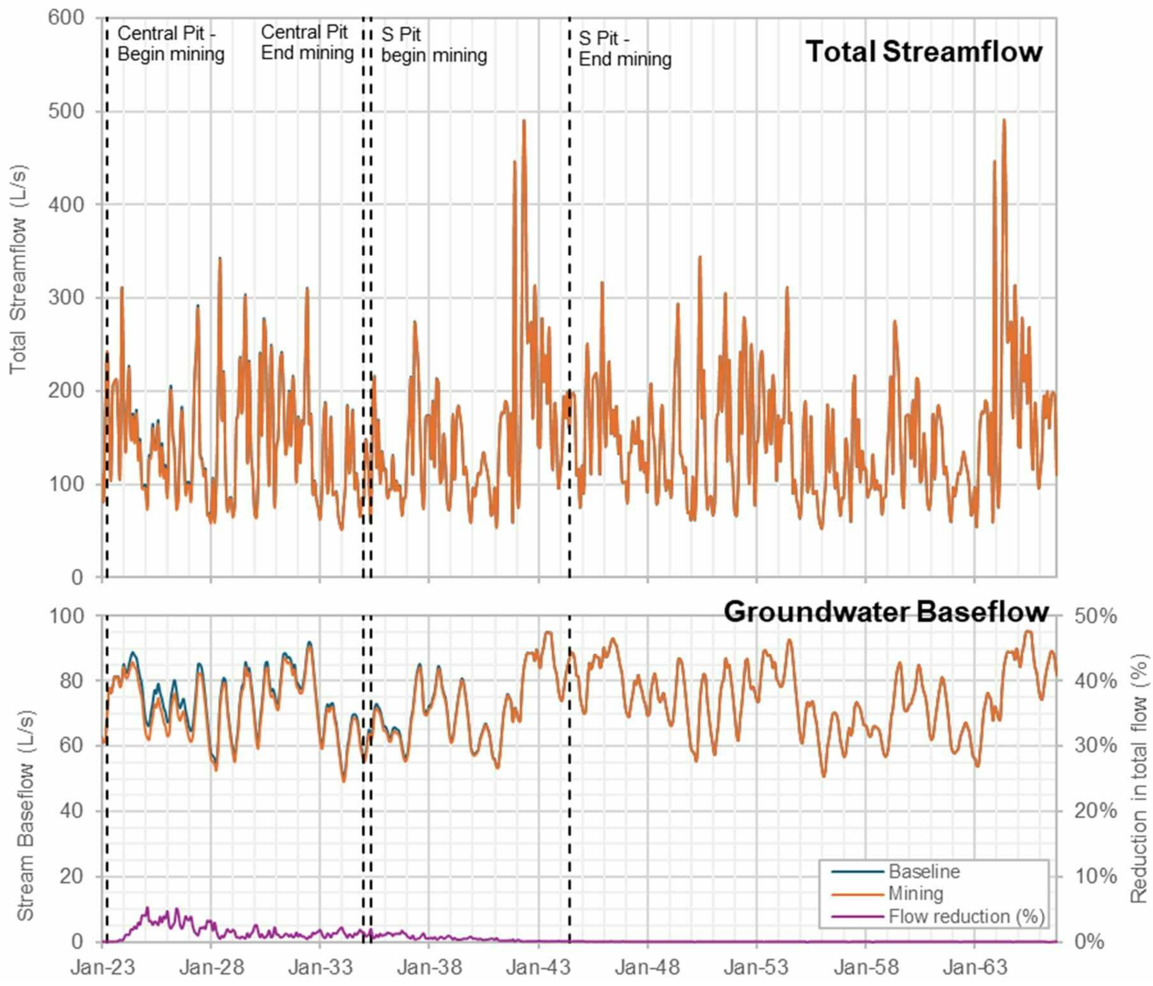



Figure 15. Simulated flow in the Mitiwai Stream for the 'Baseline' and 'Mining' scenarios – total flow & groundwater baseflow.

### 6.2.2 Wainui Stream

The Wainui Stream comprises the largest catchment in the study area, and includes the outflow from Lake Taharoa into the Wainui Stream. Sections of both the Central and Southern Blocks are located within the catchment. The analysis in this section refers to the flow in the upper and lower reaches of the Wainui Stream but does not consider flows into Lake Taharoa.

Flow in the lower reach of the Wainui Stream is governed by discharges out of Lake Taharoa, which are lake level dependent. Water levels in Lake Taharoa are governed by both inflow from tributary streams and the dam consisting of an embankment, with a culvert passing underneath it that is connected on the upstream side to a box weir and fish passage structure[6]. The discharge rate over the weir, to the downstream reach of the Wainui Stream is controlled by the water level behind the dam structure.

TIL's current Taharoa Mine Water Management Plan[7] (WMP) states a required flow rate of between 24 to 34 L/s be maintained. Therefore, currently a minimum flow of at least 24 L/s must be maintained to the Wainui Stream downstream of the dam structure, through the fish pass. It was also agreed that a residual flow requirement of 10 L/s must be maintained through the weir; hence, the total residual downstream flow requirement in the Wainui Stream is 34 L/s [24 L/s through the fish passage + 10 L/s through the weir]. Further detail of flow management of the Wainui is provided in the WWLA Hydrology report (WWLA 2025a).

[6] Further details of the lake outlet structure are provided in WWLA, 2025. Lake Taharoa Hydrology Assessment.
[7] Taharoa Ironsands Ltd, 2019. TIL – Water Management Plan. Appendix E Taharoa Compliance Management Plan. Revision 3. October 2019.

The theoretical maximum baseflow depletion at the mouth of Wainui Stream is 43.3 L/s and would occur during the excavation of Central Pit 3, during the 10th year of mining (**Figure 16**).

However, in practice there will be no reduction in Wainui Stream flows due to the following factors:

- The proposed activity comprises a continuation of current practices with no changes that will affect flow in the Wainui Stream;
- Spent water from ironsand processing is discharged back to ground with tailings disposal, hence the site water balance will be virtually non-consumptive (a small component of evaporative losses would occur); and
- Flow in lower reach of the Wainui Stream (downstream of the dam) is a function of lake levels behind the dam structure. TIL proposes a minimum flow requirement of 34 L/s (at least 10 L/s through the outlet weir, and 34 L/s through the fish passage), so the depletion of baseflow will not manifest as a change in low-flow conditions.

Given the above, no adverse effects are anticipated.

If any baseflow reduction of the Wainui Stream manifests, it would coincide with discharge into the mine pits, as discussed further in **Section 7**. As with the Mitiwai Stream, any reduction in stream baseflow in the Wainui Stream would recover to the rate in the Baseline Scenario within a 2-year time frame after the completion of mining.

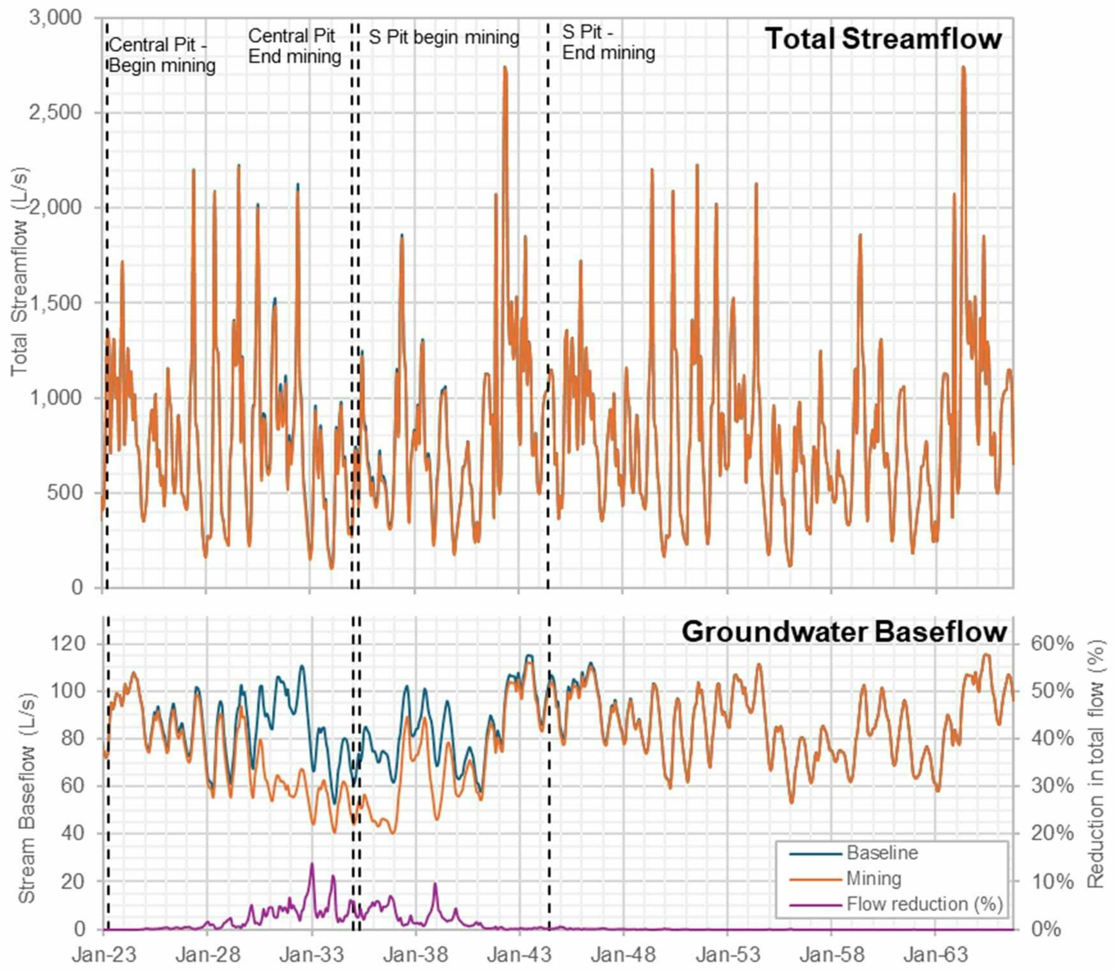



Figure 16. Simulated flow in the Wainui Stream for the 'Baseline' and 'Mining' scenarios – total flow & groundwater baseflow.

### 6.2.3 Stream Flow Effects Summary

The predicted 4.4 L/s baseflow depletion in the Mitiwai Stream amounts to 10% of MALF and 14% of the $Q_5$ flow rate calculated from the stream flow analysis based on the available monitoring data. The implication of this is that a mitigation and management package will be proposed as part of the wider application to provide assurance that the Mitiwai Stream sustains flow above the allowable minimum defined as 90% of the $Q_5$ rate.

The baseflow reduction of the Wainui Stream corresponds to discharge into the mine pits, as discussed further in **Section 7**, however the total stream flow will be controlled by the management of Lake Taharoa and augmentation under low-flow conditions, hence effects on stream flow depletion are considered to be less than minor.

## 6.3 Wetland Assessment

The vulnerability of a wetland to dewatering effects from mine excavation is a function of its degree of connection to underlying groundwater, with wetlands that are directly connected to groundwater being more vulnerable to effects. The TIGM was used to assess wetland hydrological functionality across the TIL mine site for the wetland sites listed in **Section 3.3**. The assessment involved desktop review, field review and hydrogeological analysis to estimate the primary mechanism of wetland maintenance in the Central and Southern Blocks. The information was ultimately synthesised into the numerical modelling based analysis described below.

### 6.3.1 Wetland Classification

From the transient recharge input data used in the TIGM, time periods were selected corresponding to the to the 90th (highest) and 10th (lowest) percentiles, representing extreme wet and dry conditions respectively. Associated groundwater levels during the wettest and driest recharge period within the simulation were evaluated to determine which wetlands were fully or partially connected to groundwater, and which are indicated to be entirely surface water fed (i.e. not connected to groundwater). The classification of wetlands, as used in this analysis are summarised in **Table 11**.

Table 11. Wetland type classification.

| Depth to Groundwater | Wetland Type |
|---|---|
| <1 mBGL | Groundwater connected wetland |
| 1 - 3 mBGL | Potentially groundwater connected wetland[8] |
| >3 mBGL | Surface water fed wetland (no groundwater connection). |

**Figure 17** shows the results of this analysis, with the 'Wet Conditions' represented in the left panel and 'Dry Conditions' in the right panel. The depth to water for each wetland is indicated by the colour shading as follows:

- A wetland with blue shading indicates that the water table is within 1 m of the ground surface, and it is likely to be connected to groundwater;
- A wetland with green shading indicates that the water table is between 1 and 3 m below the ground surface, with a potential or partial connection with groundwater; and
- A wetland with orange shading indicates that the water table is greater than 3 m below the surface and is disconnected from groundwater.

A wetland that has no groundwater inputs during the wet period can be assumed to be fully surface water supported. Conversely, a wetland that has groundwater connection under dry conditions can be assumed to be a groundwater and surface water supported wetland.

Under the dry conditions, the model predicted that 32 of the wetlands across the Taharoa C Block are highly likely to be groundwater connected, whilst a further 12 are within 3 m of the land surface, and hence potentially groundwater connected, as summarised in **Table 12**. Under wet conditions two additional wetlands were found to have groundwater connection and one wetland was found to increase from a potential connection to a likely connection. This indicates that the methodology produced broad stability of wetland classification under wet or dry conditions, and hence can be relied upon as a robust identifier of groundwater supported wetlands.

In total, more than half of the wetlands in the study area have at least some degree of connection to groundwater.

[8] Depth to groundwater of 3 m would not typically be considered conducive to wetland, however we have used that criterion acknowledging the uncertainty in groundwater modelled levels.

Table 12. Summary of wetland classification.

| Climatic Condition | Groundwater fed wetlands | Potentially groundwater fed wetlands | Surface water fed wetlands |
|---|---|---|---|
| Dry (10$^{th}$ Percentile) | 32 | 12 | 44 |
| Wet (90$^{th}$ Percentile) | 33 | 13 | 42 |

### 6.3.2 Wetland Effects

An ecological assessment of the characteristics and ecological value of wetlands across the Central and Southern Block is provided in SLR (2025), including appropriate mitigation measures to avoid adverse effects during and after mining. Where such effects cannot be avoided (i.e. wetlands that are within the proposed excavation area), offsetting will be required in accordance with the regulatory framework described in the ecological impact assessment report (SLR 2025).

Wetlands that are located directly in the proposed excavation areas, regardless of their hydrological functionality, will be permanently lost. Other wetlands situated near Lake Taharoa and the Wainui Stream, are proposed to be retained. These retained wetlands are potentially vulnerable to groundwater drawdown during the excavation of the Southern Pit, as indicated by the areas where groundwater drawdown intersects wetlands (refer to **Figure 13**).

This assessment is focused on the retained wetlands that are groundwater connected or partially/potentially groundwater connected, and are therefore potentially vulnerable to groundwater drawdown associated with pit dewatering. These wetlands are shown in **Figure 17**. This figure shows a hatched area within the 0.2 m drawdown contour, which represents the area where hydrological effects on wetlands (i.e dewatering) may occur over the course of mining within the Central Block (left hand pane) and Southern Block (right hand pane). Potential effects on the identified natural inland wetlands are as follows:

- Wetland #1 to #46 and #53, with the exception of Wetland #42, are outside of the TIL mining site (in the north) and outside of the 0.2 m drawdown contour and are therefore unlikely to be affected in any way (Wetland #42 is addressed separately later in this Section);
- Wetlands #50 and #51 are also north of the mining area, but within the 0.2 m drawdown contour, however both are surface water fed wetlands and will not be affected by mining.
- Wetlands #56 and #76 are along the Lake Taharoa shoreline, but outside of the 0.2 m drawdown contour and will not be affected by mining.
- No groundwater connected wetlands were observed among the 6 wetlands within the Central Block under wet or dry conditions;
- Wetlands #83 and #86 are shown in **Figure 17** as having surface water connection. Monitoring data and site investigation support that these are predominantly surface water features and will not be vulnerable to groundwater drawdown[9].
- Numerous wetlands are located directly down gradient on the western side of Lake Taharoa or adjacent to Wainui Stream, and are partially or entirely within the 0.2 m drawdown contour, hence have the potential to be affected by mining. Of these:

[9] Wetlands #83 and #86 are shown in **Figure 17** to be groundwater connected, which reflects the shallow water table at the base of the hills on the upgradient side of the wetlands. The monitoring data from the S103 monitoring piezometer, situated at the northern edge of Wetland 36 shows a groundwater level that is over 3 m below the ground surface, indicating perched conditions [i.e. not connected to regional groundwater]. Further analysis of the simulated water table shows a steep groundwater gradient in this area with the majority of both wetlands being perched. Whilst surface runoff from the adjacent low permeability greywacke hills would account for the majority of the lake water balance, an area along the southern (upgradient) edge the base of the greywacke hills is shown to have shallow groundwater. In this location there is likely to be some groundwater seepage which accounts for the groundwater connectivity classification of these wetlands in this analysis.

- 13 wetlands are anticipated to be mined as part of the mining project (including those mentioned above in the Central Block).
- 25 are proposed to be retained, which are listed for reference in **Table 13**. These retained wetlands are described in further detail below.

**Table 13. Retained wetlands within 0.2 m groundwater drawdown contour**

| Wetland ID (Refer Figure 4) | Wetland Group (based on location and topographic position) | Description | Area (ha) | Comments regarding wetland hydrology and groundwater connection |
|---|---|---|---|---|
| 42 | 1 | Adjacent to Mitiwai Stream | 2.99 | Wetland Group 1 (Wetland 42) is situated in the Mitiwai Stream valley and is interact with the stream channel, particularly during high flows, with surface water being the primary source of water in the wetland. Groundwater is within 1 m of the land surface at this location hence there is likely to be a connection between the wetland and groundwater. The wetland water level is continuously monitored by piezometer C103. |
| 57 | 2 | Lake Edge | 20.87 | All Group 2 wetlands are situated in the portion of the Wainui stream channel that is continuous with Lake Taharoa. Surface water is the primary source of water in these wetlands. These wetlands are situated within the stream valley where groundwater is within 1m of the land surface, hence a connection groundwater is also likely. Wetland 71 is situated along the margin of the lakeshore and is primarily wetted by the lake itself, although the water table is also less than 1 m below the ground surface in this area. The only portion of the wetland within the 0.2 m drawdown contour is the section that extends along the southern bank of the Wainui Stream at the lake outlet, directly across the from Wetland 57. |
| 58 | | Lake Edge | 0.03 | |
| 59 | | Lake Edge | 0.50 | |
| 60 | | Lake Edge | 0.07 | |
| 61 | | Lake Edge | 0.74 | |
| 62 | | Inland | 0.24 | |
| 63 | | Lake Edge | 1.06 | |
| 64 | | Lake Edge | 2.17 | |
| 65 | | Lake Edge | 1.08 | |
| 68 | | Lake Edge | 0.23 | |
| 71 | | Lake Edge | 4.21 | |
| 66 | 3 | Inland | 0.03 | All Group 3 wetlands are situated adjacent to the western shore of Lake Taharoa and are above the level of the lake.<br>For Wetlands 66, 67, 70, 72, and 73 the water table is between 1 and 3 m below the land surface. They are primarily surface water fed and it is likely that they are only connected to groundwater during occasional high-water events.<br>Wetlands 69 and 75 have a water table that is less than 1 m from the surface and are likely to have connection to both surface water and groundwater. |
| 67 | | Inland | 0.08 | |
| 69 | | Inland | 0.15 | |
| 70 | | Inland | 0.03 | |
| 72 | | Inland | 7.76 | |
| 73 | | Inland | 1.90 | |
| 74 | | Inland | 0.13 | |
| 75 | | Inland | 2.90 | |
| 78 | 4 | Inland | 0.02 | The Group 4 wetlands are south of the Southern mine pit. Wetland 80 has a water table between 1 and 3 m below the land surface and may be partially or intermittently connected to groundwater.<br>Wetlands 83 and 86 are predominantly perched, although there may be a degree of groundwater connection the at the base of the greywacke hills to the east[Error! Bookmark not defined.]. Wetland 78 and 88 are both perched and disconnected from groundwater. |
| 80 | | Inland | 0.20 | |
| 83 | | Perched | 0.80 | |
| 86 | | Perched | 1.19 | |
| 88 | | Inland | 1.45 | |

As shown in **Table 13**, the model results indicate that some of the wetlands directly down gradient (west) of Lake Taharoa and adjacent to the Wainui Stream are potentially connected to groundwater based on the simulated depth to groundwater in the corresponding area.

In practice it is apparent that some of these wetlands are primarily fed by surface runoff (Wetlands 73-75) or the Wainui Stream (Wetlands 58-65 are effectively located within the stream riparian margin), with groundwater connection possible when high water events occur.

**Figure 18** shows the predicted drawdown at the time when the Southern Block mine excavation is closest to these wetlands, highlighting four locations within retained wetlands for which groundwater level hydrographs are presented in **Figure 19**. Cross-sections in Figures 20 and 21 provide further detail on wetland-groundwater relationships.

**Figure 19** shows that groundwater drawdown is predicted to occur during mining at the four locations highlighted. It is noted that mining in this area has been ongoing as the mine is currently operating, yet these wetlands have been maintained. This supports the conclusion that the wetlands in this area are primarily fed by surface flows such as runoff from the surrounding higher ground and direct hydraulic connection to Lake Taharoa.

**Figure 20** illustrates that the groundwater level under baseline conditions is continuous with Lake Taharoa, with Wetland 71 situated along the lake margin and primarily fed by direct connection to the lake and Wetland 74 only 30 m from the lake with direct connection likely when the lake level is high. Wetlands 72 and 73 are above the water table and above the lake. Model results indicate that that these wetlands are not connected to groundwater under normal circumstances. The measured groundwater level in the S101 piezometer (approximately 200 m northeast of the cross-section transect) is 3.41 mAMSL which is more than 4 m below Wetland 72, which confirms the likely disconnection between the wetlands and local groundwater. These wetlands are primarily fed by surface runoff, with periodic connection to groundwater when the water table is elevated during high water events.

Wetlands 69-70 are situated near the western shore of Lake Taharoa and are similar to Wetland 73 (**Figure 20**) in terms of location, topographic position, and depth to the water table.

**Figure 21** shows that Wetlands 61 and 63 are effectively level with the Wainui Stream bed and are sustained by the normal stream flow regime which will be managed by TIL under proposed consent conditions.

Wetland 42 is situated adjacent to the channel bed of the Mitiwai Stream and Wetlands 57 and 68 are adjacent to the Wainui Stream channel. These wetlands are directly in contact with the stream, particularly during high flows, and surface flows (runoff and stream flow) comprise the primary input to both wetlands. In these cases the water table is within 1 m from the surface, similar to the profile shown for other stream adjacent wetlands shown in **Figure 21**.

To summarise the analysis of these potentially vulnerable retained wetlands:

- The evidential basis as described above, points towards the retained wetlands being primarily maintained by surface water inputs - either accumulation of rainfall runoff or direct inputs from the lake or stream, with limited, if any, connection to groundwater.

- Nonetheless, in recognition of some uncertainty in modelling for those areas further from surface water boundary conditions (i.e. inland from the lake and stream), it is recommended that:

    - a 30 m setback be established wherein mined areas will remain a minimum of 30 m from all retained wetlands in order to avoid or minimise areas potentially affected by shallow groundwater drawdown intersecting wetlands.

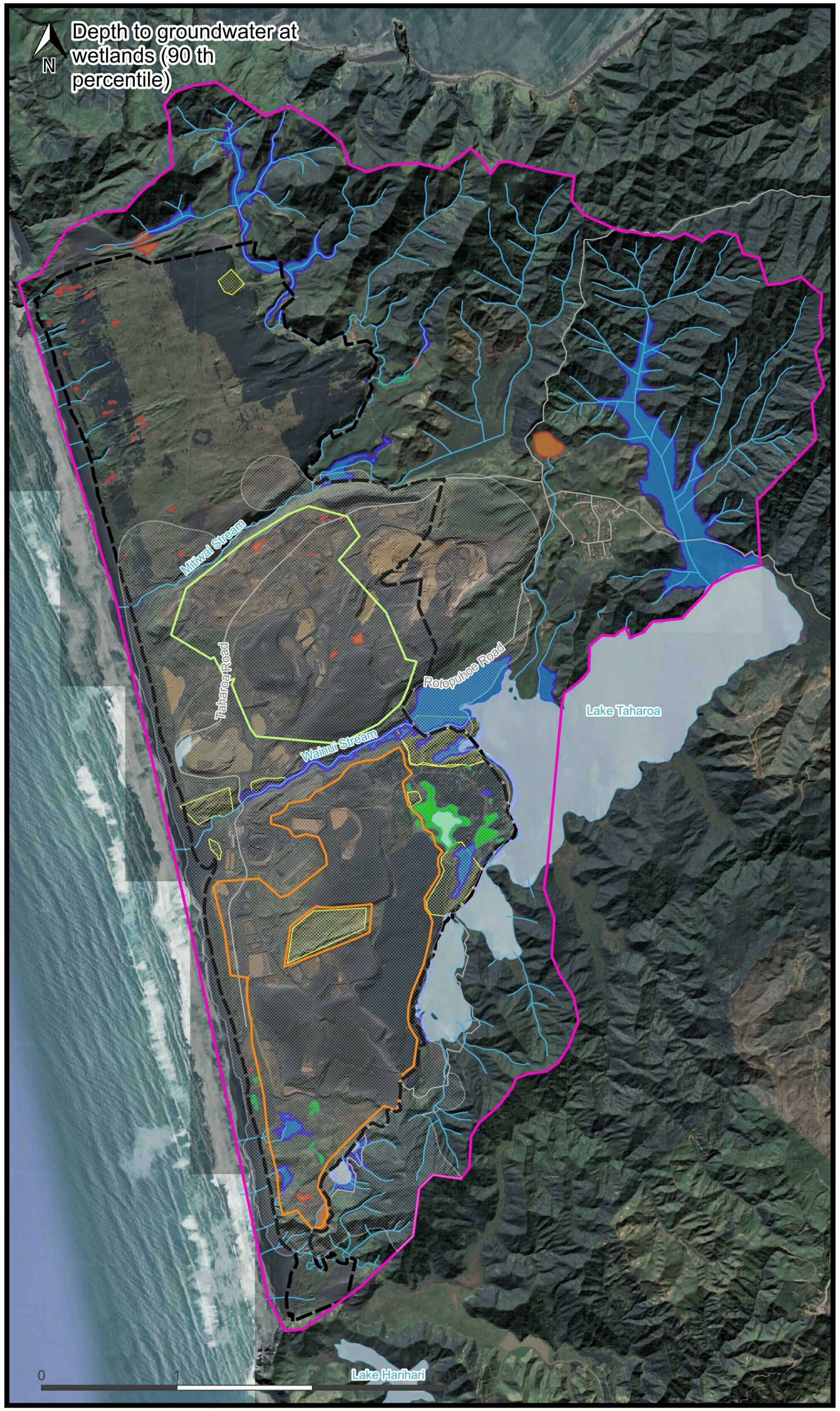
- o Water level monitoring sites be established at the retained wetland locations where drawdown may occur, and management responses provided for additional assurance that these wetlands are not partially drained over the course of mining.

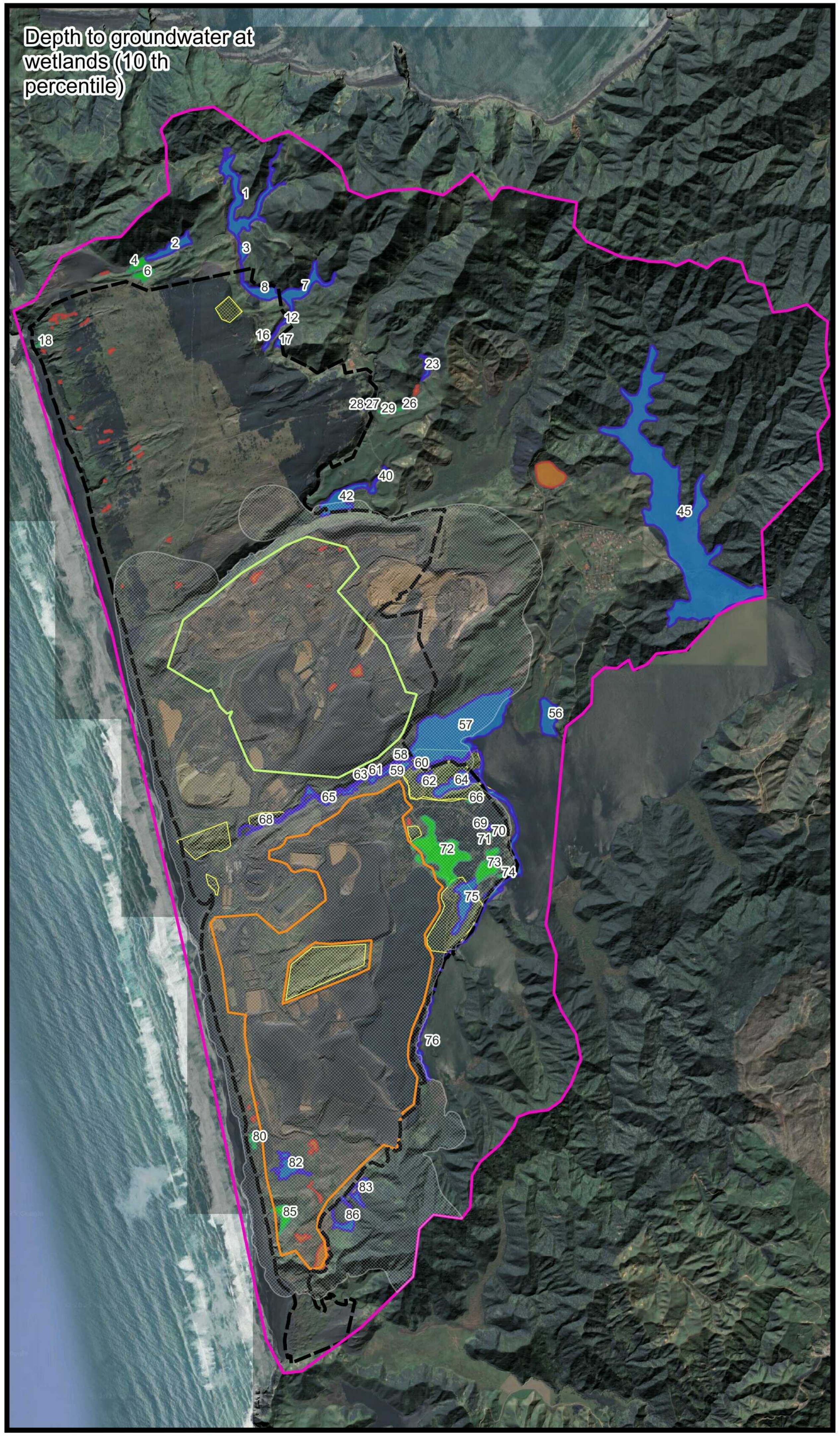
The retained wetlands can be divided into four groups (as indicated in **Table 13**) based on their locations and topographic positions, such that it can be assumed that water level in a given wetland will rise and fall in concert with the other wetlands in the same group. This will allow a monitoring and management plan to be developed where all 25 of the retained wetlands within the 0.2 m drawdown contour can be effectively monitored by implementing the following approach:

- Wetland Group 1, comprised of Wetland 42 only, is monitored by the existing piezometer C103.
- Wetland Group 2 is group of wetlands that are riparian features and will be supported via flow conditions in the Wainui Stream which are controlled by the dam as described in **Section 6.2.2**.
- Wetland Group 3 is a group of wetlands near the edge of Lake Taharoa with Wetland 72 being both the largest and closest to the excavation. It is recommended to establish a new monitoring site within Wetland 72.
- Wetland Group 4 are south of the proposed Southern Pit mining area. The wetlands to the southeast of the Taharoa C Block are predominantly surface water fed from the adjacent hills, with a pair of nested piezometers (S103) confirming the hydraulic separation of the wetlands from regional groundwater. Wetland #80, to the west of the mining area, may have a degree of connection groundwater. In light of this possibility, it is recommended that a shallow monitoring piezometer be installed in Wetland #80 to assure that appropriate mitigation measures are taken if effects manifest on the wetland during the mining of the Southern Block.

The wetland monitoring plan should envisage a 12-month baseline monitoring period during the first 12 months of exercising of the consent, which will form the basis of wetland water level long-term simulation modelling to define trigger levels for the setting of contingency measures, should water levels recede towards historical lows. Contingency measures will comprise a range of options such as cessation of dewatering in pits in close proximity to the wetlands during dry times until wetland water levels recover, or supplementation of wetland water levels with water from the mine either directly (if clean) or indirectly via ground soakage through sand beds if silty. With the implementation of these measures hydrological function will be maintained for all retained wetlands on the Taharoa C Block.

Project ecologists will provide an offset package to address wetlands affected by mining and a Wetland Management Plan for wetlands outside of the mining area but within the area where effects are possible (SLR2025). A mitigation package, should wetland effects manifest based on monitoring, will be included as part of the management plan.

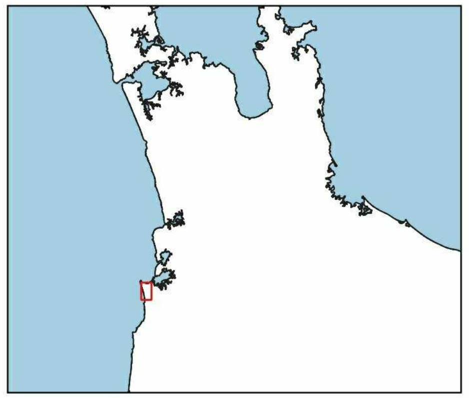



Map Title:
**Depth to groundwater at wetlands**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Road
- Streams
- Lakes
- Study Area
- Central mine block outline
- Southern mine block outline
- TIL Property Boundary
- Cultural reserves

Depth to groundwater wetland

- < 1 m
- 1 - 3 m
- > 3 m
- 0.2 m maximum drawdown area

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
16/09/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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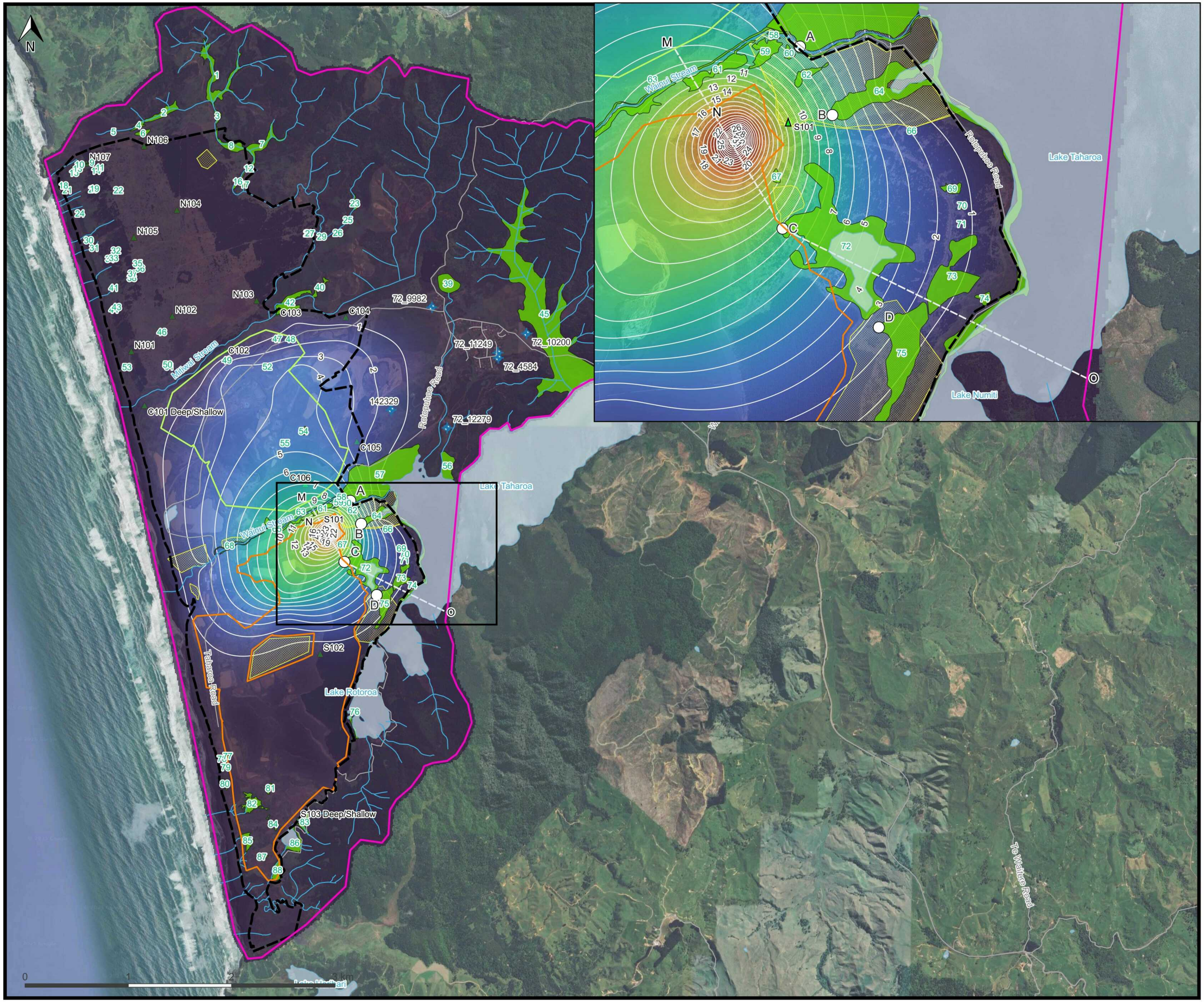
Figure 17




Map Title:
**Groundwater drawdown when excavation is near wetlands. [Cross-section (Fig. 19) and wetland water level (Fig. 20) reference locations]**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**

**Legend**

- Groundwater monitoring sites
- Road
- Streams
- Cross section (M-N-C-O)
- Lakes
- Study Area
- TIL Property Boundary
- Central mine block outline
- Southern mine block outline
- Wetlands in model area
- Cultural reserves
- Known bores
- Edge of wetland (A-57,B-64, C-72, D-75)
- Drawdown contours (m)
- Groundwater drawdown (m)
  - 25
  - 0

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
09/09/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

WILLIAMSON
WATER & LAND ADVISORY

Figure 18

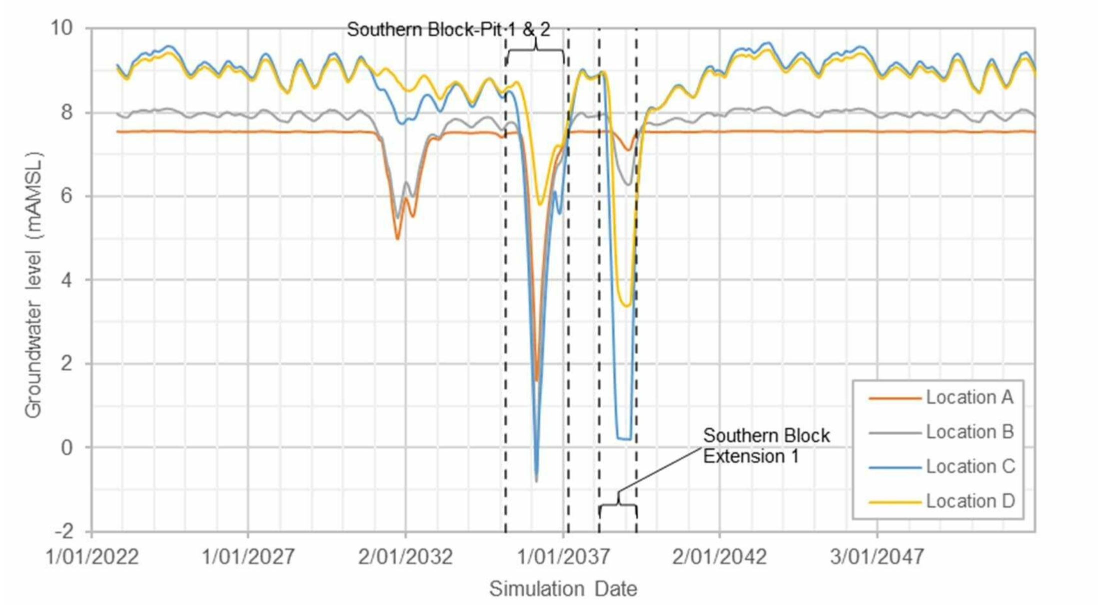



Figure 19. Cross-section highlighting groundwater level at potentially vulnerable wetland locations during dry period.

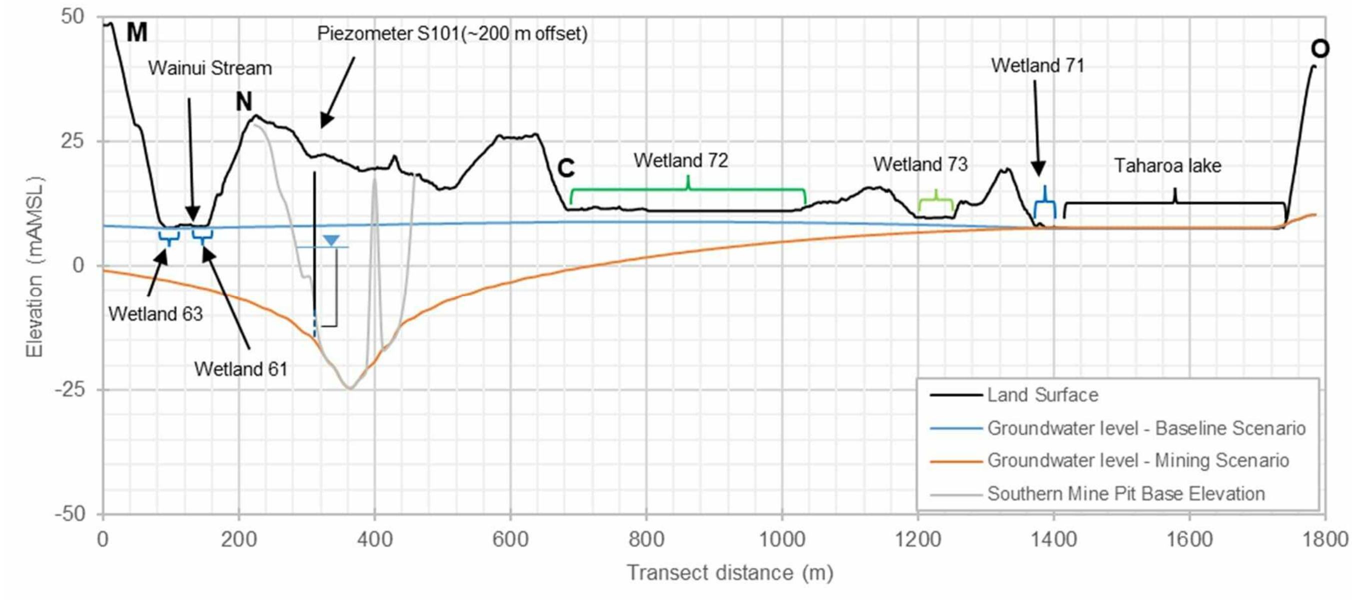



Figure 20. Cross section through Southern Block mine area and nearby wetlands.

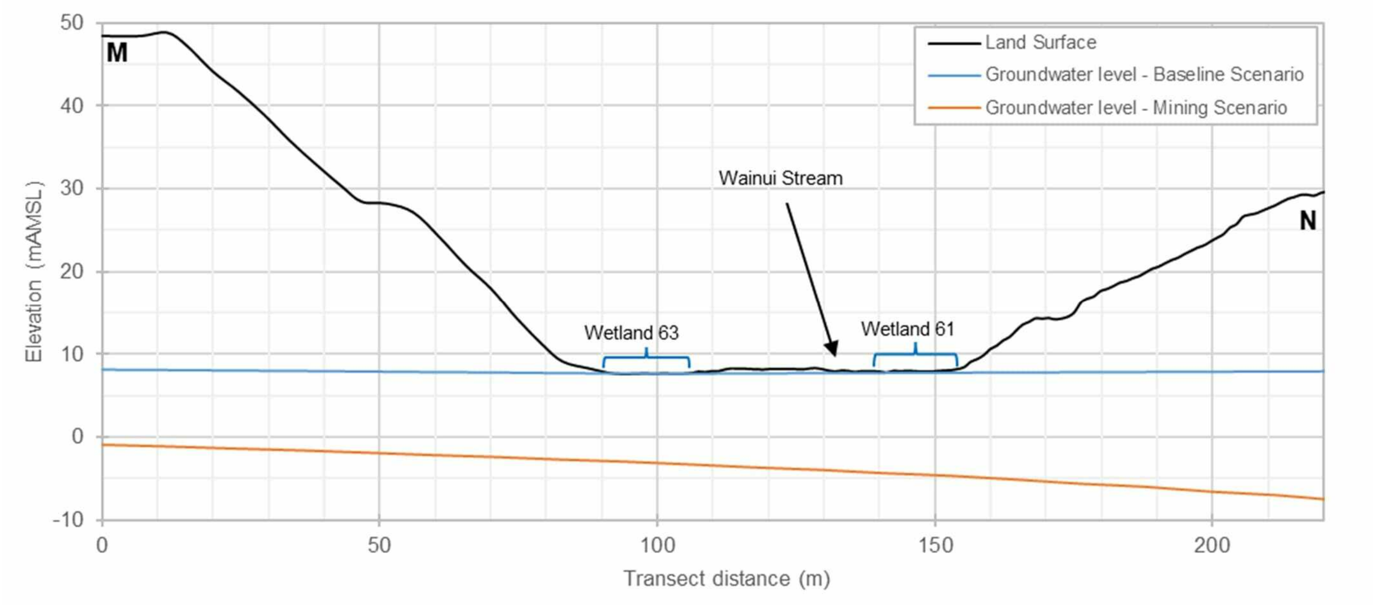



Figure 21. Cross-section through Wetlands 61 & 63, adjacent to Wainui Stream.

## 6.4 Saline Intrusion

Saline intrusion or the landward migration of the saline interface is a potential environmental effect of activities that extends below sea level in close proximity to the coast. The western edge of the Central and Southern Blocks of the Taharoa mine are approximately 500 and 230 m from the coast, respectively. As described in **Section 6.1**, maximum drawdown is predicted to occur in Central Pit 3 and Southern Pits 1 & 2. This drawdown has potential to induce lateral inland migration of the saline-fresh water interface, though this process occurs slowly and will be limited and reversible if the drawdown is temporary.

The Ghyben-Herzberg[10] relationship is commonly used to assess the depth of the saline interface based on groundwater pressure (head) along the coast and adjacent areas. The Ghyben-Herzberg relationship can be summarised as, "for every meter of head above mean sea level the saline interface will be 40 m below sea level". Along the mining boundary, saline intrusion has greatest potential to occur via lateral migration, a mechanism where water with higher salinity may seep via osmosis inland within the higher permeability layers in the sands residing above the greywacke.

The saline intrusion analysis sought to understand the worst case scenario, which is where maximum dewatering is maintained in perpetuity and saline intrusion potential would be experienced to the fullest extent.

Three forms of analysis were undertaken as described below:

- ***Planar analysis*** – this focused on identifying the planar area where saline interface would reside within the sands. The analysis was undertaken by calculating a groundwater pressure threshold required to withstand saline intrusion into the sands along the greywacke interface. If this pressure threshold was exceeded, the area was marked as having saline water in the sands;
- ***Section analysis*** – this focused on identifying the height of the saline interface based purely on groundwater pressures and assuming matrix flow in a similar manner in both the greywacke and sands.

[10] The Ghyben-Herzberg relationship describes the depth of interference between freshwater and saline faces. This relationship manifests as the formula z=(Pf/(Ps-Pf))Hf which can be simplified to state that the depth below sea level to the point of interference is 40 times the heigh of freshwater above sea level.

- ***Water Balance*** – this focused on understanding the variation in groundwater flow to the coast with time, noting that saline intrusion requires prolonged periods of reduced flow or flow reversal to initiate saline intrusion.

**Figure 22** and **Figure 23** shows the outcome of the Planar analysis for both the Baseline and Mining scenarios during the Central Pit and Southern Pit excavations, respectively. The isolated blue area shown in **Figure 22** would indicate upconing [i.e. ingress of saline water into the mine pit via vertical percolation from underlying material below the saline interface], however it would be highly unlikely to manifest due to the temporary nature of the drawdown combined with the slow process of lateral migration and the low permeability of the graywacke through which the interface would have to pass through.

**Figure 24** and **Figure 25** present the outcome of the Section analysis, with a transect across the Central and Southern Blocks, respectively. The figures show the potential worst-case position of the saline-fresh water interface assuming the period of deepest mining is held in perpetuity.

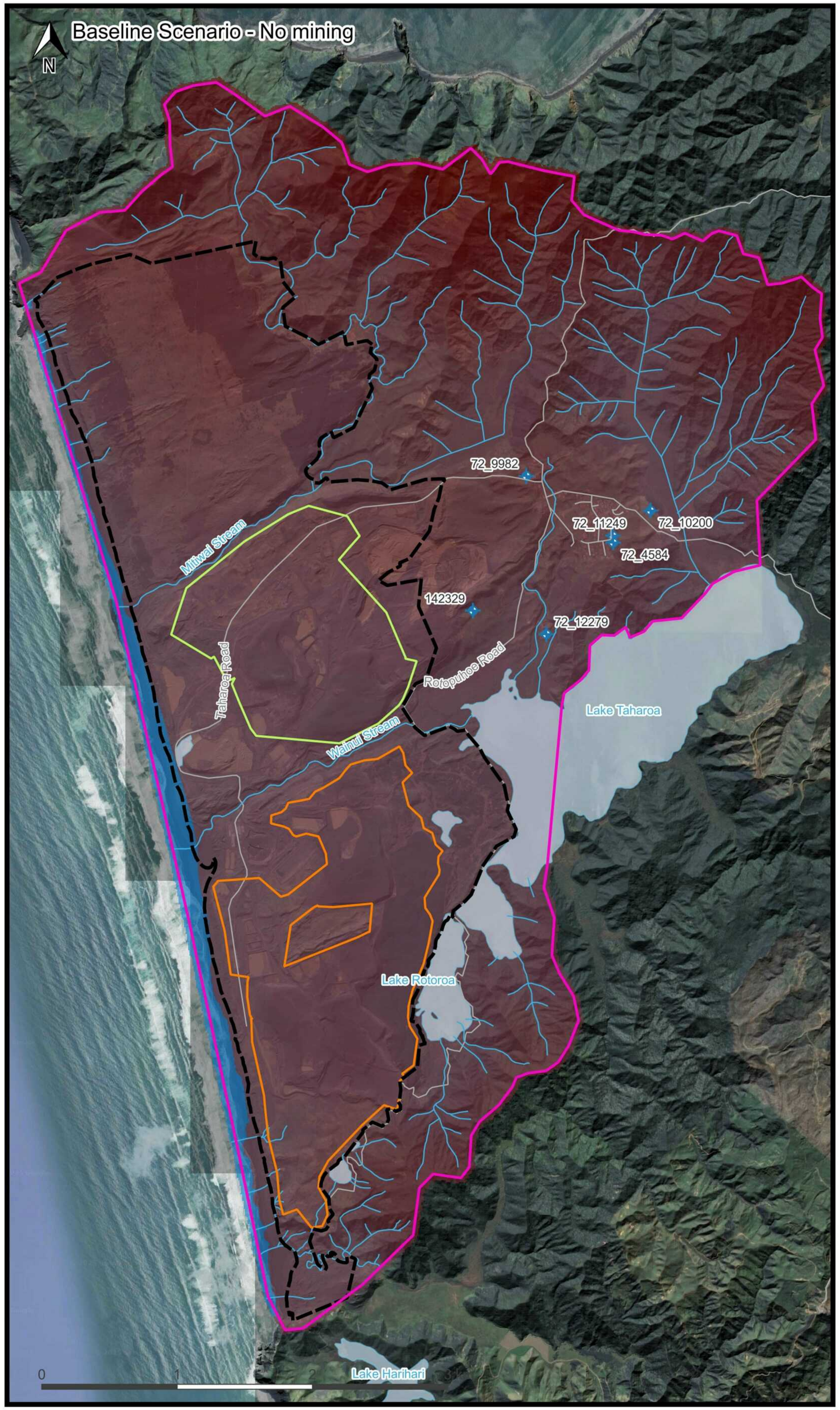
As the excavation proceeds and the landscape is restored, conditions where the hydraulic gradient between the ocean and the mine pit could potentially reverse and induce inland migration of saltwater would be transient. This is illustrated in **Figure 26** which shows a time varying representation or temporal representation of the water balance, with a focus on groundwater discharges to the coast and from the coast inland. The figure shows that there is some reduction of groundwater discharging to the coast, as some flow is intersected by the mine pits, however the flow of groundwater to the ocean is maintained (never ceases) and is far greater than a brief period of reverse flow that is predicted to occur at maximum excavation depth, as discussed below.

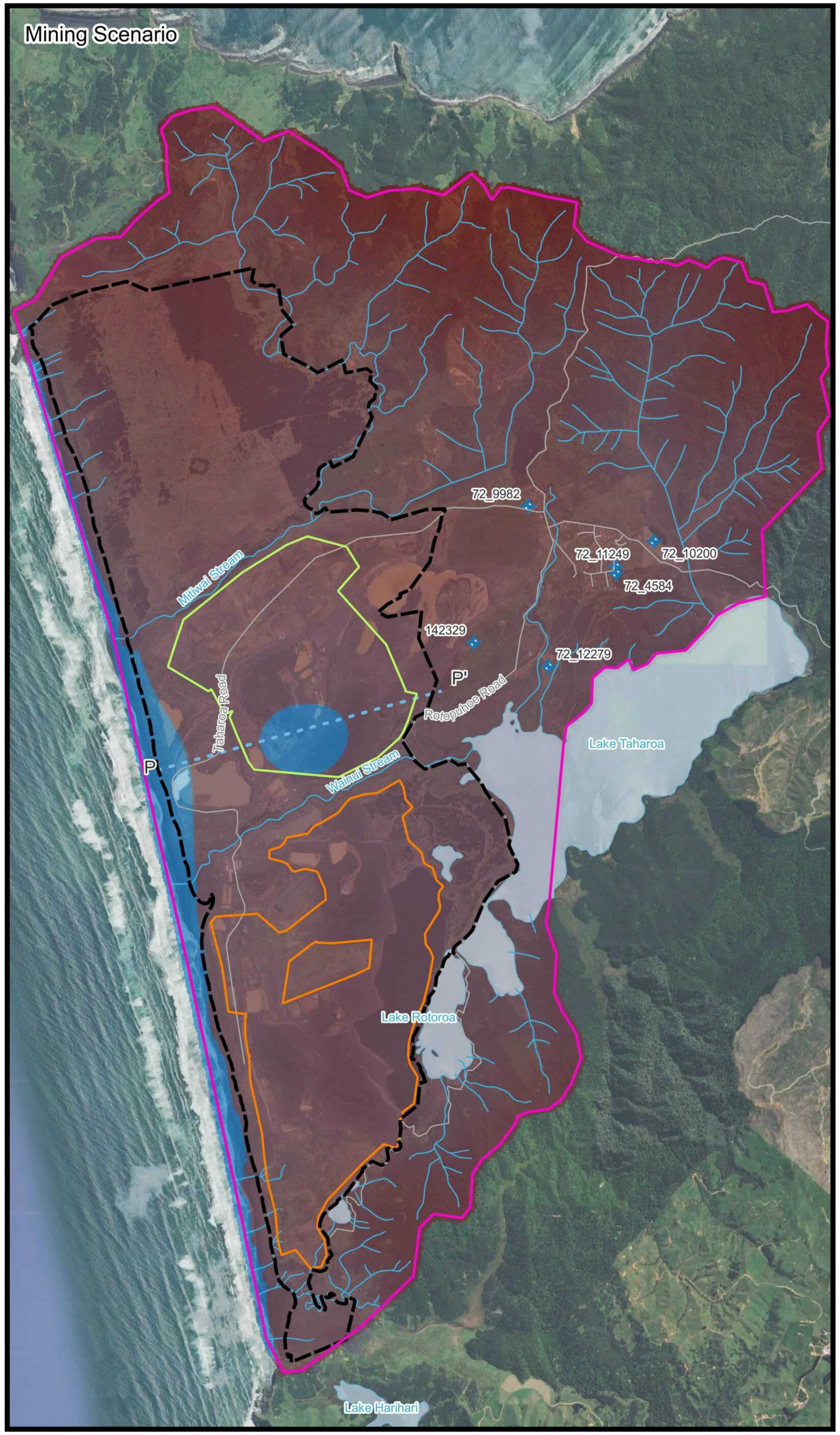
**Table 14** provides a comparison of the daily water balance at maximum excavation depth, which is considered to be one year into the excavation of the Southern Block occurring in March 2036. As alluded to above, in practice, saline intrusion is a gradual osmotic phenomenon in porous media where matric flow predominates, and would only occur if the gradient reversal occurred over a prolonged time period.

The water balance shows during this time of maximum pit depth that seepage of water from the ocean landward increases by 24 $m^3$/day in the shallow aquifer and is unchanged in the deep aquifer, amounting to an extremely small proportion of the water balance at 0.08%.

The discharge of groundwater to the coast has a more significant reduction at approximately 2,000 $m^3$/day in the shallow aquifer and 6 $m^3$/day in the deep aquifer, which is approximately or 12% of the water balance.

It should also be noted that no water users or infrastructure, other than the mine itself, are within the area where any potential saline intrusion is predicted.

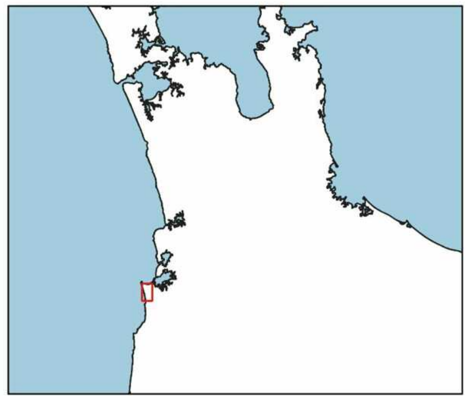



Map Title:
**Potential saline intrusion in Central block**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Known bores (Outside Taharoa Mine)
- Road
- Streams
- Lakes
- Study Area
- TIL Property Boundary
- Central mine block
- Southern mine block
- Predicted salinity intrusion
- Cross section

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
22/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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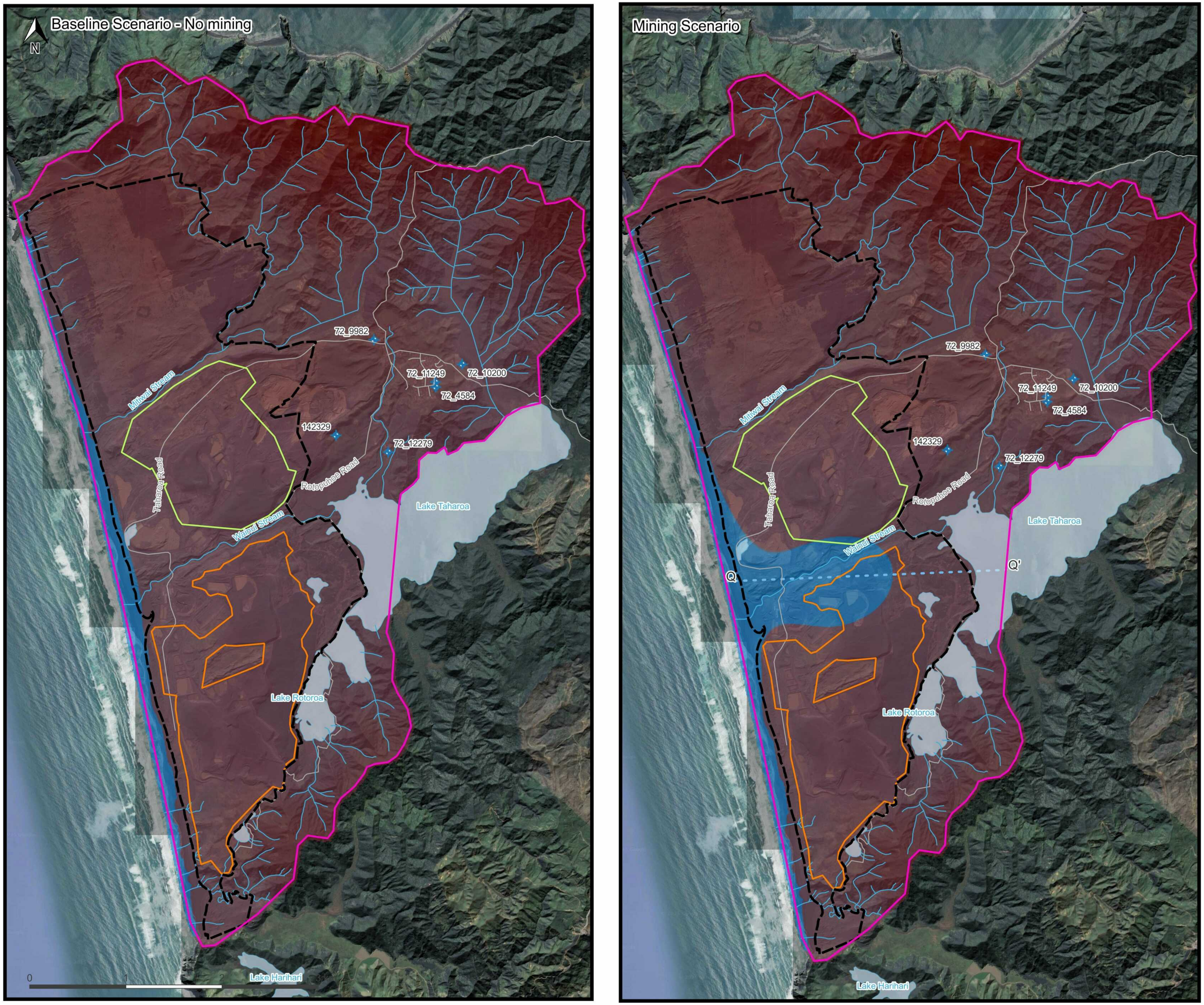
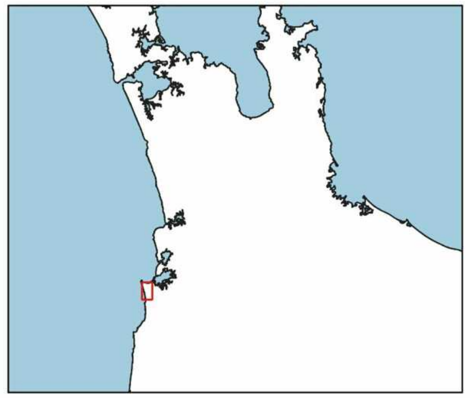
Figure 22




Map Title:
**Potential saline intrusion in Southern block**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Known bores (Outside Taharoa Mine)
- Road
- Streams
- Lakes
- Study Area
- TIL Property Boundary
- Central mine block
- Southern mine block
- Predicted salinity intrusion
- Cross section

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
22/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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Figure 23

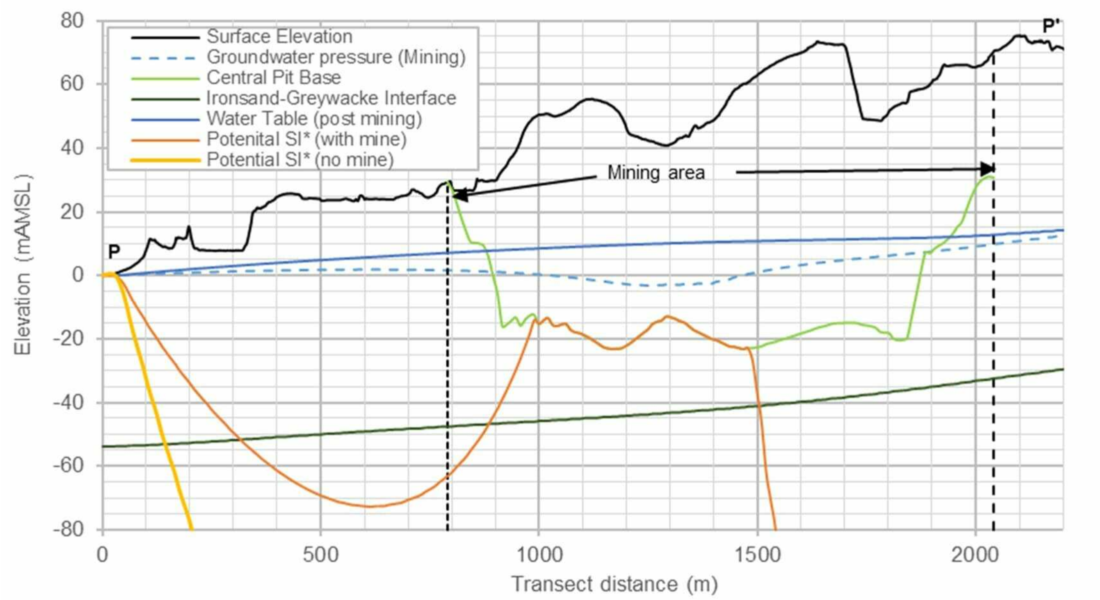


Figure 24. Probable salinity intrusion in Central pit along Transect P-P' (refer Figure 22).
*SI: Saline Interface.

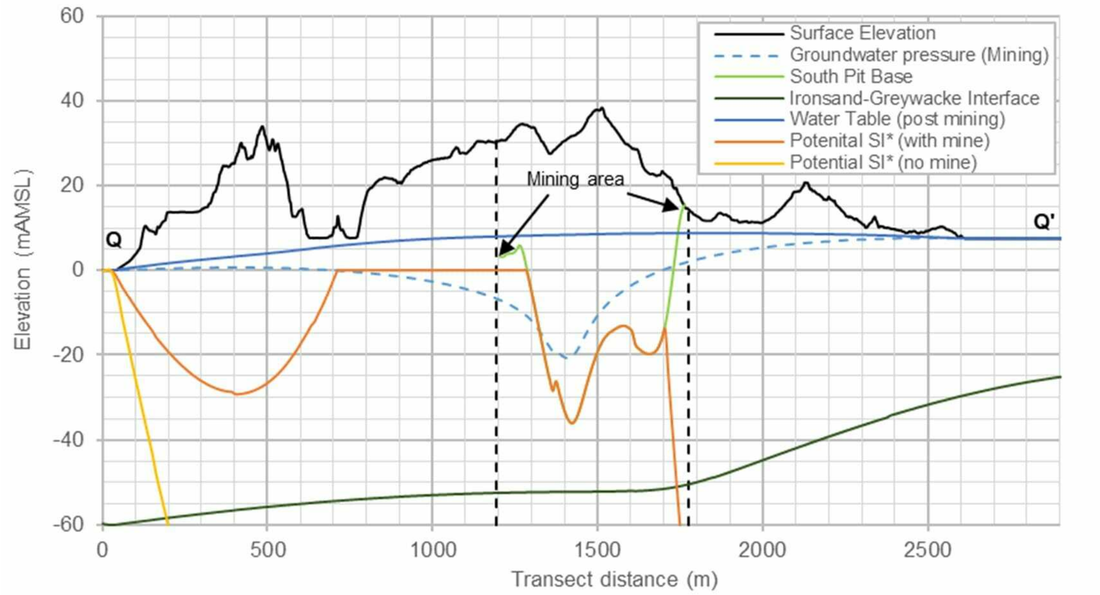


Figure 25. Probable salinity intrusion in Southern Pit along Transect Q-Q' (refer Figure 23).
*SI: Saline Interface.

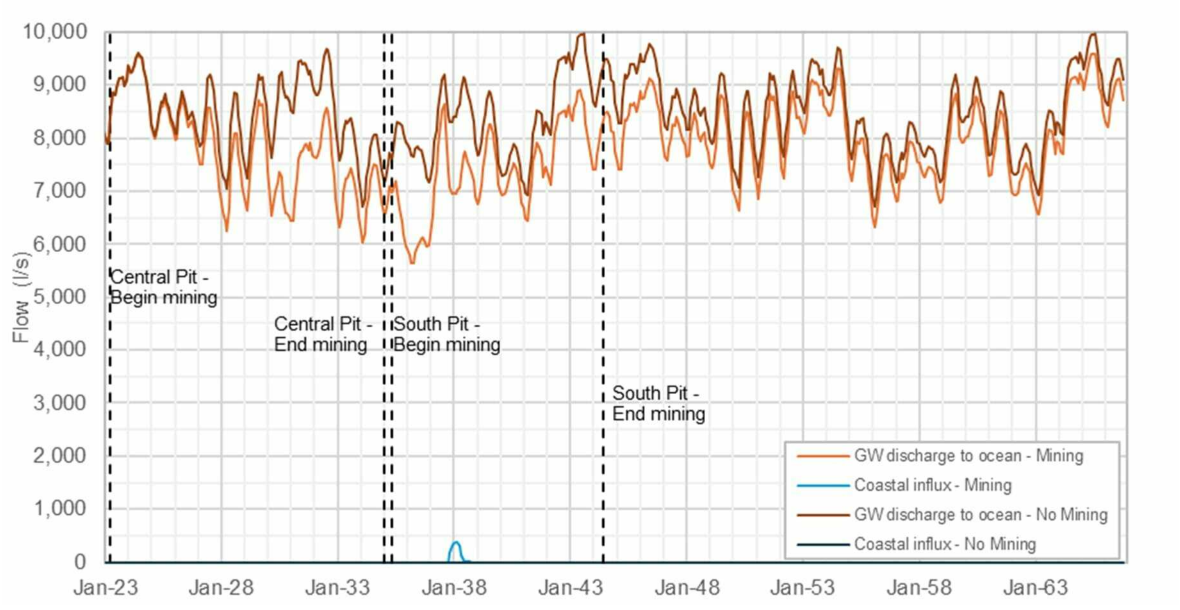


Figure 26. Simulated flow between shallow aquifer and ocean for Mining and Baseline scenarios.

Table 14. Water balance at time of peak excavation.

| Mass balance | Components | Baseline Model | | Mining Scenario | |
|---|---|---|---|---|---|
| | | Flow ($m^3/d$) | Percentage of Flow (%) | Flow ($m^3/d$) | Percentage of Flow (%) |
| Inflow | Recharge | 21,740 | 86.71% | 21,740 | 71.40% |
| | Flow from lakes into aquifer | 84 | 0.33% | 316 | 1.04% |
| | Storage | 3,247 | 12.95% | 8,365 | 27.47% |
| | Flow from ocean into shallow aquifer (Layer 1) | 2 | 0.01% | 26 | 0.09% |
| | Flow from ocean into deep aquifer (Layer 2) | 0 | 0.00% | 0 | 0.00% |
| | **Total inflow** | 25,072 | | 30,447 | |
| Outflow | Streams (groundwater baseflow) | 14722 | 58.71% | 12101 | 39.75% |
| | Flow aquifer into lakes | 2313 | 9.23% | 1575 | 5.17% |
| | Shallow aquifer (Layer 1) discharge into ocean | 7822 | 31.20% | 5869 | 19.28% |
| | Flow from deep aquifer into ocean (Layer 2) | 202 | 0.80% | 196 | 0.64% |
| | Flow into mine pits | | | 9850 | 32.35% |
| | Storage | 15 | 0.06% | 855 | 2.81% |
| | **Total outflow** | 25,074 | | 30,446 | |
| Percentage discrepancy | | -0.01% | | -0.00% | |

## 6.5 Effect of post-mining Groundwater Conditions

The TIGM was developed with the assumption that at the end of the life of the mine, as a result of rehabilitation required by the proposed consent conditions, the land would be restored to approximate a smoothed impression of the original topography, with the exception of a lake remaining in the final excavation area. It is also assumed that since the ELF will be composed of the tailing of the native material, which is primarily loose sand and silt, the conductivity of the material will return to its original state. It is evident in **Section 6.2** that both the Mitiwai and Wainui Stream baseflows will return to baseline conditions within 1.5 and 2 years after the end of mining, respectively.

Given that the baseflow is a signal of groundwater elevation, it follows that the same timeframes are indicative of the length of time that will be required for groundwater levels to be restored to a pre-mining condition. This is verified by model results that show the groundwater levels at the end of the Mining scenario equal to those in the Baseline scenario. Cross-section examples across the Central and Southern pits are provided in **Figure 27** and **Figure 28**, respectively.

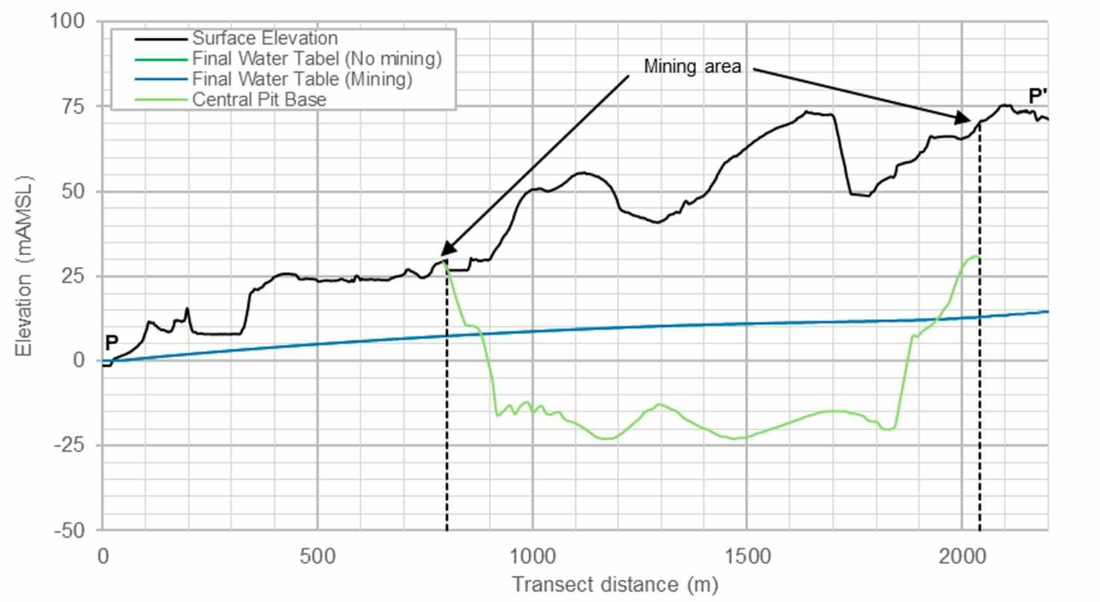


Figure 27. Groundwater elevation across Transect P-P' (refer Figure 22) from Baseline Model and Post-Mining Model.

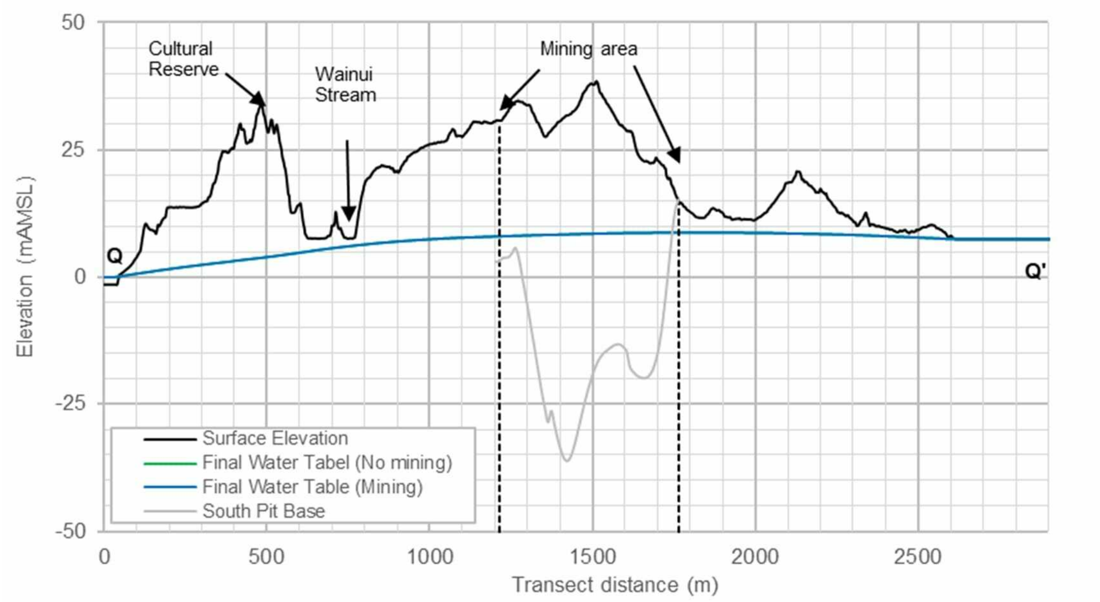


Figure 28. Groundwater elevation across Transect Q-Q' (refer Figure 23) from Baseline Model and Post-Mining Model.

# 7. Mine Dewatering Analysis

The expected discharge of groundwater into the mine pit, along with the minimum level of the excavation is shown in **Figure 29**, which shows the peak flow occurs during the deepest period of mining. The following observations are made on mine dewatering analysis.

- Maximum flow is expected in Central Pit 3, and Southern Pit 1 & 2, as these two pits locations are where the deepest excavations occur.
- As shown in **Figure 29** the maximum flow into the Central Pit is predicted to be of 83 L/s, and occur eight years into the excavation process (May 2031 in terms of the timeline used in the model). The maximum flow into the Southern Pit is predicted to be of 132 L/s, one year after the excavation of the Southern Pit begins (January 2036 in terms of the model timeline).
- There are several other occasions where the pit drainage reaches temporary peaks when a new stage of the pit intersects the water table.
- The majority of the excavation of the Southern pits are relatively shallow and does not intersect the water table, and hence little or no flow is predicted in these areas.

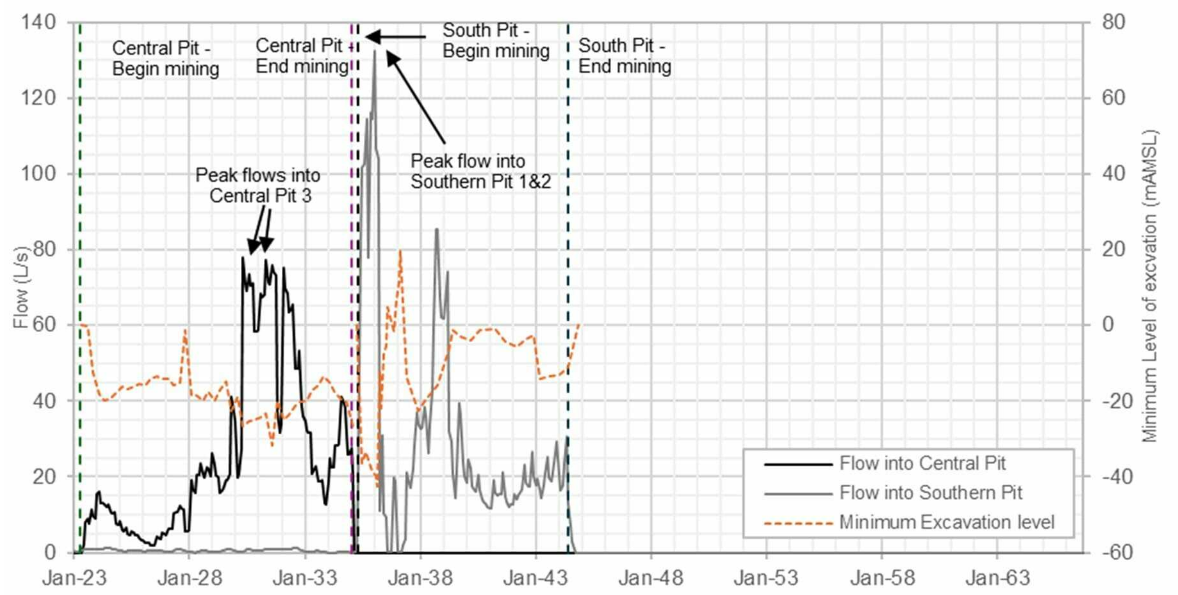


Figure 29. Predicted groundwater flow into the mine pit and excavation level.

# 8. Conclusions

WWLA has completed an AEE in support of the consent application for the proposed excavation of the Central Pit and Southern Pit of the TIL mine.

This analysis was done through the development and application of a numerical model, the details of which are provided in a separate technical report.

With consideration for all mitigation and compensation packages that are included as part of this application all effects of the proposed mine excavations were found to be less than minor. Specifically:

- No bore will be affected by drawdown to a degree that jeopardizes normal operation of the bore based on current practices.
- Monitoring and trigger levels are proposed for the Mitiwai Stream, with flow augmentation recommended if stream flow falls below the minimum flow requirement.
- Flow management protocols are recommended for the Wainui Stream that amount to a continuation of current practices wherein a minimum flow of 34 L/s is maintained below the weir and fish passage.
- Wetlands that are directly in the mining area are being addressed via a compensation package.
- There are 25 wetlands within the area that may be affected by groundwater drawdown. All of these wetlands are primarily surface water fed, although some may have connection to groundwater under high flow conditions. Monitoring is recommended for the wetlands that are considered to be potentially the most vulnerable; specifically Wetland #42 which already has a monitoring site, and Wetland #72 and Wetland #80, for which new monitoring sites are recommended.
- An analysis of potential saline intrusion confirms that a net discharge of groundwater flow into the ocean will be sustained trough the mining process. If there is any a reverse flow (i.e. inland flow seawater), it will be of short duration and limited extent, only affecting a portion of the excavation area.
- After the completion of mining and landscape restoration, groundwater and streamflow will return to the pre-mining conditions.

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Williamson Water & Land Advisory (WWLA), 2025b. Taharoa Ironsand Slug Testing Summary and Analysis. Consultancy report prepared for Taharoa Ironsands Limited

# Appendix A. Groundwater Model Development and Calibration – Technical Report

# Taharoa Ironsand

# Groundwater Model Development

TAHAROA IRONSAND LIMITED

WWLA1303 | Rev. 2

09 September 2025

# Groundwater Model Development

| | |
|---|---|
| Project no: | WWLA1303 |
| Revision: | 2 |
| Date: | 09 September 2025 |
| Client name: | Taharoa Ironsand Limited |
| Project manager: | Jon Williamson |
| Author(s): | Jake Scherberg and Asanka Thilakerathne |
| File name: | G:\Shared drives\Projects\Taharoa Ironsands Limited\WWLA1303_Taharoa Hydrogeological Modelling\Deliverables\Reports\Groundwater Model\WWLA Rep_Taharoa Ironsand_Groundwater Model_(AEE_Appendix)_Final 090925.docx |

Williamson Water & Land Advisory

Auckland | Whangārei | Tauranga
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## Document history and status

| Rev | Date | Description | By | Review | Approved |
|---|---|---|---|---|---|
| 1 | 11 July 2025 | Draft for client review | Asanka Thilakerathne | Jake Scherberg | Jake Scherberg |
| 2 | 8 August 2025 | Updated to address Enviser & T&T review comments | Asanka Thilakerathne | Jake Scherberg | Jake Scherberg |
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## Distribution of copies

| Rev | Date issued | Issued to | Comments |
|---|---|---|---|
| 1 | 11 July 2025 | TIL and Project Team | For Project Team review. |
| 2 | 8 August 2025 | TIL and Project Team | For Project Team review. |
| 3 | 9 September 2025 | TIL and Project Team | Final copy. |
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| | | | |

# Executive Summary

| | |
|---|---|
| **Project Overview and Objectives** | Williamson Water & Land Advisory (WWLA) was commissioned by Taharoa Ironsand Limited (TIL) to develop a 3D numerical groundwater model to simulate groundwater levels and fluxes in the area surrounding the open pit sand mine operated by TIL at Taharoa and surrounding catchments.<br>This report is provided as a companion to the Assessment of Environmental Effects (AEE) to provide technical documentation of the conceptualisation, development, and calibration of the Taharoa Ironsands Groundwater Model (TIGM) used to undertake the groundwater effects analysis and is provided in supplement to the AEE.<br>The purpose of the model is to facilitate the AEE analysis pertaining to groundwater, as required to obtain all necessary consents to continue mining activities across the Central and Southern Blocks. The groundwater effects assessment quantifies the effects of the proposed mine activities on the local groundwater system and connected water bodies, and comprised the following assessments:<br>a) Evaluation of the depth and extent of drawdown resulting from pit excavations;<br>b) Assessment of neighbouring bore interference effects;<br>c) Assessment of the potential streamflow depletion resulting from mine pit dewatering;<br>d) Assessment of potential impacts wetlands within and adjacent to the proposed mining area;<br>e) Estimation of groundwater seepage into excavation areas (i.e. pit dewatering); and<br>f) Long term changes in the hydrogeological regime following mining and land reclamation. |
| **Background Information** | A conceptual model was developed based on the current understanding of the groundwater system using data provided by TIL, findings from installation and hydraulic testing of 18 newly installed monitoring piezometers (WWLA, 2025), and literature review (Pain, 1976; Edbrooke, 2005).<br>The model area is divided into two main lithological units:<br>1. Interbedded sand deposits - which comprise the iron sand resource occurring through the excavation area adjacent to the coast, occurring above the “Resource Basement”.<br>2. Greywacke – which underlies the sand layers and represents the lower permeability basement layer in the groundwater model. Greywacke forms the rugged hills to the east (inland) of the mine, as well as outcropping along the coast to the north of the mine.<br>The characteristics of these layers that influence groundwater flow patterns through the study area are:<br>• The ironsand unit dips towards the ocean and basin like, with the overall thickness being variable as governed by the basement rock topography; tending to be greater in the middle of the unit and thinning toward the north and south.<br>• Groundwater recharge occurs through the percolation of rainfall through the soil profile. Recharge in the greywacke region is considerably lower than in the ironsand area on account of lower permeability, and steeper slopes, which promote surface runoff over groundwater recharge.<br>• Groundwater broadly flows towards the ocean, with localised convergence into the Mitiwai and Wainui Streams.<br>Cross sections across the study area are shown in the main body of this report to illustrate the conceptual hydrogeological model of the area. |
| **Numerical Modelling Methods** | Based on this conceptual hydrogeologic model, a two-layer numerical model was developed in AquaVeo’s Groundwater Modelling System (GMS) using the MODFLOW Unstructured Grid (MODFLOW-USG) code, developed by the United States Geological Survey (USGS). The model comprises two vertical layers with lateral boundary defined by catchment boundaries.<br>Two versions of the model were developed – a steady state model for model calibration, and a transient model for the predictive simulation and effects assessment.<br>The model was developed with a base grid spacing of 40 m applied to cells through the mine area, with enhanced resolution 5 m cells aligned with major streams, and 20 m spacing in mountainous areas to appropriately simulate the steeper hydraulic gradients developed by topographical variations.<br>The model layers were developed to represent the two distinct hydrogeological environments that occur in the model area; specifically the sand-silt-clay sequences of the Te Ake Ake Sands and Upper Tauranga Group and the low permeability greywacke that comprises the basement and the mountainous areas east of the TIL property. |

The top elevation of the model cells were determined from 1 m resolution LiDAR data and the interface between the two model layers was informed by drilling results from the piezometers installed by WWLA and previous mining reports (Geotechnics (2014); GWS (2011)), along with some hydrogeological judgement where necessary to ensure compatibility with the TIL mine plan.

Geologic materials within the TIL property area are represented as follows:

- Layer 1 represents the ironsand resource within which the proposed mining will occur; and
- Layer 2 represents the undisturbed greywacke basement.

Based on this interpretation, the interface between the layers broadly corresponds to the base of the Te Ake Ake sand (Resource layer). Outside of the TIL property, the upper layer of the model represents greywacke and is therefore of lower permeability and assigned parameters accordingly. Along the coastal boundary where the surface is at the sea level, the model thickness is 200 m and at the highest point in the model the total thickness of material (layers one and two) is 498 m.

Groundwater recharge was determined by using the Soil Moisture Water Balance Model (SMWBM) to determine daily recharge rates based on rainfall and evaporation data and parameters representing the physical conditions of the soils within the catchments. The SMWBM was calibrated to measured stream flow data. Appropriate boundary conditions were developed and assigned to the model to represent:

- Streams;
- Lake Taharoa;
- The coastline; and
- Mining areas

The simplified modelling approach reduces the parameterisation requirements and the computational complexity, while allowing the fundamental characteristics of the geologic materials and the key hydrological features to be represented in the model.

**Summary of Results**

The model was calibrated using a combination of zonal and pilot point methods to generate a simulated water table that best matched the measured water levels in the monitoring piezometers. The calibrated hydraulic parameters are shown in **Table E1**.

**Table E1. Hydraulic parameters used in groundwater model.**

| Model Layer | Calibration Zone | Calibration method | Calibrated Horizontal k (m/day) [m/sec] |
|---|---|---|---|
| 1 | Ironsand | Pilot points | 0.00864 – 4.32 m/day [$1x10^{-7}$ – $5.0x10^{-6}$ m/s] |
| | Greywacke outcrop | Zonal | 0.00864 m/day [$1.0x10^{-7}$ m/s] |
| | Mitiwai stream buffer | Zonal | 0.0864 m/day [$1.0x10^{-6}$ m/s] |
| 2 | Greywacke | Zonal | 0.00432 m/day [$5.0x10^{-8}$ m/s] |
| | Mitiwai and Wainui stream buffer | Zonal | 0.432 m/day [$5.0x10^{-6}$ m/s] |

The root mean square error (RMSE), a standard metric for evaluating numerical modelling results, was calculated from the difference been mean water level at the 18 monitoring piezometers and steady-state model results at the corresponding locations. The RMSE for this model was 2.7 m, which is 4.1% of the measured range in groundwater levels across the model domain. An RMS error less than 10% is typically considered acceptable for a catchment scale groundwater model, indicating the TIGM is suitable for this application.

Parameters from the Steady-State model were transferred into a transient simulation setup to allow simulation of a range of hydrological conditions that included both wet and dry time periods and the full mine excavation process as indicated in the mine plan.

| | |
|---|---|
| **Key Conclusions** | The mining sequence of across Central and Southern pits was applied to the calibrated model along with a time series derived from historic climate conditions. The potential effects that may occur from mining were determined by comparing simulated groundwater conditions to a Baseline version of the model in which no mining was simulated, using the same climate and groundwater recharge conditions.<br>In summary, the numerical model presented here is suitable for the groundwater effects investigations detailed in this report and can be readily applied for further inquiries when needed. An Assessment of Effects informed by this modelling has been completed and comprises the primary component of this report with this Appendix providing documentation of the methodologies used in for technical analysis. |

## Contents

# 1. Introduction

Williamson Water & Land Advisory (WWLA) was commissioned by Taharoa Ironsand Limited (TIL) in January 2025 to develop a numerical groundwater model to simulate groundwater fluxes in the area surrounding the open pit sand mine operated by TIL at Taharoa.

The Taharoa Ironsand mine is situated along the west coast of the North Island, approximately 88 km southwest of Hamilton, within the Waikato Region **Figure 1**. This report comprises technical documentation of the development and calibration of the Taharoa Ironsands Groundwater Model (TIGM) used to undertake the groundwater effects analysis and is provided in supplement to the Assessment of Environmental Effects (AEE).

## 1.1 Objective and Scope

The purpose of the model is to facilitate an Assessment of Environmental Effects (AEE) pertaining to groundwater, as required to obtain all necessary consents to continue mining activities across the Central and Southern Blocks. The groundwater effects assessment quantifies the effects of the proposed mine activities on the local groundwater system and connected water bodies, and comprised the following assessments:

a) Evaluation of the depth and extent of drawdown resulting from pit excavations;

b) Assessment of neighbouring bore interference effects;

c) Assessment of the potential streamflow depletion resulting from mine pit dewatering;

d) Assessment of potential impacts wetlands within and adjacent to the proposed mining area;

e) Estimation of the rate and volume of groundwater seepage into excavation areas (i.e. pit dewatering);

f) Long term changes in the hydrogeological regime following mining and land reclamation;

A 3D numerical groundwater model was developed to facilitate these assessments. This report provides technical documentation of the model's conceptualisation, development, calibration and predictive simulation, and is being provided to support the AEE that comprises the primary component of this document.

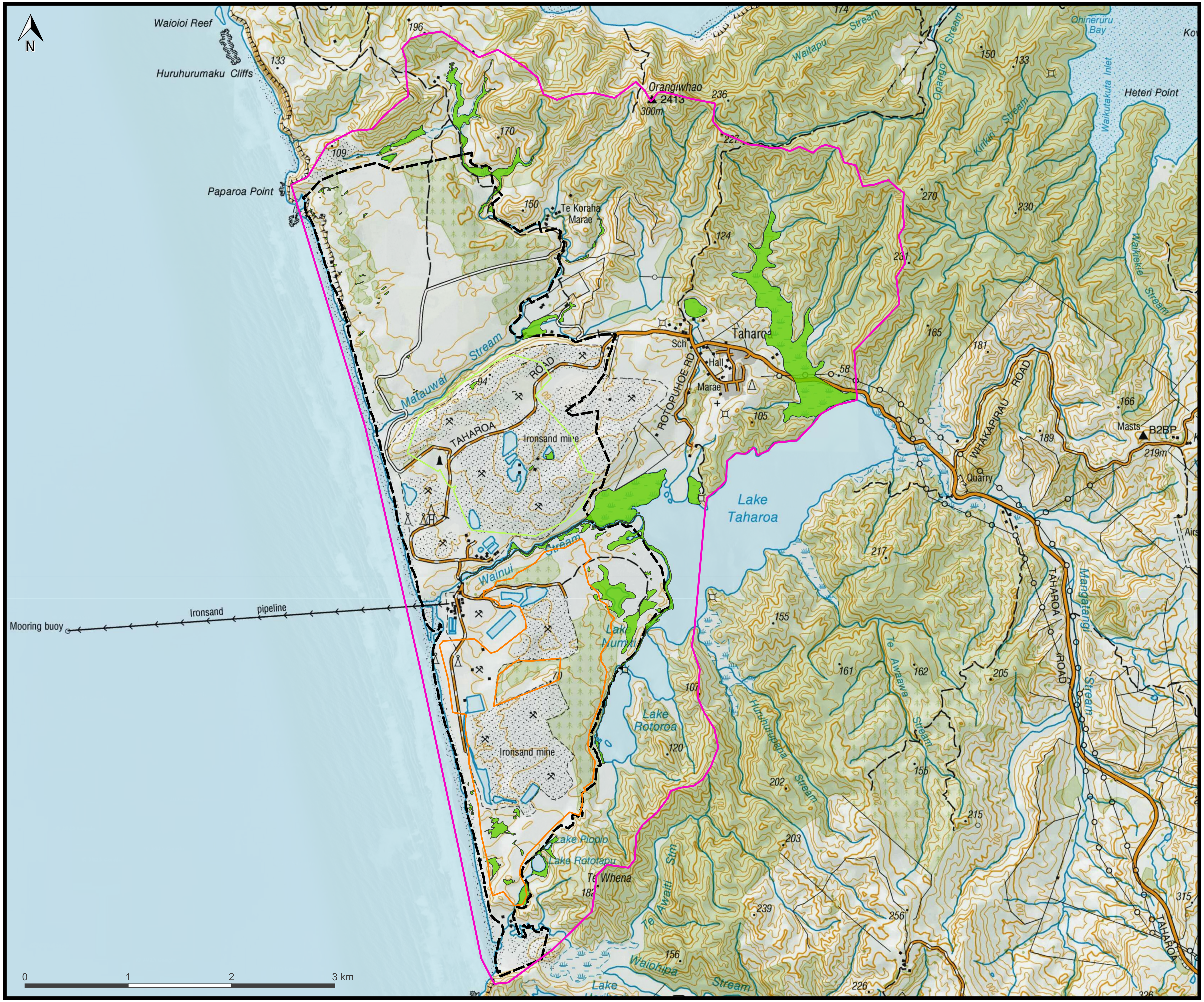
## 1.2 Project Overview

The mining area consists of Northern, Eastern, Central and Southern Blocks, all within the Taharoa C boundary shown in **Figure 1**. To date, mining has been undertaken in Central and Southern Blocks only. The current proposal aims to continue to mine in the Central and Southern Blocks, and includes mining above and below the water table. We understand the mine plan for the Northern Block is still being finalised and is not part of this report.

## 1.3 Report Structure

The report comprises descriptions of:

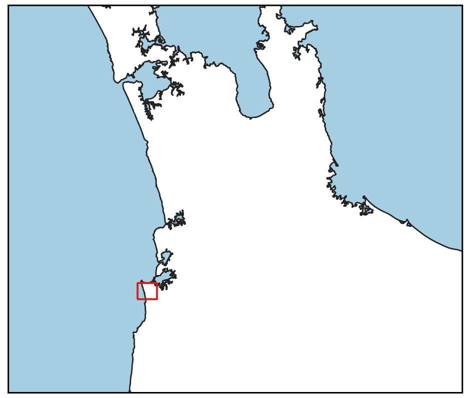
- The Conceptual Hydrogeological Model (**Section 2**);
- Numerical Groundwater Model Development (**Section 3**);
- Numerical Groundwater Model Calibration (**Section 4**); and
- Conclusion (**Section 5**).




Map Title:
**Taharoa Mine Locality Map**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Study area
- TIL Property Boundary
- Wetlands
- Central mine block outline
- Southern mine block outline

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
07/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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**Figure 1**

# 2. Conceptual Hydrogeological Model

A conceptual model was developed based on the current understanding of the groundwater system based on data provided by TIL, findings from installation and hydraulic testing of 18 monitoring piezometers (WWLA, 2025), and literature review (Pain, 1976; Edbrooke, 2005). A summary of description of major inputs into the model is provided below:

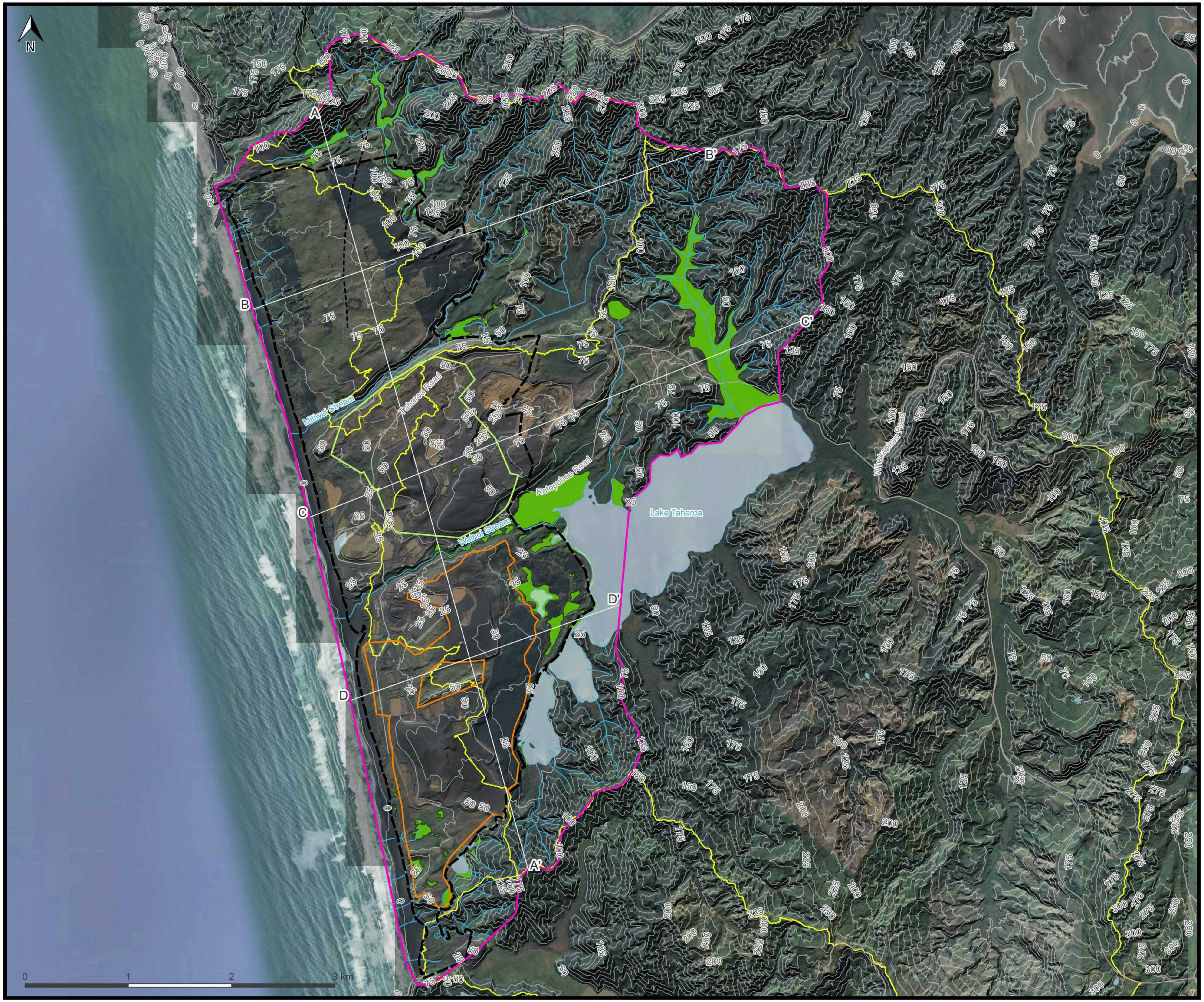
- The model area is divided into two main lithological units:

  1. ***Interbedded sand deposits*** - which comprise the iron sand resource occurring through the excavation area adjacent to the coast, occurring above the "Resource Basement". This material has variable permeability with areas of higher permeability unconsolidated dune sands and areas where moderately low permeability materials such as peat and compacted iron pans predominate.

  2. ***Greywacke*** – which underlies the sand layers and represents the lower permeability basement layer in the groundwater model. Greywacke forms the rugged hills to the east (inland) of the mine, as well as outcropping along the coast to the north of the mine.

- The ironsand unit dips towards the ocean, with the overall thickness being variable, and tending to be greater in the middle of the unit and thinning toward the north and south.
- Groundwater recharge within the model area occurs through the percolation of rainfall through the soil profile. Recharge in the greywacke region is considerably lower than in the ironsand area on account of lower permeability, and steeper slope, which promote surface runoff over groundwater recharge.
- Groundwater broadly flows towards the ocean, with localised convergence into the Mitiwai and Wainui Streams.

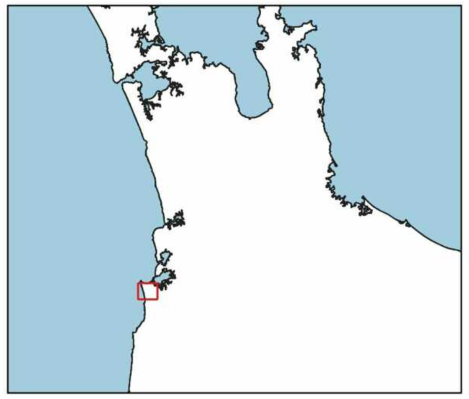
Based on this conceptual hydrogeologic model, a two-layer numerical model was developed as described in the following section. **Figure 2** shows the cross section map and respective cross sections were shown in **Figure 3** to **Figure 6**, to elaborate the conceptual hydrogeological model of the area.




Map Title:
**Major hydrogeological features and transects**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Road
- Cross sections
- Surface contours
- Faults
- Streams
- Study Area
- Lakes
- Wetlands
- Catchments
- Central mine block outline
- Southern mine block outline
- TIL Property Boundary

Data Provenance
GIS Layers

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07/08/2025

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Taharoa Iron Sand Mine-Hydrogeological Modelling

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Figure 2

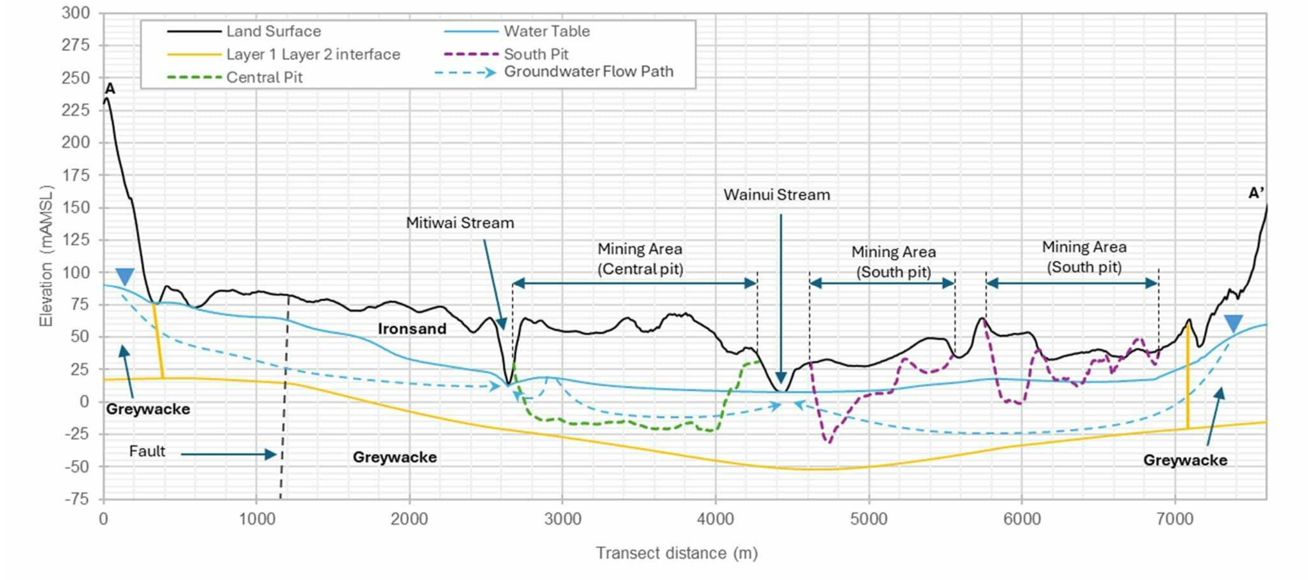



Figure 3. Conceptual groundwater flow pattern across Transect A-A'

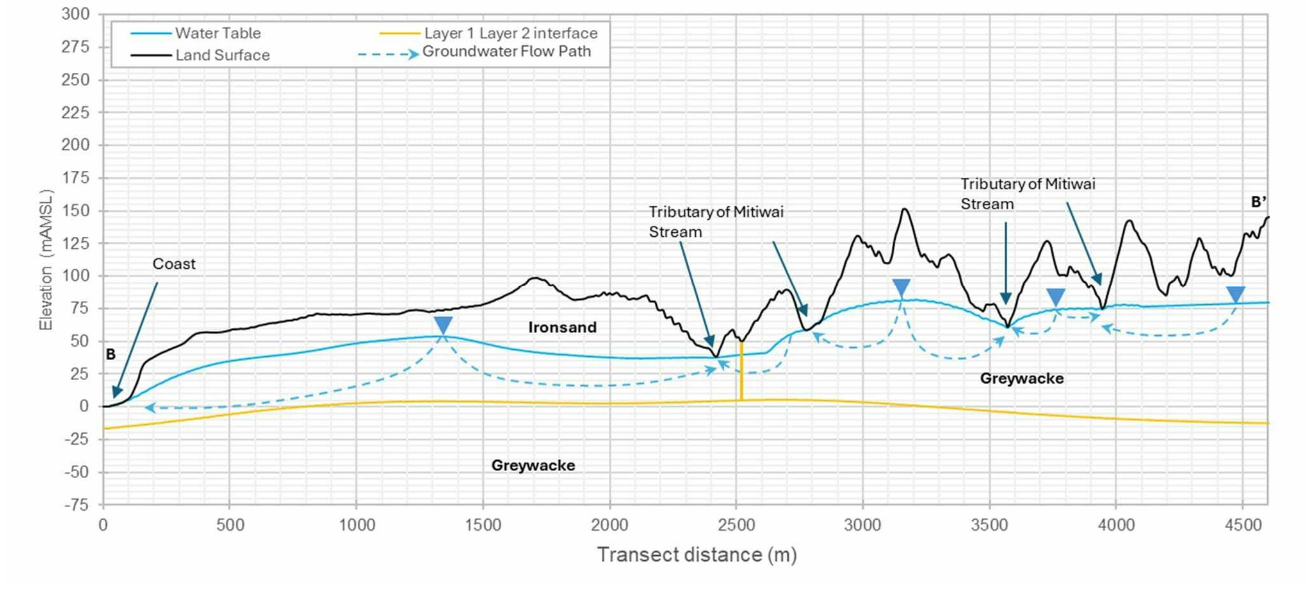



Figure 4. Conceptual groundwater flow pattern across Transect B-B'.

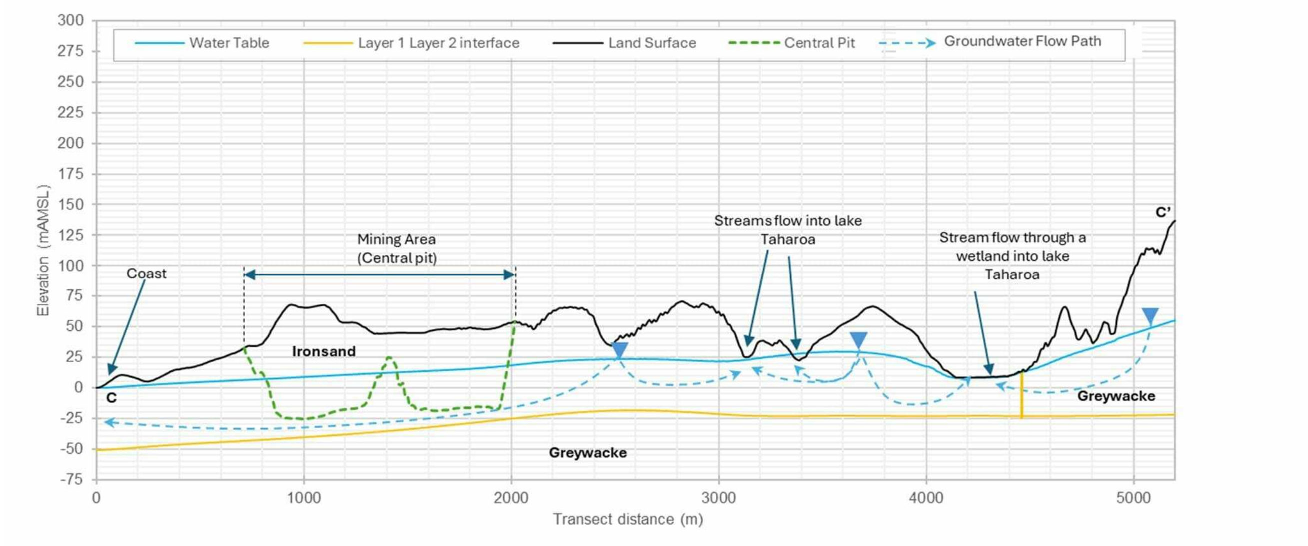



Figure 5. Conceptual groundwater flow pattern across Transect C-C'.

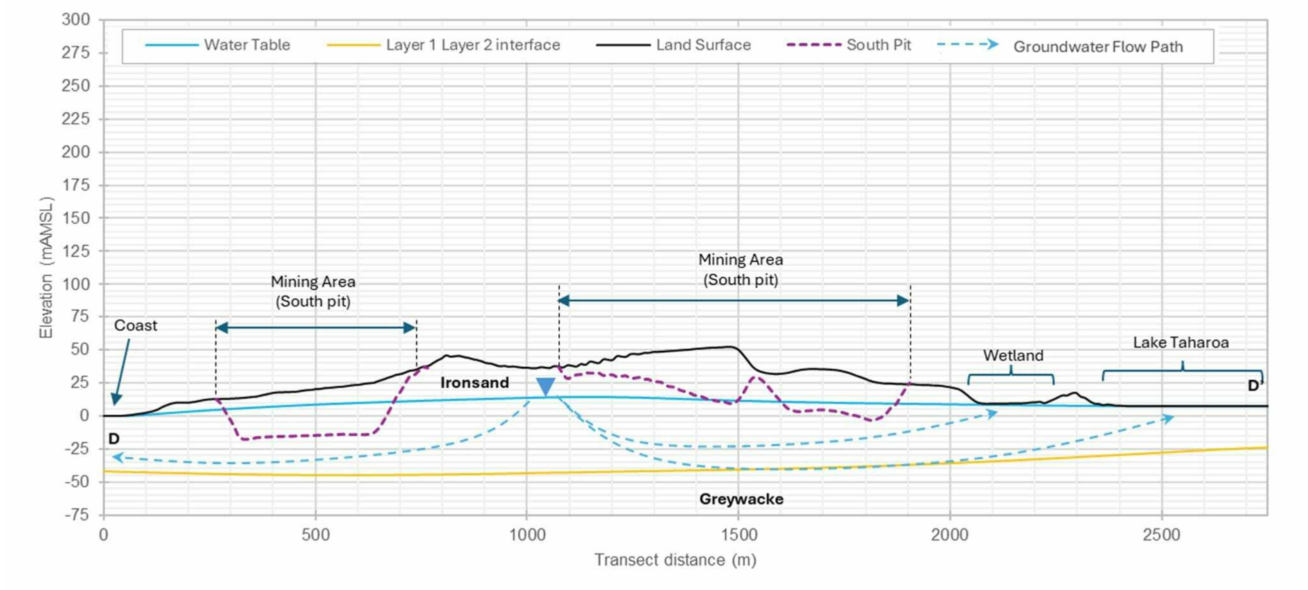



Figure 6. Conceptual groundwater flow pattern across Transect D-D'.

# 3. Numerical Model Development

The model has been developed in AquaVeo's Groundwater Modelling System (GMS) using the MODFLOW Unstructured Grid (MODFLOW-USG) code, developed by the United States Geological Survey (USGS). The model comprises two vertical layers with lateral boundary defined by catchment boundaries.

## 3.1 Modelling Methodology

Two versions of the model were developed – a steady state model for model calibration, and a transient model for the predictive simulation and effects assessment. The following sections describe the development of the model grid, boundary conditions assigned to represent the features within the model area that interact with groundwater, and hydraulic parameters used to assign the hydrogeologic materials being represented by the numerical model.

## 3.2 Grid Layout

### 3.2.1 Horizontal Discretisation

The model was developed with a base grid spacing of 40 m applied to cells through the mine area, with enhanced resolution 5 m cells aligned with major streams, as shown in **Figure 7**. Cell grids of 20 m were assigned in mountainous areas in the eastern portion of the model area to appropriately simulate the steeper hydraulic gradients developed by topographical variations in this area. The spatial variation in grid size allows for high resolution in potentially sensitive areas, while larger grid cells allow more efficient model run times yet still provide information to assess groundwater conditions at a larger scale.

As indicated above, the boundary of the model coincides with surface catchment divides, where were derived using the QGIS watershed analysis function and manual adjustment, particularly along the southern boundary of the model and through Lake Taharoa.

### 3.2.2 Vertical Discretisation

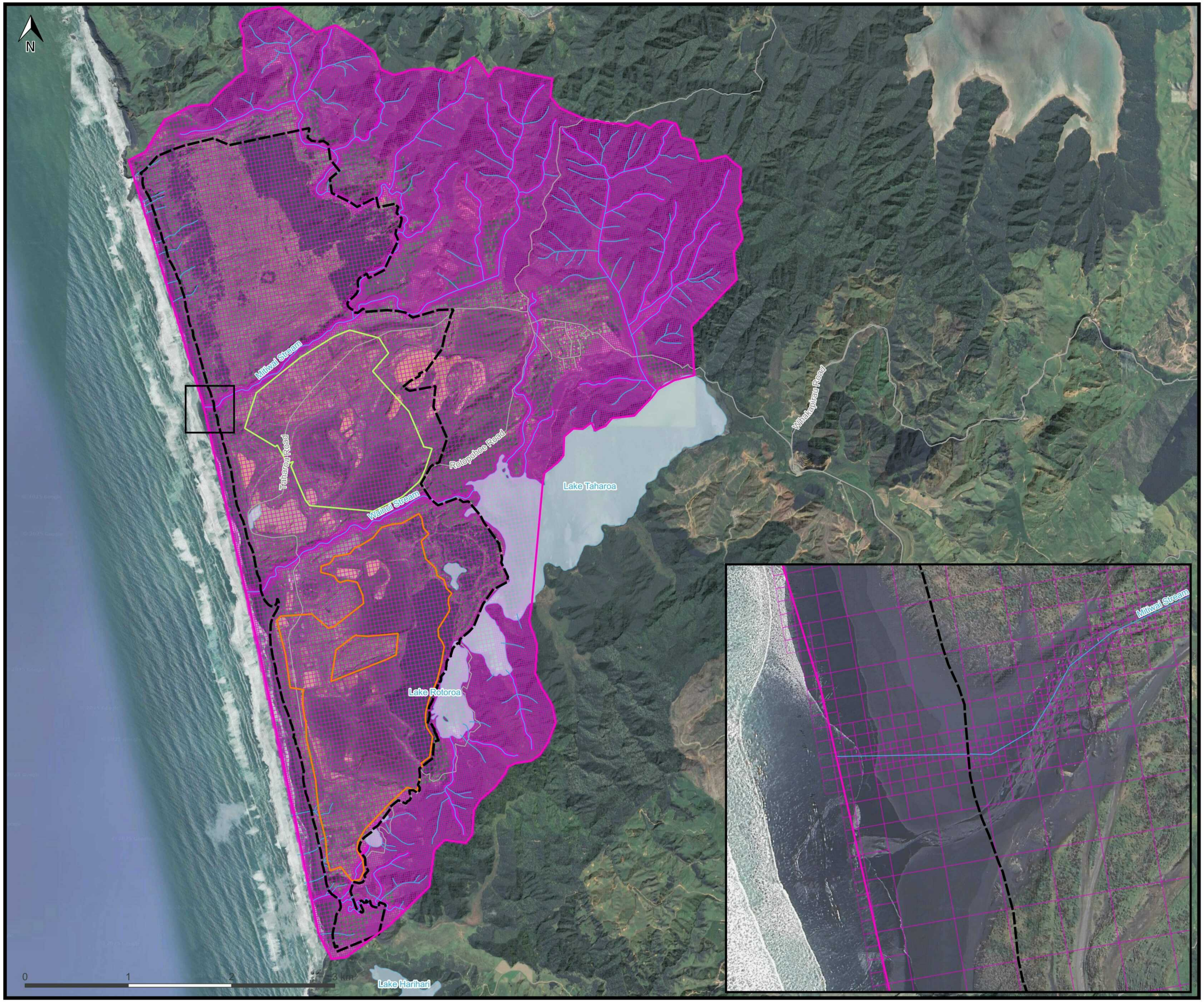
The two-layer model was developed to represent the two distinct hydrogeological environments that occur in the model area; specifically the sand-silt-clay sequences of the Te Ake Ake Sands and Upper Tauranga Group and the low permeability greywacke that comprises the basement and the mountainous areas east of the TIL property.

The top elevation of the model cells were determined from 1 m resolution LiDAR data for the Waikato region. The interface between the two model layers was partially informed by drilling results from the piezometers installed by WWLA and previous mining reports (Geotechnics (2014); GWS (2011)), along with some hydrogeological judgement where necessary to ensure compatibility with the TIL mine plan.

Within the TIL property area, Layer 1 represents the ironsand resource within which the proposed mining will occur and Layer 2 represents the undisturbed greywacke basement. Based on this interpretation, the interface between the layers corresponds to the base of the Te Ake Ake sand (Resource layer). Outside of the TIL property, the upper layer of the model represents greywacke and is therefore of lower permeability and assigned parameters accordingly.

As mentioned above, the lower layer of the model represents undisturbed low-permeability material. The base was set to an elevation of -200 m mAMSL, to assure that the lower boundary was well below the potential effects of excavation and dewatering. Hence, along the coastal boundary where the surface is at the sea level, the model thickness is 200 m and at the highest point in the model the total thickness of material (layers one and two) is 498 m.

The base of the ironsand unit dips towards the ocean, with variable thickness that tends to be greater toward the centre of the model areas and thinner to toward the north and south, reflecting the documented information as it pertains to the regional hydrogeological environment. The simplified modelling approach reduces the parameterisation requirements and the computation complexity while allowing the fundamental characteristics of the geologic materials and the key hydrological features to be represented in the model.




Map Title:
**Groundwater model grid**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**

**Legend**
- Road
- Streams
- Lakes
- Study Area
- Model grid
- TIL Property Boundary
- Central mine block outline
- Southern mine block outline

Data Provenance
GIS Layers

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07/08/2025

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Taharoa Iron Sand Mine-Hydrogeological Modelling

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Figure 7

## 3.3 Boundary Conditions

### 3.3.1 Streams

Drain boundary conditions were applied to all stream channels shown within the model area as shown in Figure 7. Stream bed elevations were set by assigning the lowest elevation from the LiDAR coverage within each model grid cell that was intersected by a stream (i.e. a stream cell). This assured that the drain within a stream cell would be active (i.e. groundwater discharge would be simulated) whenever the water table reached the low point within the cell boundary. Stream conductance was set to a high value so that the only restriction on the interaction between the stream to the underlying groundwater system was driven by the hydraulic gradient between the stream bed and the aquifer, and the hydraulic conductivity of intervening geological materials.

### 3.3.2 Lakes

The four lakes within the model area were set as constant head boundaries, reflecting an assumption that the lakes are fed by sources external to the model area and interact directly with the surrounding geologic material. The head assigned to the constant head boundary was equal to the water level as indicated in the LiDAR coverage.

### 3.3.3 Coastline

A constant head boundary condition was used to assign a 0 mAMSL groundwater head for Layer 1 along the coastline. This was applied to represent the mean hydraulic head of the ocean at these locations.

A general head boundary (GHB) was applied along the coastal boundary for Layer 2 of the model. A GHB allows for simulated flow to occur as a function of driving pressure and conductivity through the boundary and is typically used to represent connection to water bodies outside of the model area.

In this case the pressure (hydraulic head) on the GHB was set to 0 m to represent the influence of the ocean and GHB conductivity was calibrated to reflect the low permeability of the greywacke being represented. Assigning independent boundary conditions to the two model layers allowed for the model to reflect the different level of discharge flowing through the subsurface geologic layers based on their relative conductivity.

### 3.3.4 Groundwater Recharge

The Soil Moisture Water Balance Model (SMWBM) is a semi-deterministic rainfall runoff water balance modelling tool that incorporates daily rainfall and evaporation data, in combination with parameters representing hydrogeological conditions to generate daily hydrological fluxes within the system being modelled. In this case, the SMWBM was used to determine the groundwater recharge rates across the model area based on climate data (AEE Report - **Section 3.1**), soil characteristics (AEE Report – **Section 3.4**), and surface geology, as shown in QMAP data (AEE Report **Section 3.6**).

The model simulates a partitioning of rainfall between surface runoff, evapotranspiration, interception, soil storage, and deep percolation (i.e. groundwater recharge) on a daily basis. Daily climate data (rainfall and PET) are input into the model while parameters representing soil infiltration rates, soil storage capacity, deep percolation rates, vegetation cover, and slope are varied within realistic bounds based on the topography, land cover, soil type, and geology for a given area.

The SMWBM model was calibrated to the water level measurements at Flow Site 3, installed by WWLA at Mitiwai stream on October 2024 (WWLA, 2024). To achieve calibration, simulated streamflow (a combination of surface runoff and groundwater baseflow) was compared to the measured data from the monitoring station. The model area was classified into two permeability zones, ironsand and greywacke, based on underlying geology of Mitiwai catchment as shown in **Figure 8**. Simulated flow generation for each material was combined to calculate a total flow based on areal coverage of the two materials within the Mitiwai catchment (i.e. a weighted average based of the proportion of the catchment area for each material was applied).

The parameter values used in the SMWBM for both land cover types are summarised in **Table 1** and the resulting water balance is shown in terms of proportion of rainfall in **Table 2**. The groundwater recharge calculated in this analysis was 476 mm/year for ironsand and 112 mm/year for greywacke, equating to 41% and 10.0% of annual rainfall, respectively.

The recharge rates calculated for the ironsand and greywacke areas was applied to the model cells corresponding to the given materials, as illustrated in **Figure 8**.

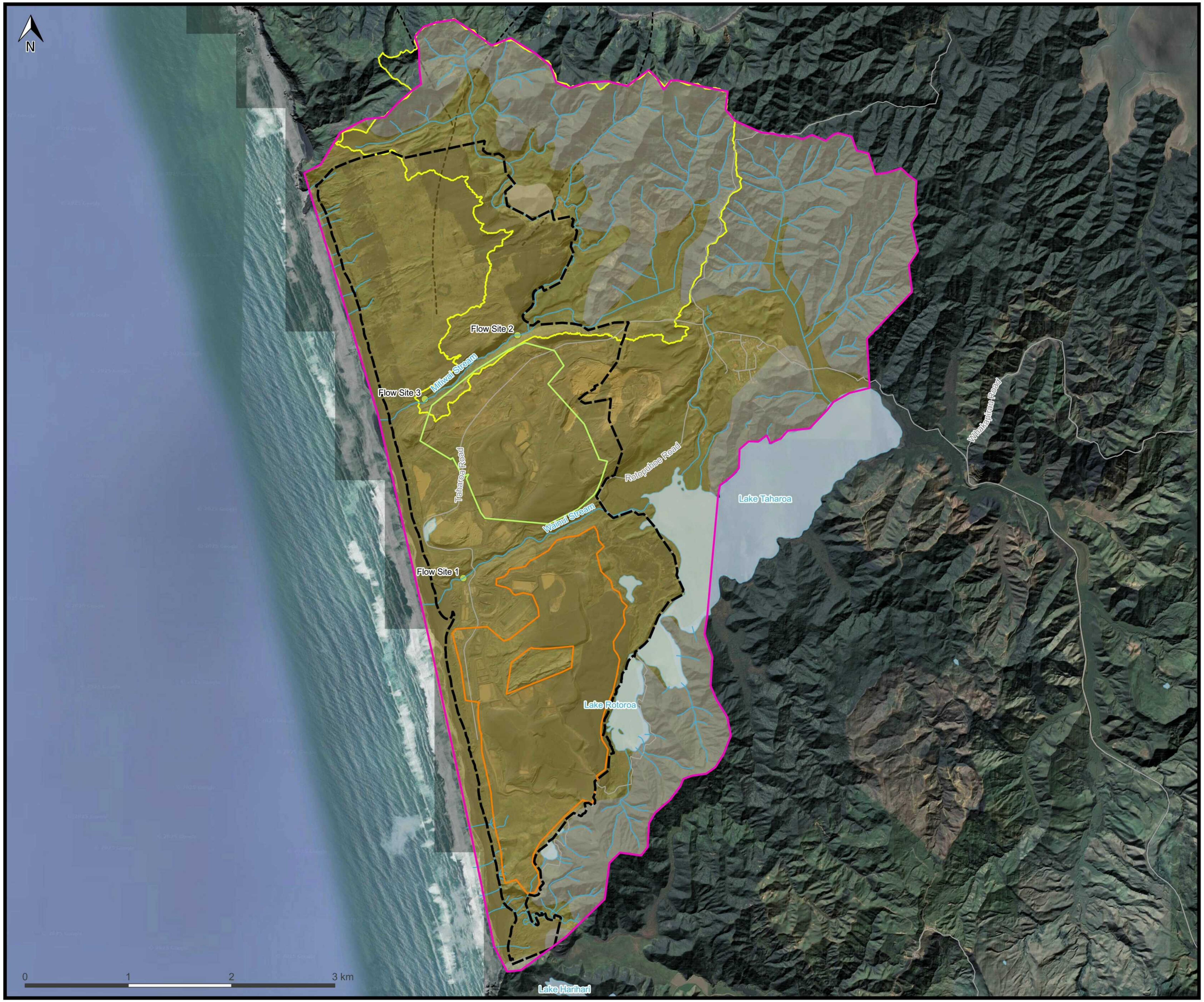
Table 1. Land cover SMWBM parameters and water balance components.

| Land Cover | SMWBM Parameters | | | |
|---|---|---|---|---|
| | ST | ZMax | FT | PI |
| | (mm) | (mm/hr) | (mm/d) | (mm) |
| Greywacke | 200 | 3 | 0.5 | 2 |
| Ironsand | 400 | 10 | 2.1 | 2 |

Notes: ST is soil storage capacity (mm); Zmax is maximum soil infiltration rate (mm/hr); FT is maximum sub-soil drainage rate; PI is canopy interception (mm).

Table 2. Simulated water balance from SMWBM.

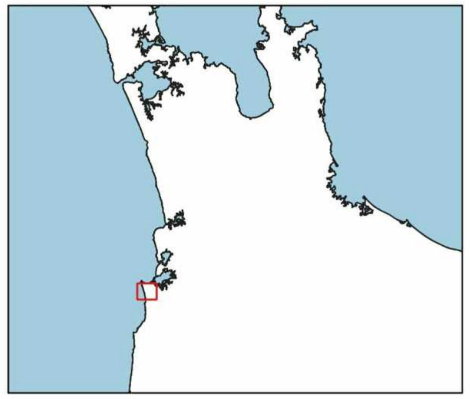
| Land Cover | Water Balance Components | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Interception Loss | | Evapo-transpiration | | Surface Runoff | | Groundwater Recharge | | Change in soil storage | |
| | % of rainfall | mm/year | % of rainfall | mm/year | % of rainfall | mm/year | % of rainfall | mm/year | % of rainfall | mm/year |
| Greywacke | 20 | 229 | 27 | 315 | 44 | 511 | 10 | 112 | -1 | -11.2 |
| Ironsand | 20 | 229 | 29 | 338 | 11 | 125 | 41 | 476 | -1 | -11.2 |




Map Title:
**Recharge classification areas and Mitiwai Stream catchment used for calibration.**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Stream flow monitoring gauges
- Road
- Streams
- Faults
- Lakes
- Study Area
- TIL Property Boundary
- Mitiwai Catchment
- Central mine block outline
- Southern mine block outline
- Greywackey
- Ironsand

Data Provenance
GIS Layers

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07/08/2025

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**Figure 8**

#### 3.3.5 Mining Areas

The mine excavation sequence followed the TIL mine plan. This was implemented by converting cells within an excavation area to drain cells, where the base elevation of the drain in a given cell was set to equal the pit base elevation indicated in the mine plan and supporting documents provided by TIL. A linear interpolation function was applied to simulate the time required for the excavation process to occur. The dates from Central Block mine plan provided by TIL were adjusted to match the time period simulated in the transient model. The excavation of the Southern Block was assumed to follow the completion of the Central Block, with the proposed expansion areas added into the excavation sequence.

For all mine pits it was assumed that the once the excavation was complete in a given area it remained open as the adjacent area was excavated, and then backfilled with engineered land fill (ELF) primarily composed of tailings as the excavation proceeded to the following area. The final area to be excavated in both the Central and Southern Blocks was left open as an open void after mining was complete.

#### 3.3.6 Mining Below Water Table

With regard to mining below the water table, the following boundary condition assumptions were applied in model development:

- If the excavation is above sea level the drain level is assigned as the base of the pit.
- If the excavation is below sea level but within the reach of the dredge ladder (i.e. above -14 mAMSL), it is assumed that material below the water table is being excavated, and the drain elevation is assigned as 0 mAMSL to reflect the elevation of the dredging machine.
- If the excavation depth is greater than 14 m below sea level, it follows that the excavation is below the water table and that groundwater levels must be lowered to enable the dredge to reach greater depths; hence the drain elevation is assigned as 14 m above the excavation level indicated in the mine plan.

### 3.4 Hydraulic Properties

The materials within Layer 1 and Layer 2 of the model grid were represented in terms of their bulk hydrogeological properties, with zonation applied to facilitate the applied hydraulic parameters being appropriate for the materials they represent. These zones are shown in **Figure 9** and are described as follows:

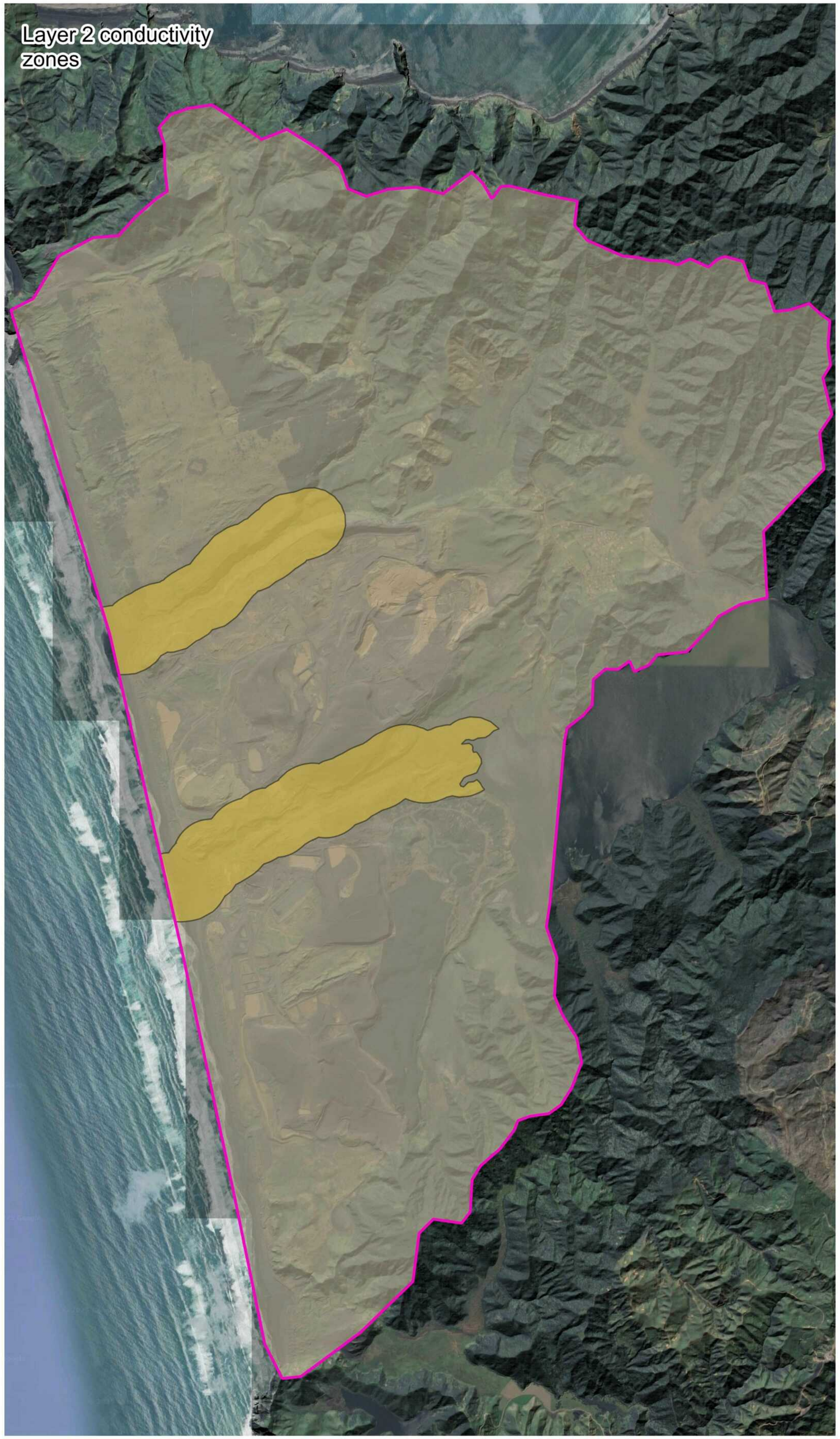
**Layer 1 Ironsand –** representative of the Waiau Formation and Upper Tauranga Group materials within and surrounding the mining area.

**Layer 1 Stream Buffer** – representative of the area surrounding the Mitiwai Stream where groundwater monitoring data indicates that fluvial action has had a localised influence on hydraulic conductivity.

**Layer 1 Greywacke** – Representative of the areas where greywacke is the predominant geologic material at or near the land surface.

**Layer 2 Stream Buffer** – representative of the area surrounding the Mitiwai and Wainui Streams where groundwater monitoring data indicates that a localised area of elevated conductivity underlying the stream valley.

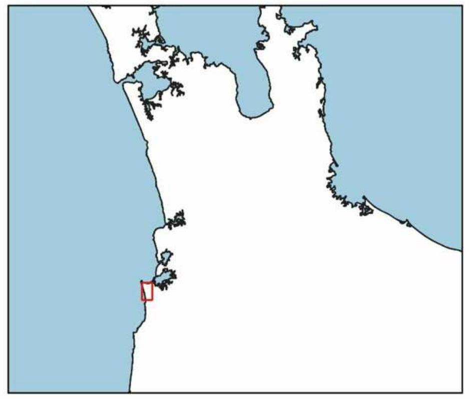
**Layer 2 Greywacke** – Representative of the low-permeability bulk basement material underlying the ironsand resource and continuous with Layer 1 Greywacke where it is present.


Map Title:
**Calibration zones as used for model development**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- **Pilot points**
- **Study Area**

Layer 1 conductivity zones
- **Greywackey**
- **Ironsand**
- **Mitiwai buffer**

Layer 2 conductivity zones
- **Greywacke**
- **Mitiwai and Wainui stream buffer**

Data Provenance
GIS Layers

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31/07/2025

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**Figure 9**

# 4. Model Calibration

Calibration of a numerical model entails adjusting hydraulic parameters assigned to the model cells to produce a simulation that matches measured data as closely as possible.

The model was calibrated to reflect groundwater elevation data from the groundwater monitoring sites detailed in the AEE report. Due to the limited monitoring period and minimal variation in groundwater level over that period, the model was only calibrated in steady-state conditions.

## 4.1 Hydraulic Parameters

The model calibration was undertaken by assigning variable conductivity parameters to each of the material types described in **Section 3.4**. The MODFLOW Parameter Estimation Tool (PEST) was applied to achieve the optimal calibration for the steady state version of the model. The model applies PEST tools by allowing the conductivity for a given parameter to be automatically adjusted within a user-defined range that is based on realistic upper and lower limits for the given material.

The key parameters that govern the groundwater dynamics in a relatively homogenous system are hydraulic conductivity (or transmissivity with depth) and the storage parameters, specific yield for shallow materials and specific storage for deeper layers. They are briefly described below:

- Hydraulic conductivity reflects material permeability and determines the rate water moves through ground materials;
- Specific yield is the drainable porosity of the material which influences the magnitude of response to heavy rainfall or periods of drought; and
- Specific storage (aka storativity) is the amount of groundwater that an aquifer will yield per unit change in pressure within the aquifer.

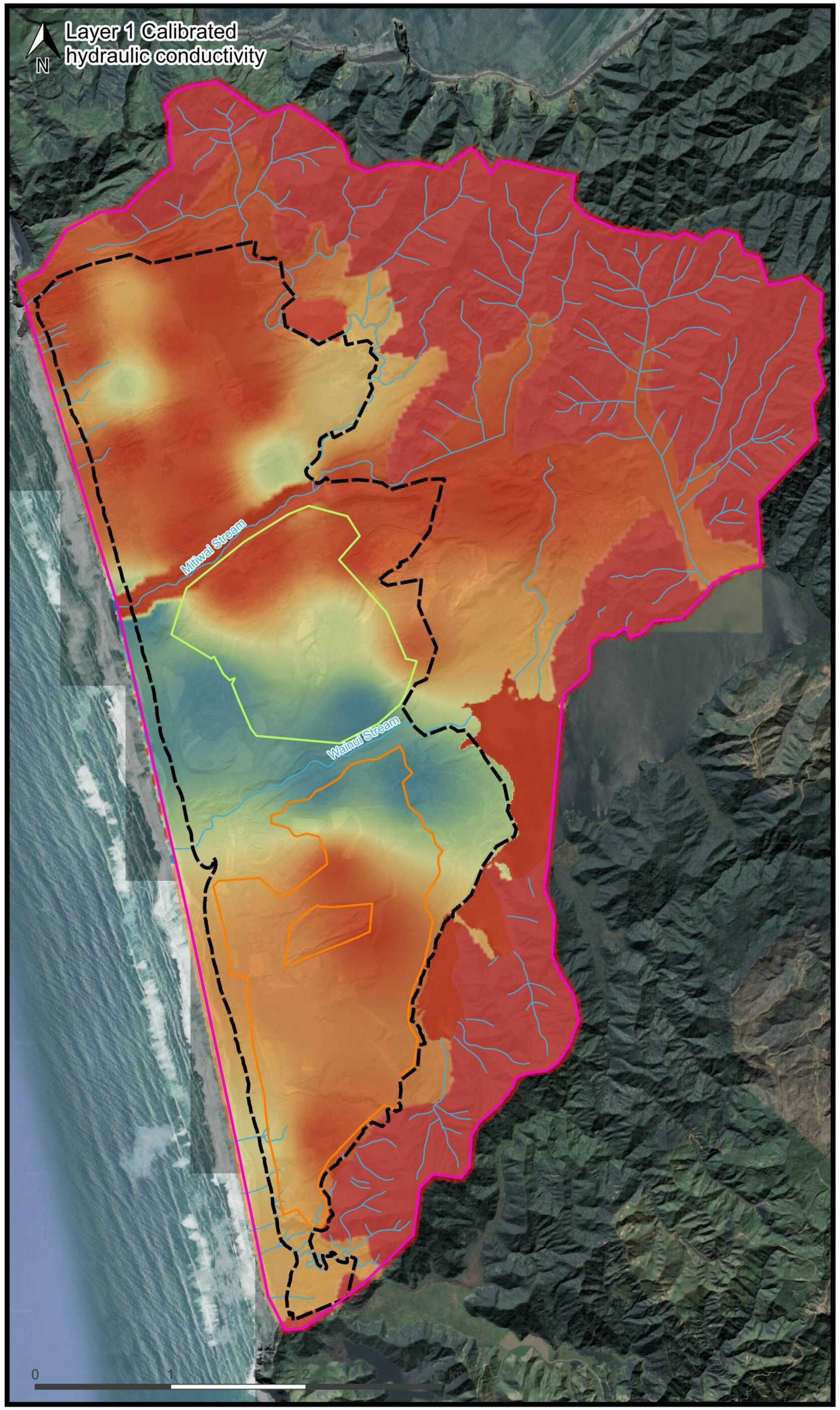
For the Layer 1 – Ironsand material type pilot points were distributed across the corresponding area and used as in the model calibration process. The pilot point method allows the model to simulate variable conductivity that aligns with the heterogeneity of materials that is known to occur, allowing the model to reflect low-permeability areas where clay is prevalent and higher permeability areas where there are unconsolidated sands within the same geologic unit.

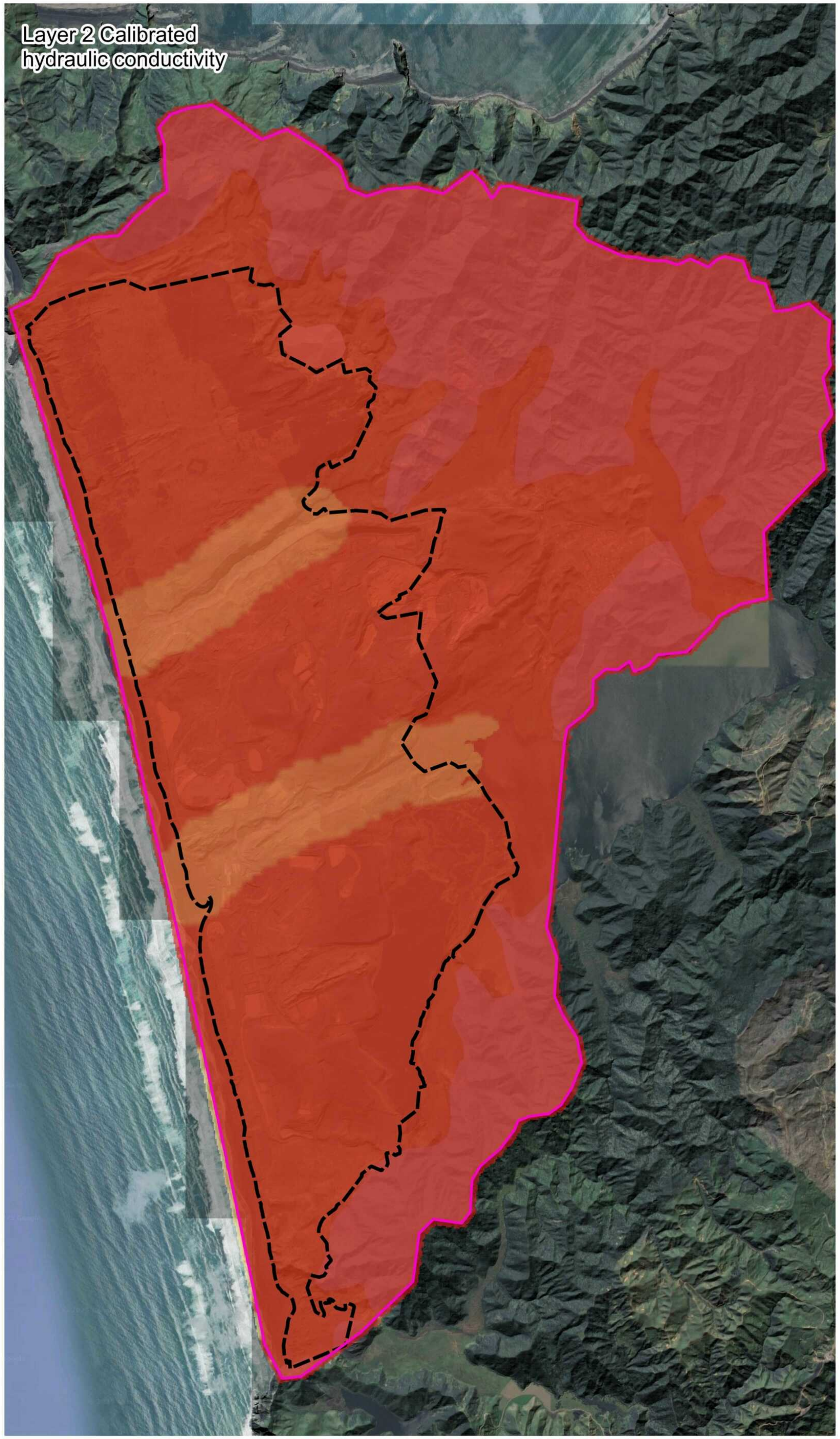
For the area where pilot points were used, the conductivity is adjusted for each individual point during the PEST calibration process and interpolated in between points. The range of conductivity values Layer 1 - Ironsand material was constrained to the range found in the results of hydraulic testing documented in **Section 3.7.4** of the AEE report.

Zonal calibration was applied for all other materials, where a variable parameter was assigned and calibrated through the PEST framework. Each material was constrained within an upper and lower limit appropriate for the material type based.

Specific Yield and Specific Storage were set to textbook values suitable for the materials that occur within the model area. A low-conductivity value was applied to the Layer 2 GHB boundary along the coast representing the low-permeability of the greywacke being represented.

Hydraulic conductivity, as determined through the calibration process is shown in Figure 10. **Table 3** also provides the calibrated conductivity values for the various materials represented in the model, and the upper and lower limits applied in the PEST calibration process. The area where pilot point calibration was applied reflects a range of values corresponding the final conductivity determined for the various points.

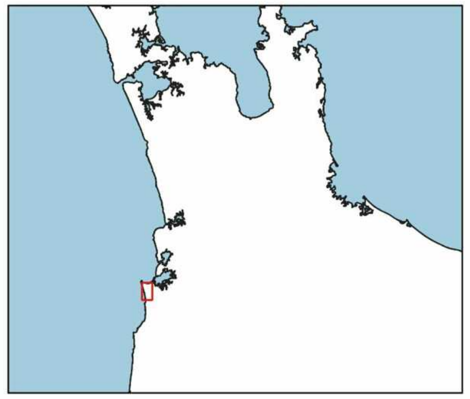



Map Title:
**Calibrated hydraulic conductivity**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- **Streams**
- **Study Area**
- **Central mine block outline**
- **Southern mine block outline**
- **TIL Property Boundary**

Calibrated hydraulic conductivity
**(m/day)**
**4.32**
**0.00864**

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
07/08/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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**Figure 10**

Table 3. Hydraulic parameters used in groundwater model.

| Model Layer | Calibration Zone | Calibration method | Calibrated Horizontal k (m/day) [m/sec]* | Calibration limits (m/day) | |
|---|---|---|---|---|---|
| | | | | Maximum | Minimum |
| 1 | Ironsand | Pilot points | 0.00864 – 4.32 m/day [1x10$^{-7}$ – 5.0x10$^{-6}$ m/s] | 0.008604 | 4.32 |
| | Greywacke outcrop | Zonal | 0.00864 m/day [1.0x10$^{-7}$ m/s] | 0.0000864 | 0.0864 |
| | Mitiwai stream buffer | Zonal | 0.0864 m/day [1.0x10$^{-6}$ m/s] | 0.043 | 0.5 |
| 2 | Greywacke | Zonal | 0.00432 m/day [5.0x10$^{-8}$ m/s] | 0.0000864 | 0.0864 |
| | Mitiwai and Wainui stream buffer | Zonal | 0.432 m/day [5.0x10$^{-6}$ m/s] | 0.0432 | 0.5 |

* See Figure 10 for distribution of calibrated conductivities

## 4.2 Calibration Results

### 4.2.1 Steady State

The results of the model calibration process are shown in **Figure 11**, with simulated groundwater level at each monitoring location (with available data) plotted against to the corresponding measured groundwater level.

The root mean square error (RMSE) is a standard metric for evaluating numerical modelling results. It quantifies the average error of a model across a group of reference points, which in this case are the monitoring piezometers for which there is data.

The root mean square (RMS) error for the piezometers used for model calibration is 2.7 m, which is 4.1% of the measured range in groundwater levels across the model domain, the highest measured groundwater being at N106 and the lowest point being at the C101 piezometers near the coast. An RMS error less than 10% is typically considered acceptable for a catchment scale groundwater model (Anderson and Woessner, 1992). The greatest over-simulation (simulated water level above corresponding measured value) was 4.8 m at Piezometer S101 and the greatest under-simulation was 4.3 m at Piezometer N104.

C101_Shallow and C101_Deep are nested piezometers with monitoring depths of 14 and 23 mBGL respectively, observed the same water level which is a good indication of deep and shallow aquifer connectivity in the area.

**Figure 12** provides the piezometric surface (water table) from the calibrated steady state model. This shows that the groundwater in the model area generally flows from north-northeast to the western coast, with a steep gradient in the hills to the north of the model area, that softens considerably in the lower lying areas where the ironsand resource is located. The simulated groundwater flow pattern is broadly comparable to the interpolated piezometric surface derived from measured and inferred groundwater level data shown in **Section 3.7.2** of the AEE report (refer Figure 8).

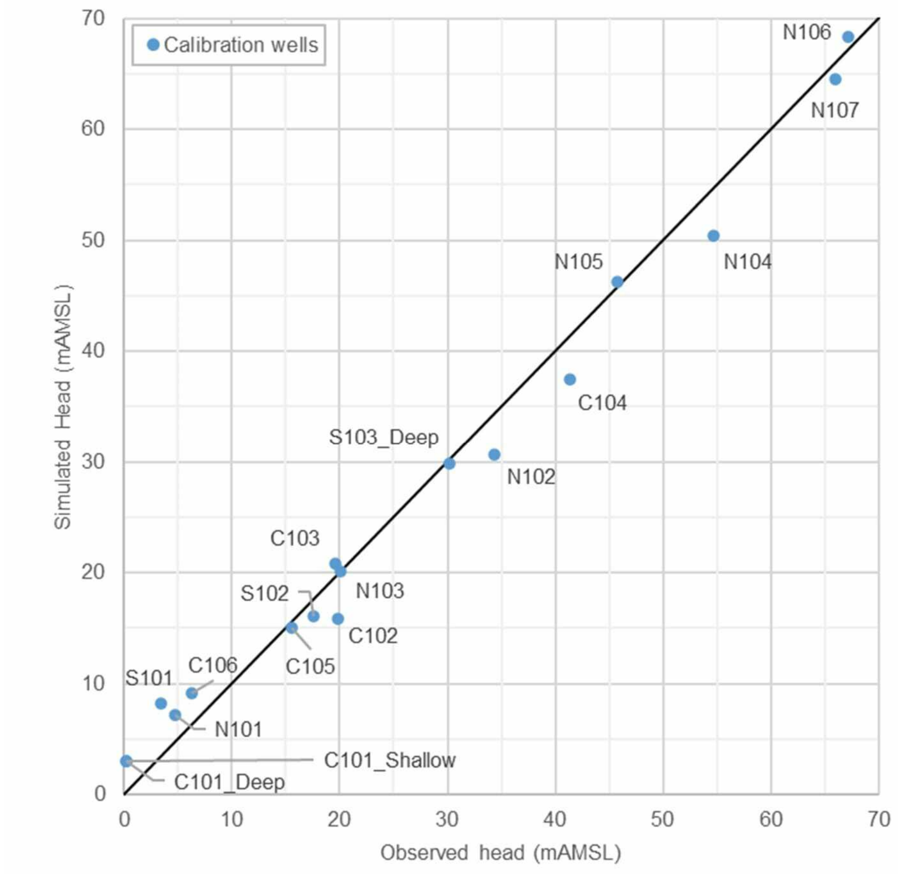
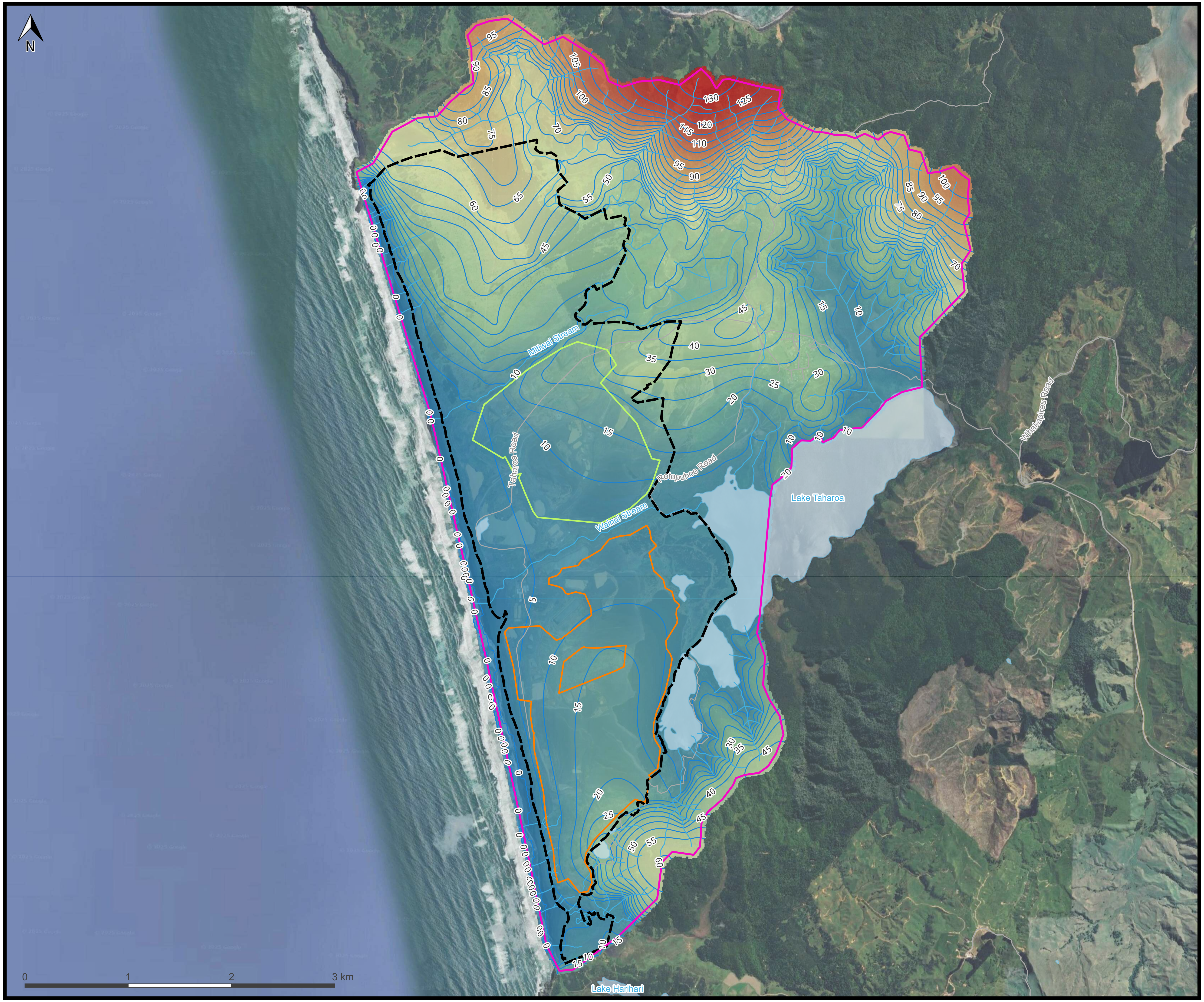


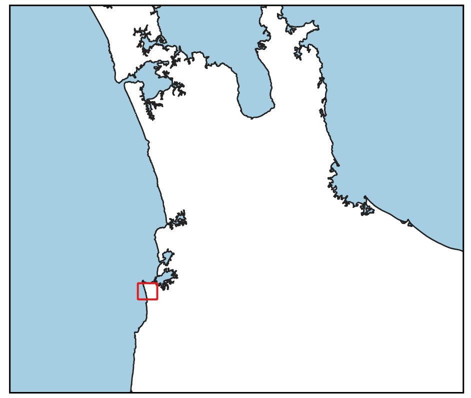

Figure 11. Modelled versus measured groundwater levels




Map Title:
**Calibrated model steady state piezometric surface**

Project:
**Taharoa Ironsand Groundwater Effect Assessment**

Client:
**Taharoa Ironsand Limited**



**Legend**

- Streams
- Road
- Water tablel elevation contours (mAMSl)
- Study Area
- Lakes
- Central mine block outline
- Southern mine block outline
- Taharoa Leased Boundary copy

Water table elevation (mAMSL)
130
0

Data Provenance
GIS Layers

Drawn by: Asanka Thilakerathne
07/08/2025

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**Figure 12**

### 4.2.2 Transient Simulation

Parameters from the Steady-State model were transferred into a transient simulation setup to allow simulation of a range of hydrological conditions that included both wet and dry time periods and the full mine excavation process as indicated in the mine plan. The 22 years of historical climatic data spanning from January 2003 to through December 2024 was extended by repeating the same data set through two cycles to generate a 44-year simulation period, which allowed the model to run long enough to evaluate the long-term effects after mining and land restoration was complete. The 44-year transient model was run with a monthly stress period, meaning that in all the simulation spanned 528 months.

The long-term average water balance for the transient model is provided in **Table 4**, which indicates that nearly all of the inputs into the groundwater system are from rainfall recharge and that outflows occur primarily via discharge into streams (groundwater baseflow) and finally into the ocean. Over the long term, aquifer storage inputs and outflows are approximately in balance, and there is limited groundwater connection to neighbouring catchments.

Table 4. Average daily water balance for 44-year simulation from 01/01/2003 to 31/12/2046.

| **Mass balance** | **Components** | **Baseline Model** | |
|---|---|---|---|
| | | **Flow (m$^3$/d)** | **Percentage of Flow (%)** |
| Inflow | Recharge | 28,005 | 91.00% |
| | Flow from lakes into aquifer | 82 | 0.27% |
| | Storage | 2,686 | 8.73% |
| | Flow from ocean into shallow aquifer (Layer 1) | 2 | 0.01% |
| | Flow from ocean into deep aquifer (Layer 2) | 0 | 0% |
| | **Total inflow** | 30,776 | |
| Outflow | Streams (groundwater baseflow) | 16,664 | 54.15% |
| | Flow aquifer into lakes | 2,617 | 8.50% |
| | Shallow aquifer (Layer 1) discharge into ocean | 8,377 | 27.22% |
| | Flow from ocean into deep aquifer (Layer 2) | 207 | 0.67% |
| | Storage | 2,913 | 9.47% |
| | **Total outflow** | **30,779** | |
| Percentage discrepancy | | -0.01% | |

# 5. Conclusions

WWLA has developed a groundwater model to provide a quantitative representation of the groundwater conditions within the proposed TIL mining areas and the surrounding catchments. This model was used to estimate the effects of proposed mining on environmental conditions both during mining and after the mine area was restored to approximate the original topography after mining is complete.

A 2-layer groundwater model was developed to simulate the native geologic material within and around the proposed mine. The upper layer of the model represents the moderately high permeable ironsand, which is the resource layer of the mine, and lower layer is comprised of greywacke. The surrounding rugged hills in the upper layer are also comprised of greywacke.

The model was calibrated to measured groundwater levels in 17 monitoring piezometers. The model calibration process was guided by results of in-situ hydraulic testing undertaken at the monitoring piezometers and stream water levels at several gauges and reference locations.

The mining sequence of across Central and Southern pits, as indicated in the mine plan provided by TIL, was applied to the calibrated model along with a time series derived from historic climate conditions. The potential effects that may occur from mining were determined by comparing simulated groundwater conditions to a Baseline version of the model in which no mining was simulated, using the same climate and groundwater recharge conditions.

In summary, WWLA has developed a numerical model that is fit for purpose for the groundwater effects investigations detailed in this report and can be readily applied for further inquiries when needed. An Assessment of Effects informed by this modelling comprises the primary component of this report with this Appendix provided as a supporting document wherein the methodology used in the technical analysis is presented.

# 6. References

Edbrooke, S.W. (2005) Geology of the Waikato Area, 1:250,000. *Institute of Geological & Nuclear Sciences Ltd.*

Geotechnics (2014). Taharoa Ironsand Deposit-Revised geological model, Geotechnics Limited. Ref; 615815.005-1(June 2014)

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Pain, C.F. 1976. Late Quaternary dune sands and associated deposits near Aotea and Kawhia Harbours, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics 19: 153-177.*

Williamson Water & Land Advisory (WWLA), 2024. Taharoa Streamflow Monitoring. Consultancy memo prepared for Taharoa Ironsands Limited.

Williamson Water & Land Advisory (WWLA), 2025. Taharoa Ironsand Slug Testing Summary and Analysis. Consultancy report prepared for Taharoa Ironsands Limited.

# Appendix B. Mining Sequence and Dredge Path Central Block

## Taharoa Mine - TIL

# Mining Sequence and Dredge Path Central Taharoa

### Preliminary View

**4/2/2025**

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# Total Reserves in Pits Suitable for Dredging Central and South Taharoa

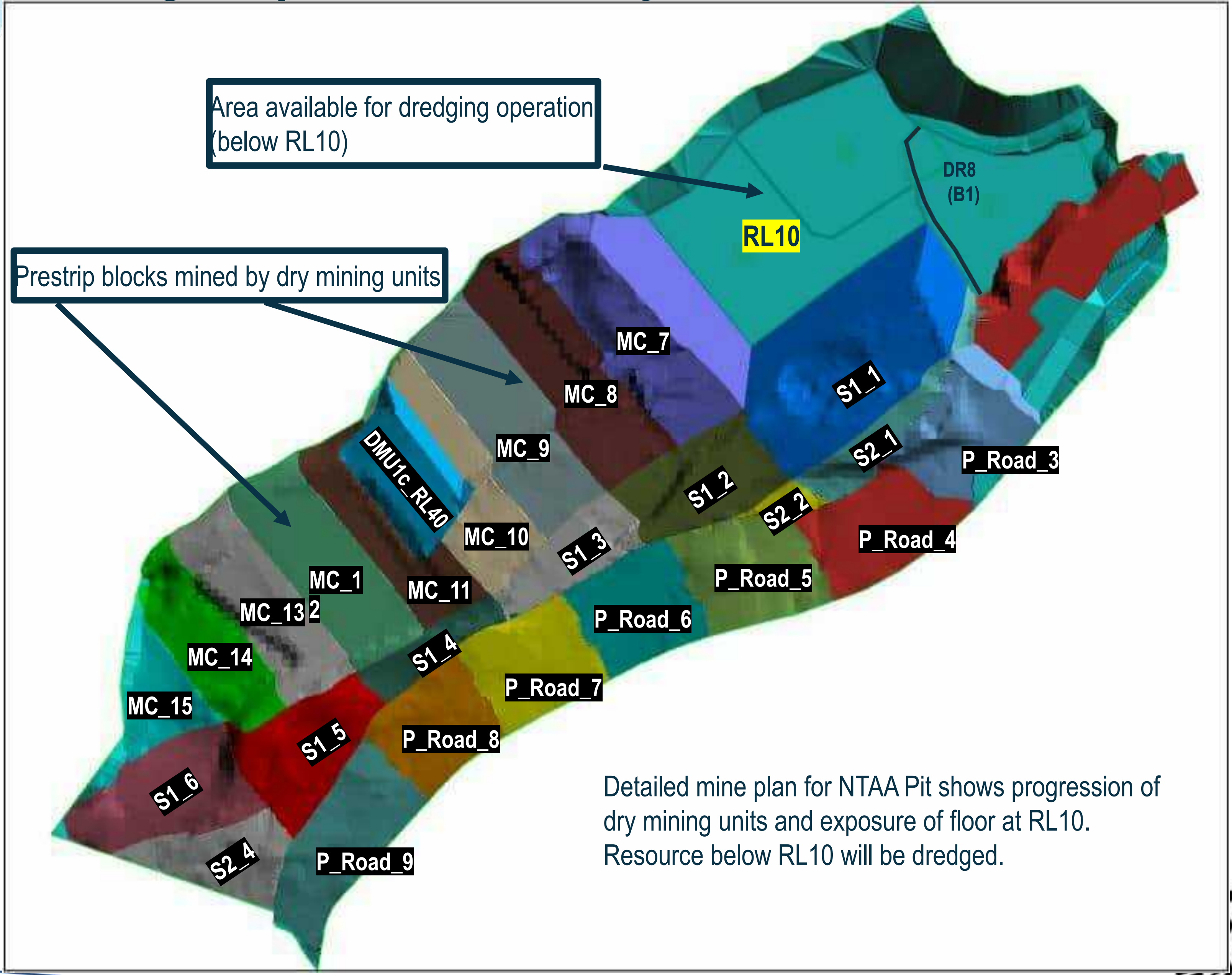
| Taharoa Region | Pit / Area | Volume | Head Feed | Concentrate | FeMags | Mags | Slimes | Yield |
|---|---|---|---|---|---|---|---|---|
| CENTRAL | NTAA Pit | 26,629,283 | 55,482,816 | 10,774,930 | 57.54 | 23.53 | 8.06 | 0.18 |
| CENTRAL | Pit 2 | 23,389,911 | 47,755,597 | 6,570,082 | 56.45 | 20.09 | 7.40 | 0.13 |
| CENTRAL | Pit 3 | 35,692,517 | 71,334,224 | 7,626,817 | 54.29 | 19.38 | 5.95 | 0.10 |
| CENTRAL | Pit4 | 23,604,654 | 48,193,712 | 7,740,416 | 56.81 | 21.35 | 7.88 | 0.15 |
| CENTRAL | 33kV Hill | 4,881,353 | 10,314,173 | 2,157,123 | 57.11 | 28.67 | 5.96 | 0.20 |
| **Totals:** | | **114,197,718** | **233,080,521** | **34,869,368** | **56.13** | **21.30** | **7.14** | **0.14** |

| Taharoa Region | Pit / Area | Volume | Head Feed | Concentrate | FeMags | Mags | Slimes | Yield |
|---|---|---|---|---|---|---|---|---|
| SOUTH | Pit 1 | 13,576,999 | 26,789,654 | 3,326,445 | 50.72 | 22.40 | 3.69 | 0.12 |
| SOUTH | Pit 2 | 11,461,670 | 20,995,053 | 2,275,113 | 51.29 | 20.84 | 4.72 | 0.10 |
| SOUTH | Pit 3 | 32,432,378 | 59,862,777 | 8,966,099 | 53.04 | 25.25 | 5.50 | 0.14 |
| **Totals:** | | **57,471,047** | **107,647,484** | **14,567,656** | **52.14** | **23.70** | **4.92** | **0.13** |

Reserves available in Central and South Taharoa as on December 2024.
Reserves in Te Mania were excluded from the summary as this part of the resource is on higher ground, not suitable for dredging. The same assessment stands for North Taharoa Pit 1.
Note that the available reserves presented in table above will be mined by combination of dry mining units and dredging units.
Central area has a more advanced and detailed plans and updated geological model.

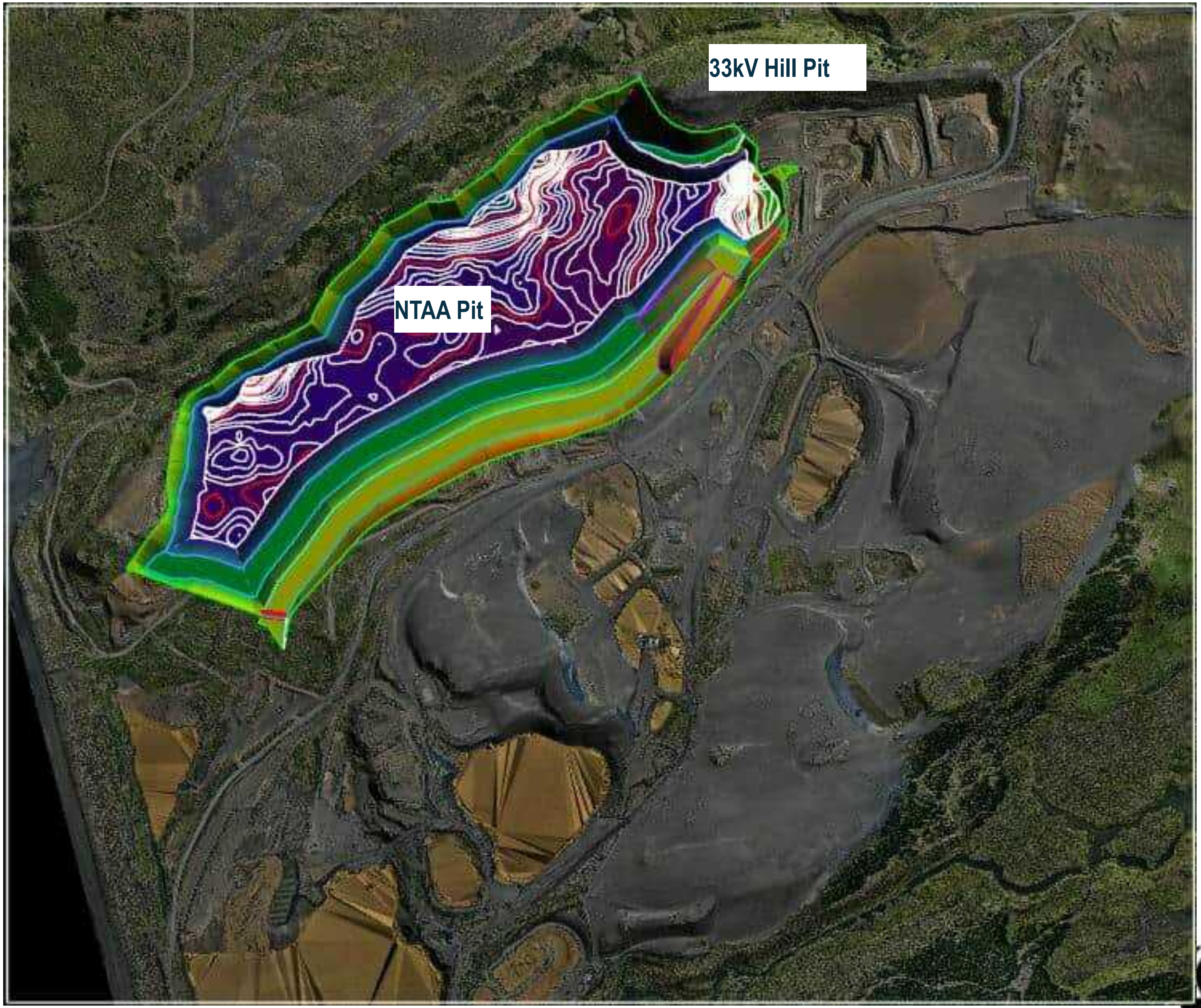
# Central  Taharoa Mining and Dredging Sequence

# Mining Sequence, February 2025 NTAA Pit

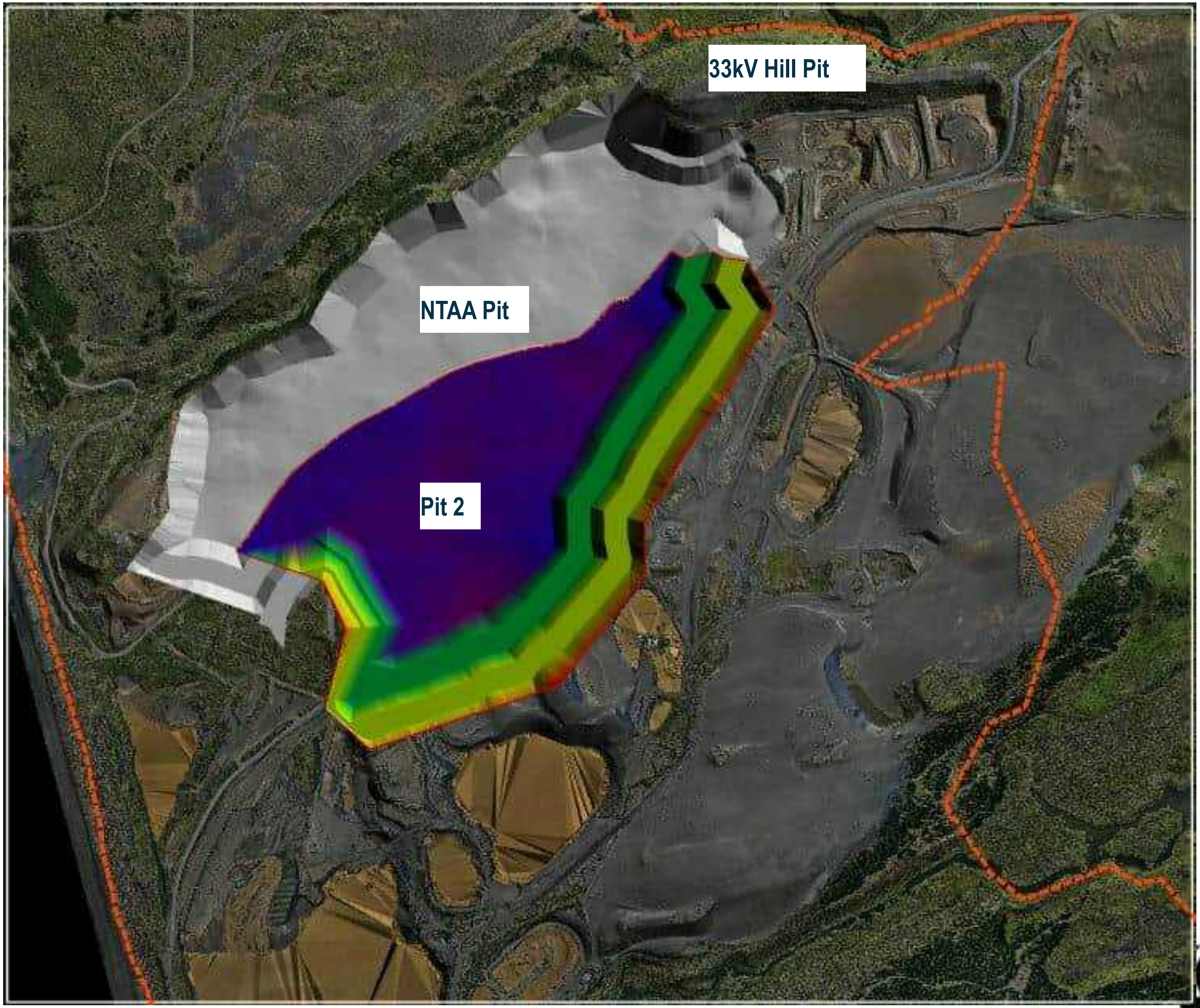



Detailed mine plan for NTAA Pit shows progression of dry mining units and exposure of floor at RL10. Resource below RL10 will be dredged.

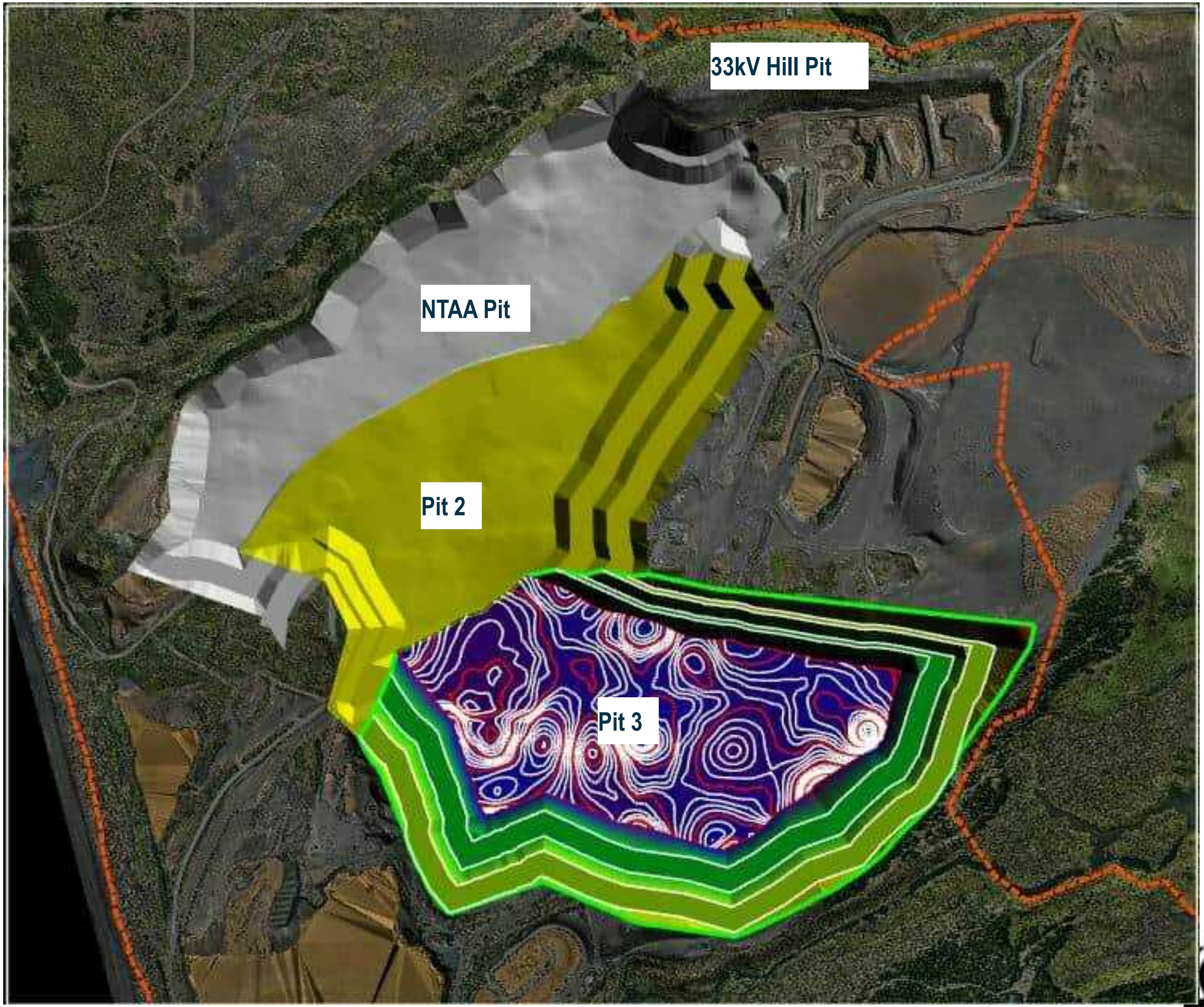
# Pits in Central Area – NTAA Pit (current)



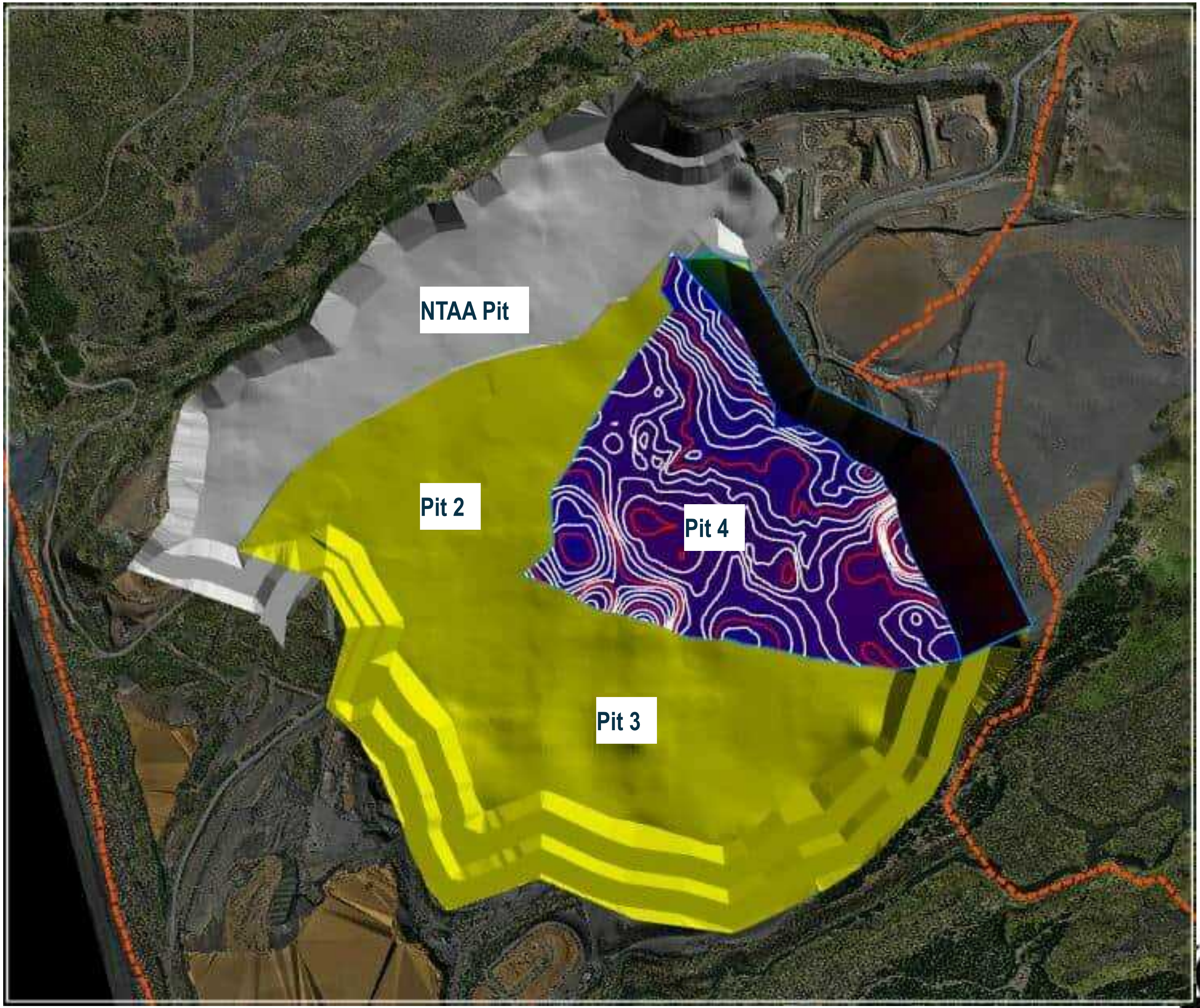
# Pits in Central Area – Pit 2



# Pits in Central Area – Pit 3

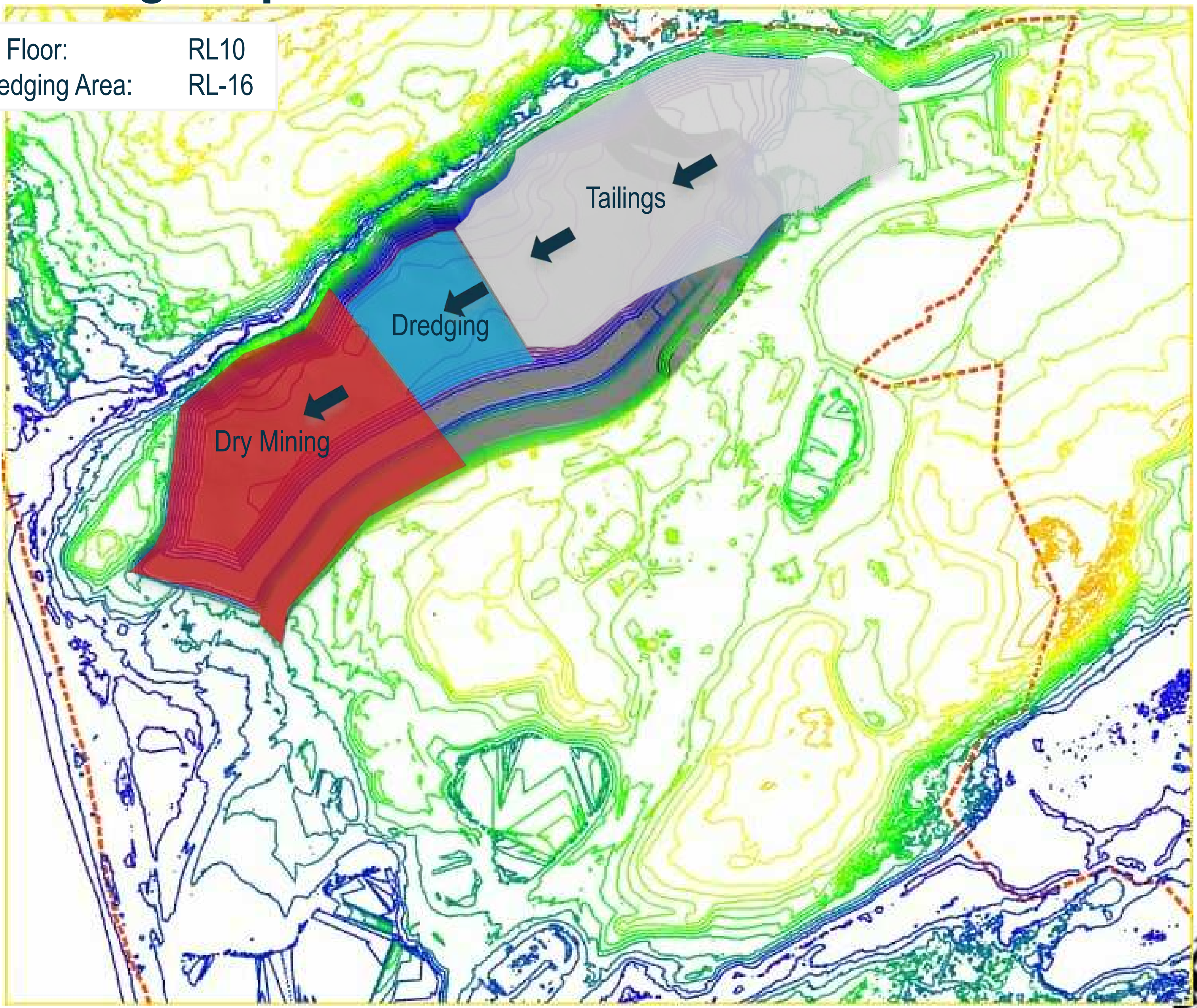


# Pits in Central Area – Pit 4



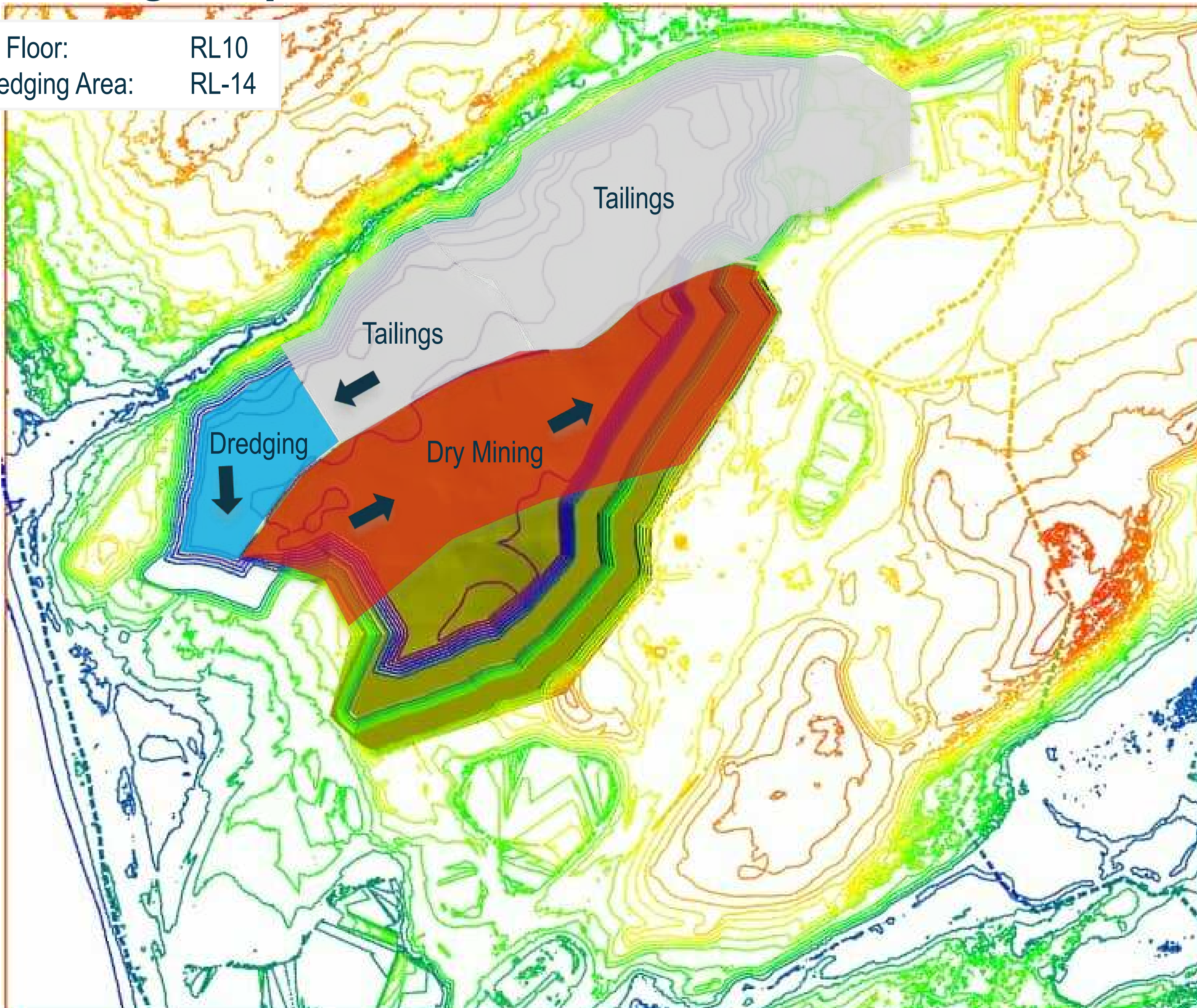
# Mining Sequence

Dry Mining Floor: RL10
Floor in Dredging Area: RL-16



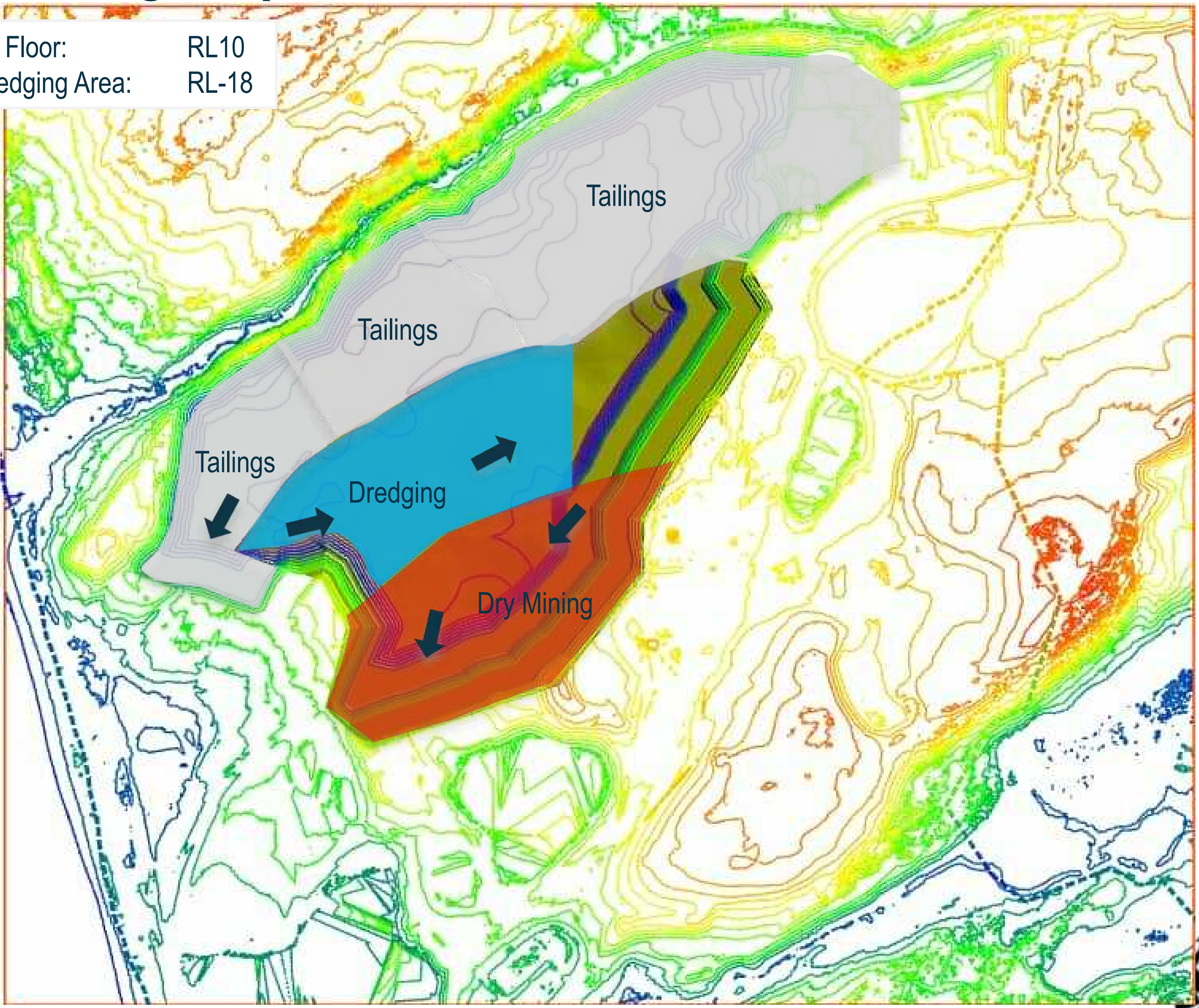
# Mining Sequence

Dry Mining Floor: RL10
Floor in Dredging Area: RL-14



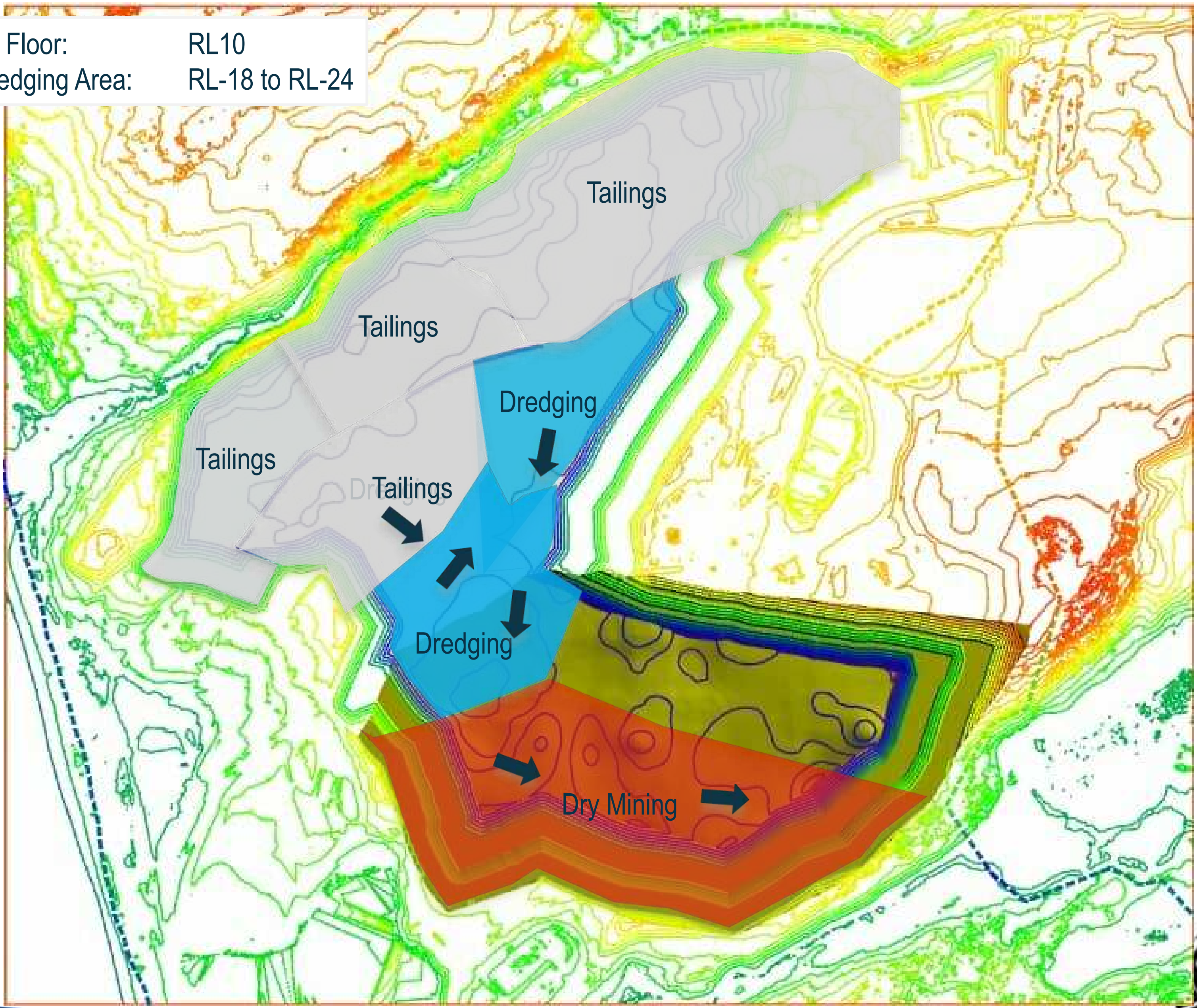
# Mining Sequence

| | |
|---|---|
| Dry Mining Floor: | RL10 |
| Floor in Dredging Area: | RL-18 |



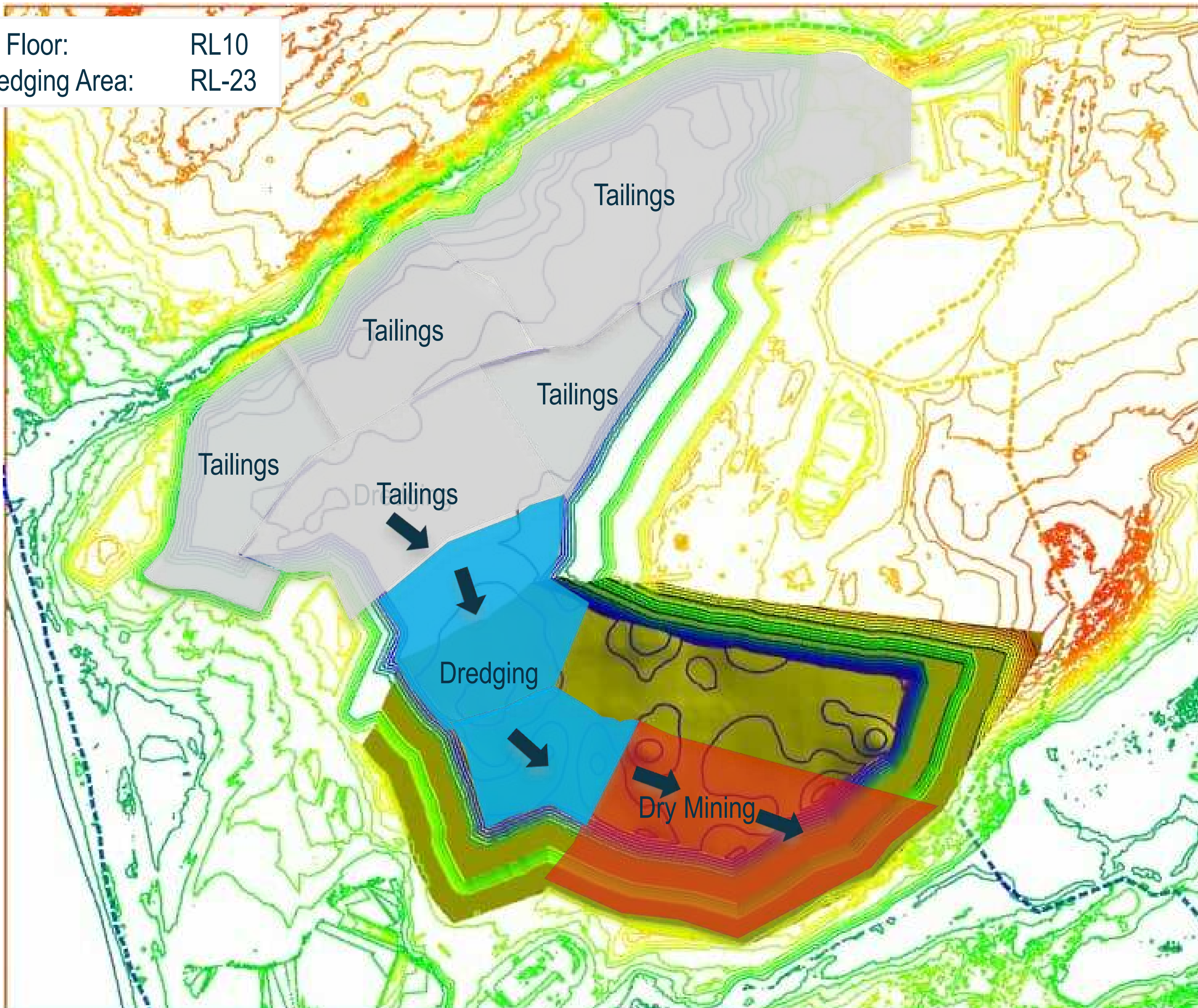
# Mining Sequence

Dry Mining Floor: RL10
Floor in Dredging Area: RL-18 to RL-24



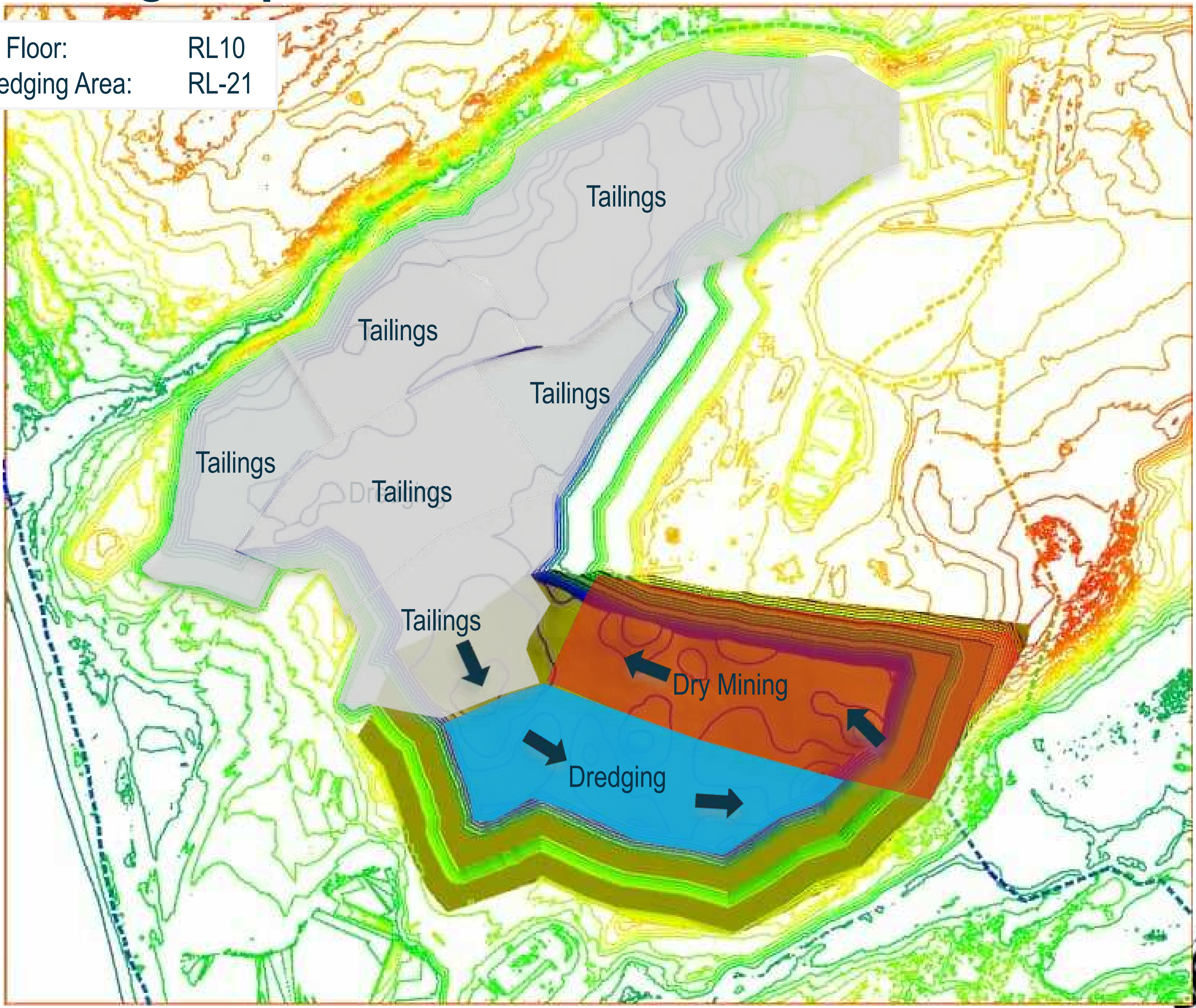
# Mining Sequence

| | |
|---|---|
| Dry Mining Floor: | RL10 |
| Floor in Dredging Area: | RL-23 |



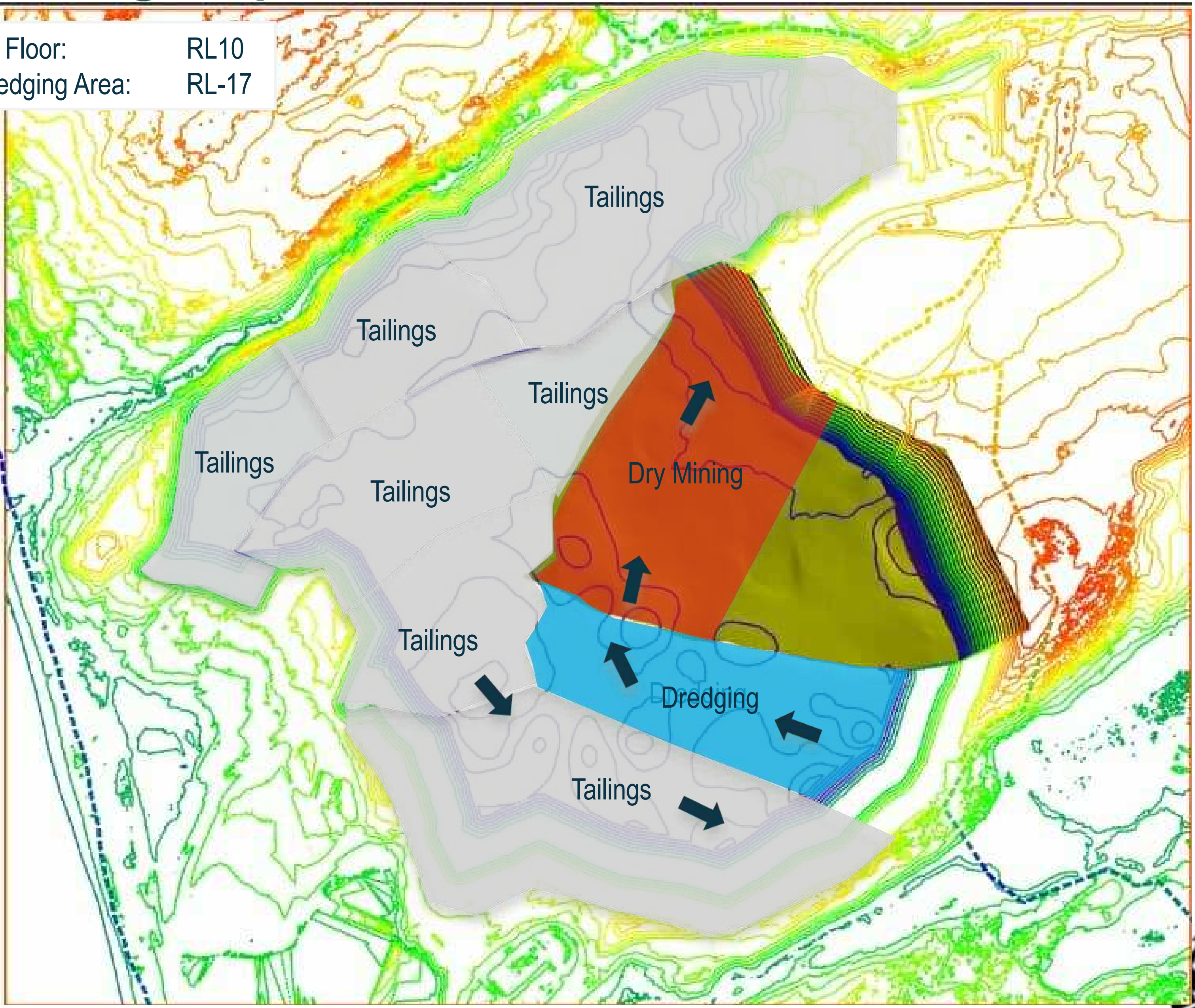
# Mining Sequence

Dry Mining Floor: RL10
Floor in Dredging Area: RL-21



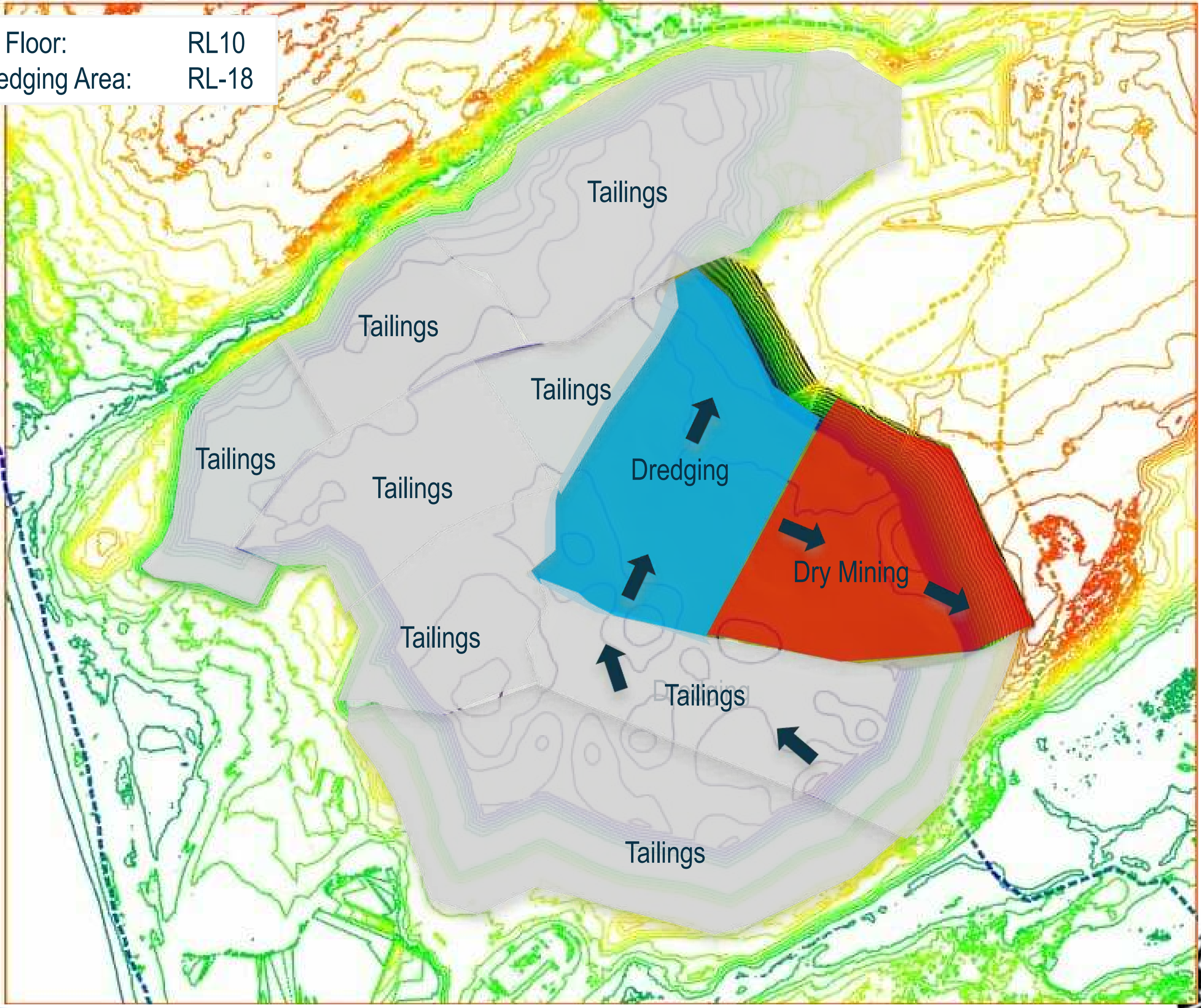
# Mining Sequence

Dry Mining Floor: RL10
Floor in Dredging Area: RL-17



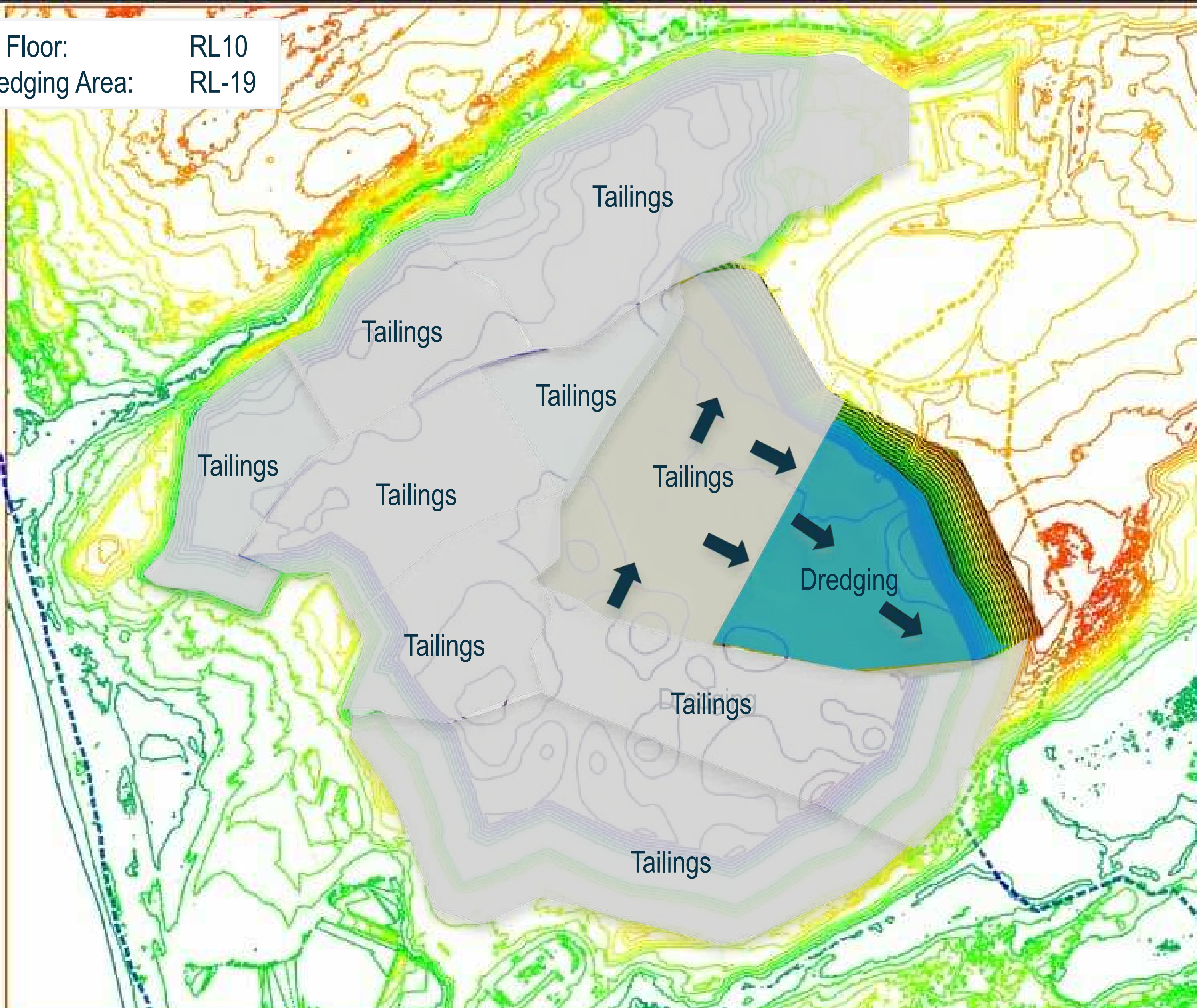
# Mining Sequence

Dry Mining Floor: RL10
Floor in Dredging Area: RL-18

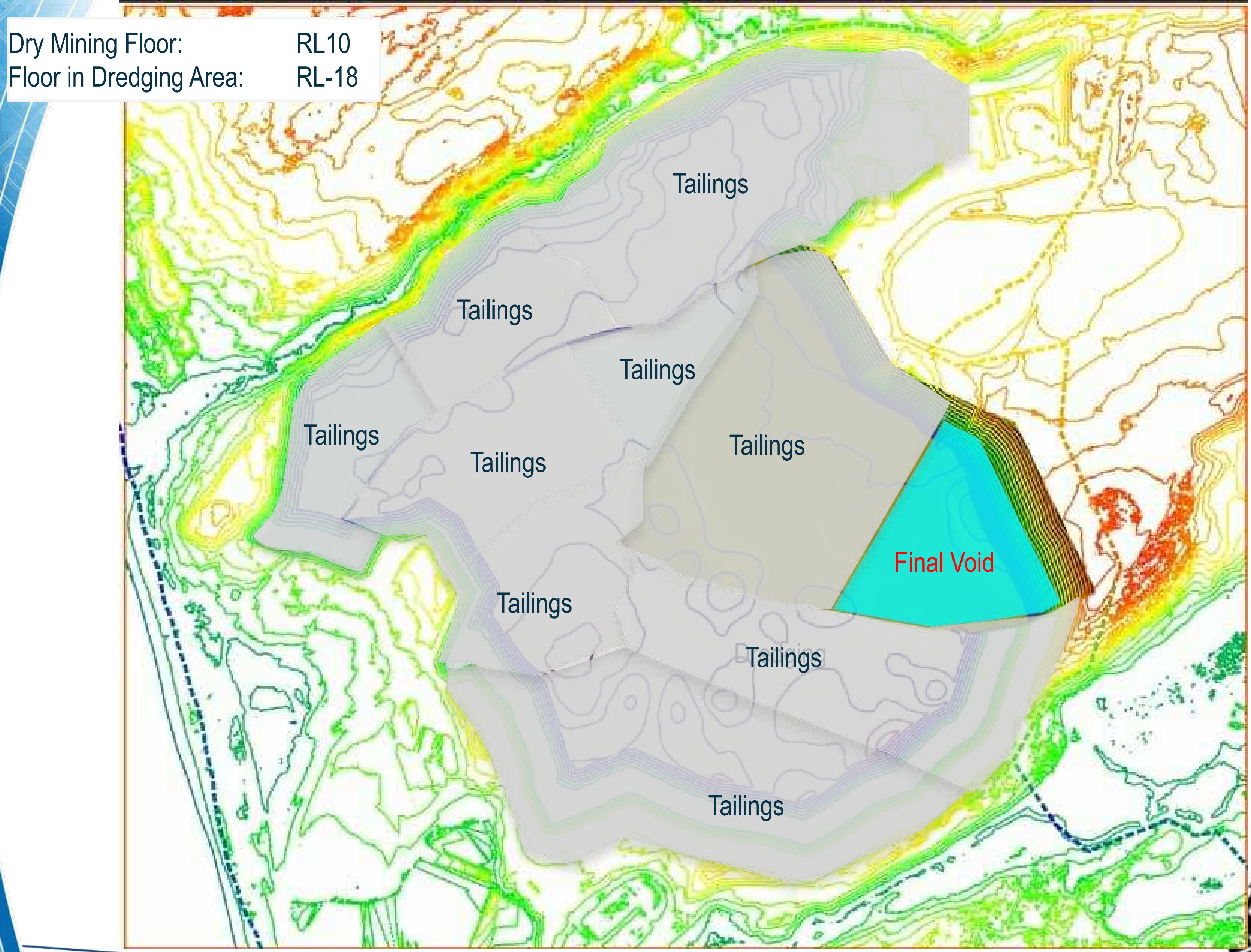


# Mining Sequence

| | |
|---|---|
| Dry Mining Floor: | RL10 |
| Floor in Dredging Area: | RL-19 |



# Mining Sequence



# Appendix C. Mining Sequence and Dredge Path Southern Block

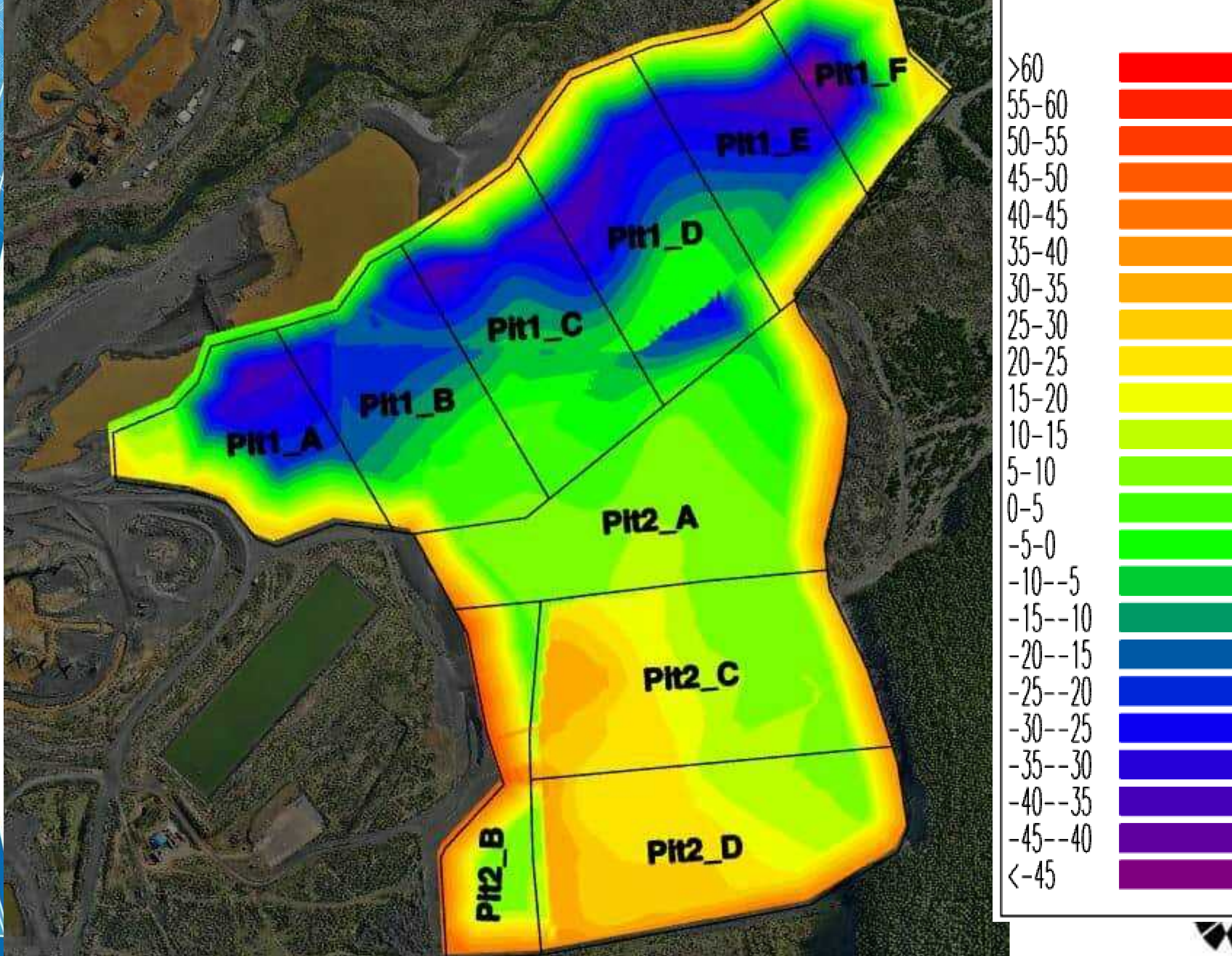
# Taharoa Mine - TIL

## South Taharoa
## Preliminary Pit Designs
## Pit floor elevations in 5m Increments

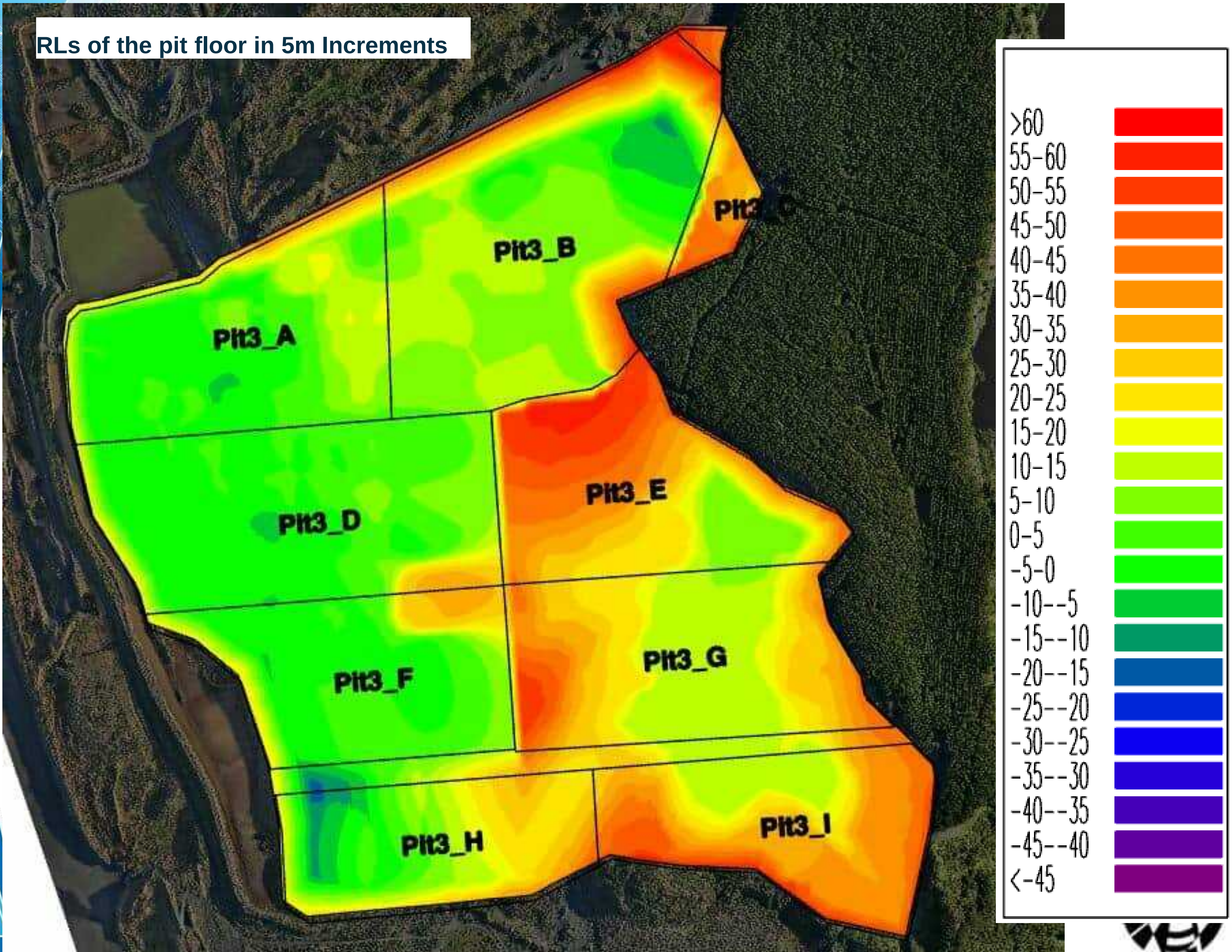
22/5/2025

DRAFT

# RLs of the pit floor in 5m Increments



## RLs of the pit floor in 5m Increments

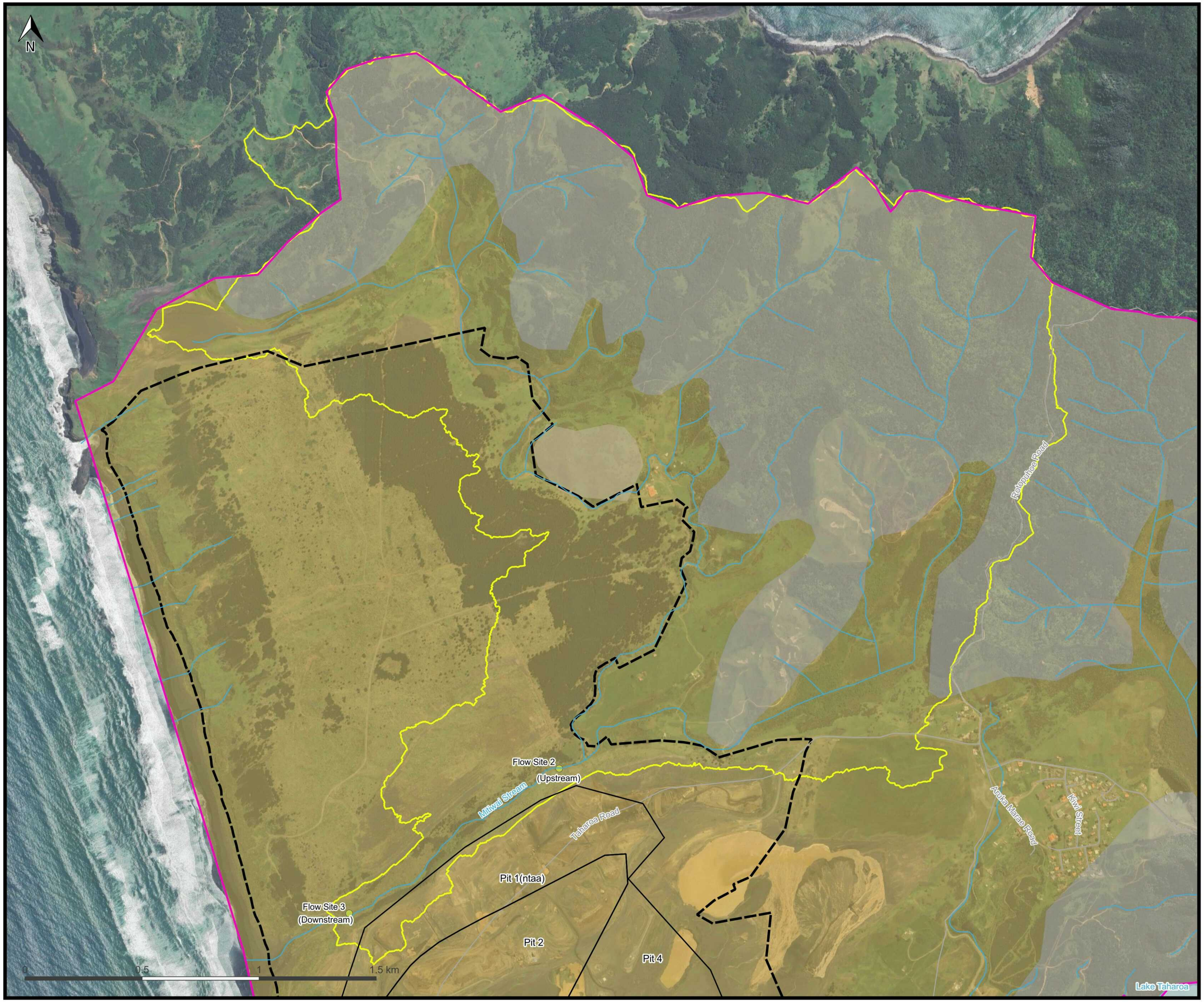


# Appendix D. Mitiwai Stream Flow Calibration

As detail in **Appendix A**, a Soil Moisture Water Balance Model (SMWBM) was developed to simulate the groundwater recharge profile and quantify and characterise the flow regime of the Mitiwai Stream. This appendix details the site-specific flow monitoring data collected and comparison to the simulated Mitiwai Stream Flow.

## D.1 Rated Flow Data

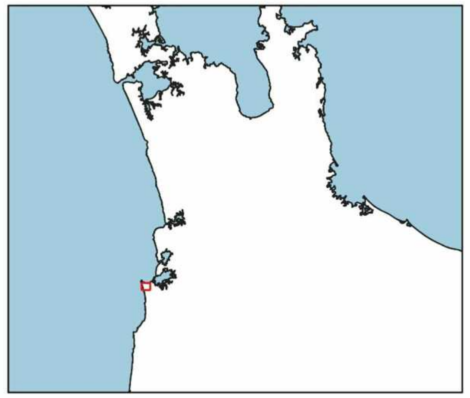
Streamflow in natural environments is typically measured indirectly via the measurement of water levels, and the development of a rating curve, relating the water levels to a corresponding flow rate. Two water level sensors were installed on the Mitiwai Stream in April 2024. The locations of these are shown in **Figure D 1** of the main body of this report.




Map Title:
**Mitiwai Catchment and Flow Monitoring Locations**

Project:
**Taharoa Iron Sand Groundwater Effect Assessment**

Client:
**Taharoa Iron Sand Limited**



**Legend**
- Stream flow monitoring sites
- Roads
- Streams
- Lakes
- Study area
- TIL property boundary
- Greywacke
- Ironsand
- Mitiwai Stream Catchment
- Central mine blocks

Data Provenance
Land information New Zealand

Drawn by: Asanka Thilakerathne
09/09/2025

Layout & Project File
Taharoa Iron Sand Mine-Hydrogeological Modelling

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**Figure D 1**

The resulting measured water level data is presented in **Figure D 2**  As expected, both sites show similar response fluctuations in water levels through time.  One subtle difference is that the upstream site appears to show a slow decreasing trend in baseflow water levels into winter, whereas this is not as evident at the downstream site.  This is more likely a result of erosion/scour lowering the streambed at this site (and hence lower water levels) than an actual reduction in water level and flows.

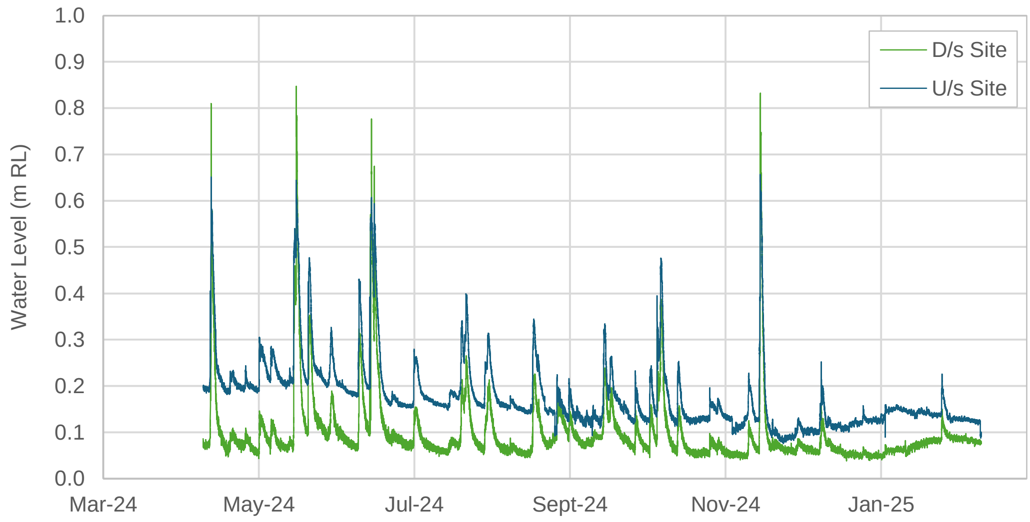


Figure D 2.  Mitiwai Stream – measured water levels.

In order to develop site specific rating curves for the two sites a series of manual flow gaugings were collected under differing water level and flow conditions.  To date, three manual flow gaugings have been collected at each site.  The flow gaugings were measured via standard stream wading gauging, using a Sontek 2 Acoustic Doppler Velocimeter (ADV).  The manual flow gaugings are tabulated in **Table D 1**.

Table D 1.  Mitiwai Stream – manual flow gaugings.

| Date | Upstream Site | | Downstream Site | |
|---|---|---|---|---|
| | Water Level (m RL)* | Flow (L/s) | Water Level (m RL)* | Flow (L/s) |
| 27 May 2024 | 0.207 | 136 | 0.103 | 122 |
| 07 October 2024 | 0.459 | 566 | 0.365 | 627 |
| 15 February 2025 | 0.132 | 28 | - | - |
| 18 February 2025 | - | - | 0.084 | 50 |

Note: water levels relative to the stream bed at each sensor site.

Rating curves were developed by fitting a power curve function to the manual measured flow gauging data.  The rating curve was then applied to the full record of measured water levels from each site, and the resulting rated flow datasets presented in **Figure D 3**.

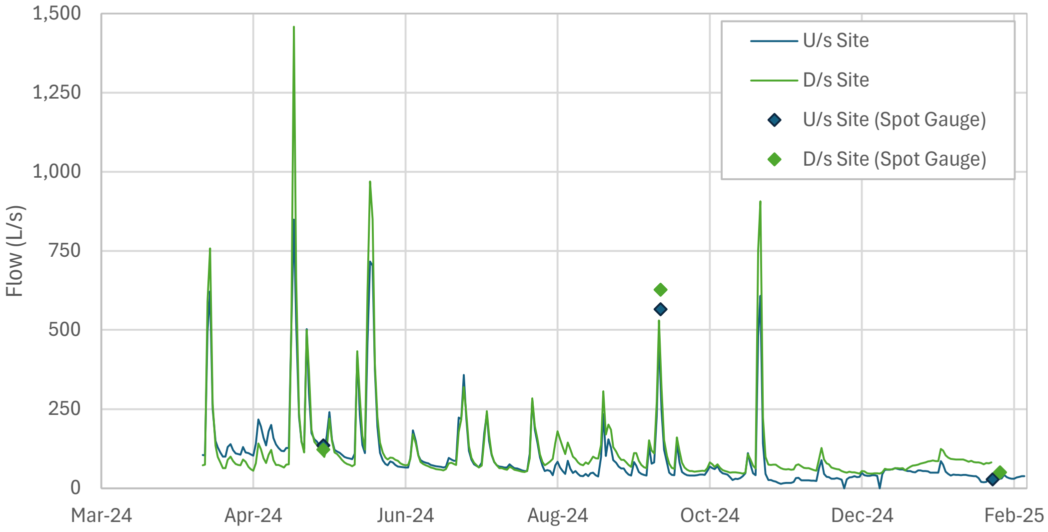


Figure D 3. Mitiwai Stream – rated flow data.

## D.2 Comparison of Measured and Simulated Flows

A comparison of the rated flow data and simulated flow records for the upstream and downstream Mitiwai monitoring sites are presented in **Figure D 4**, and **Figure D 5**, respectively. These plots demonstrate reasonable calibration of the SMWBM to the rated flow data, acknowledging the uncertainty in rated flow data due to the sandy and mobile nature of the stream bed at these locations.

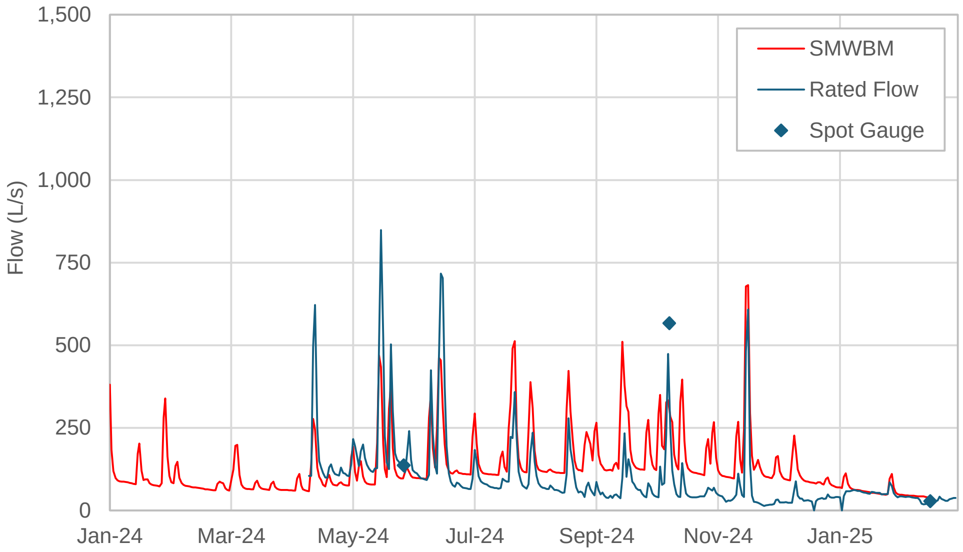


Figure D 4. Comparison of simulated and rated flow for the upstream Mitiwai monitoring site.

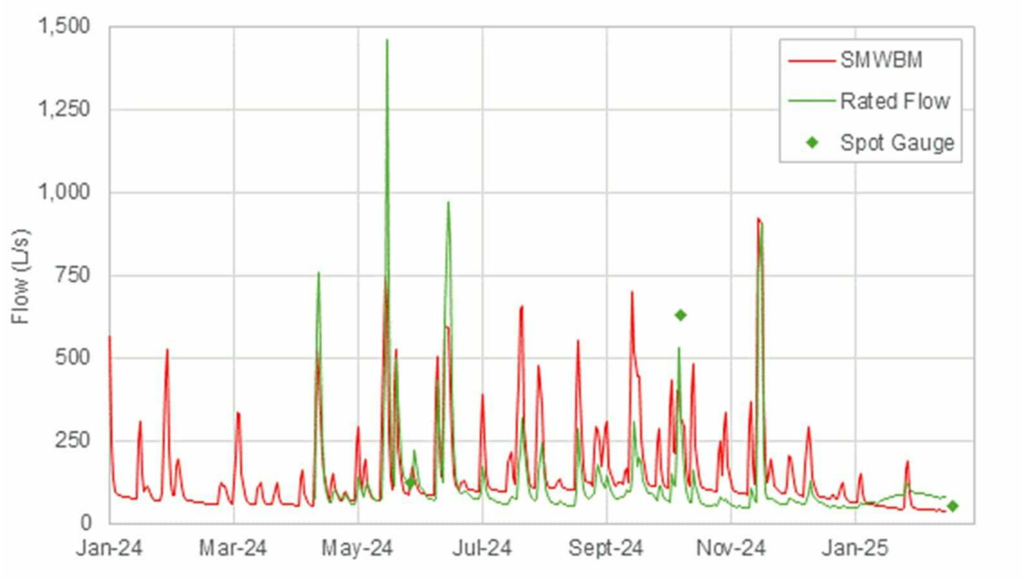


Figure D 5. Comparison of simulated and rated flow for the downstream Mitiwai monitoring site.

## D.3 Simulated Flow Statistics

Simulated streamflow statistics for the downstream Mitiwai site are presented in **Table D 2**.

Table D 2. Downstream Mitiwai – simulated flow statistics.

| Statistic | Flow (L/s) |
|---|---|
| Minimum | 13 |
| Q5 MALF | 31.26 |
| 25th Percentile | 65.24 |
| Median | 95.84 |
| Mean | 151.27 |
| 75th Percentile | 171.49 |
| 95th Percentile | 445.16 |
| Maximum (daily average) | 5,180 |