

RIO TINTO COPPER (RTC)

H3 Hydrogeological Assessment

Winu Project Area

Document no. Rev 1: REP-HG-032

20 March 2025

Level 14, 240 St Georges Terrace
Perth WA 6000
Australia

T: +61 8 9278 8111
Worley Services Pty Ltd
ABN 61 001 279 812

© Copyright 2025 Worley ACN 096 090 158. No part of this document or the information it contains may be reproduced or transmitted in any form or by any means electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from Worley.

[worley.com](https://www.worley.com)



Disclaimer

This report has been prepared on behalf of and for the exclusive use of Rio Tinto Copper (RTC), and is subject to and issued in accordance with the agreement between Rio Tinto Copper (RTC) and Worley Services Pty Ltd. Worley Services Pty Ltd accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party. Copying this report without the permission of Rio Tinto Copper (RTC) or Worley Services Pty Ltd is not permitted.

The information contained in these documents is protected by the Global Data Protection Regulation (GDPR). Worley complies with the provisions of the Regulation and the information is disclosed on the condition that the Recipient also complies with the provisions of the (GDPR). In particular, all of the resumes and the information contained therein, must be kept securely, must be used only for the purposes of assessing the suitability of the individuals to perform the tasks proposed and/or assessing the overall capabilities of Worley to undertake the Work proposed and must be destroyed upon completion of those purposes.

Details on how personal information provided to Worley is processed can be found at <https://www.worley.com/site-services/privacy>.

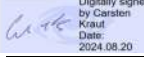
PROJECT 311012-01475 - REP-HG-032: H3 Hydrogeological Assessment - Winu Project Area							
Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev A	For Internal Review	G. Jacobs	C. Kraut	M Simonic	22 July 2024		
Rev B	For Client Review	G. Jacobs	C. Kraut	M Simonic	29 July 2024		
Rev 0	For Client Use	 G. Jacobs	 C. Kraut	 M Simonic	20 August 2024	E. McGivern	
Rev 1	For Client Use	 Gerhard Jacobs	 C. Kraut	 M Simonic	20 March 2025	E. McGivern	

Table of contents

Executive summary	1
Acronyms and abbreviations.....	3
1. Introduction.....	4
1.1 Overview.....	4
1.2 Key objectives	4
1.3 Scope of assessment	5
1.4 Project location and setting	5
1.4.1 Proposed mining operation	7
1.4.2 Topography	9
2. Climate.....	11
2.1 Rainfall, temperature and evaporation	11
2.2 Hydrology	12
2.2.1 Surface water features and drainage.....	12
2.2.2 Surface water quality	13
3. Hydrogeology.....	15
3.1 Geological Overview	15
3.1.1 Regional geology	15
3.1.2 Lithology	15
3.1.3 Geological lineaments	16
3.2 Hydrostratigraphic units and geological structural features	19
3.3 Groundwater recharge	22
3.3.1 Groundwater isotope study	22
3.4 Groundwater levels and flow directions	23
3.5 Discharge and losses	25
3.6 Groundwater surface water interaction.....	25
3.7 Compartmentalisation.....	26
4. Existing groundwater use	27
4.1 Onsite groundwater use at Winu	27
4.2 Other groundwater users.....	27
4.2.1 Pastoral.....	27
4.2.2 Mining – third parties	27
4.2.3 Aboriginal communities	27
4.2.4 Environmental receptors.....	28
4.3 Abstraction and licensing.....	31
5. Groundwater investigations.....	33
6. Drilling.....	34
7. Test pumping	40
7.1 Pumping test locations.....	40
7.2 Step rate tests (SRT)	42
7.3 Constant rate tests (CRT).....	46
7.4 Test results and interpretation	57
7.4.1 WINU0076 (2019)	57
7.4.2 WINU0080	57
7.4.3 WINU0706	57
7.4.4 WINU0708	58

7.4.5	WINU0910	59
7.4.6	WINU0913	61
7.4.7	WINU0917	62
7.4.8	WINU0076 (2023)	63
7.4.9	WINU0925	64
7.4.10	WINU01305	64
7.5	Summary of key findings.....	65
7.6	Aquifer properties compiled from studies and test pumping	66
8.	Groundwater chemistry	68
8.1.1	Unconfined sandstone	68
8.1.2	Metasediments	69
8.1.3	Hydrochemical types.....	69
9.	Groundwater modelling	71
9.1	Hydrogeological conceptual model	71
9.2	Numerical model development	76
9.2.1	Background	76
9.2.2	Approach to numerical model	77
9.2.3	Model platform	77
9.2.4	Model grid	77
9.2.5	Model Layers.....	78
9.2.6	Hydraulic properties	82
9.2.7	Boundary conditions	84
9.2.8	Temporal discretisation	85
9.3	History matching (calibration)	87
9.3.1	Calibration approach	87
9.3.2	Calibration targets	87
9.3.3	Spatial variation of hydraulic properties.....	88
9.3.4	Calibration results.....	88
9.3.5	Calibration of hydraulic properties	94
9.4	Predictive modelling	96
9.4.1	Predictive model setup	96
9.4.2	Dewatering strategy.....	96
9.4.3	Water supply strategy	101
9.4.4	Predicted drawdown at LoM	105
9.4.5	Model water balance	107
9.4.6	Model confidence level classification.....	108
9.5	Uncertainty Analysis	108
9.5.1	Uncertainty analysis approach	108
9.5.2	Dewatering rate uncertainty.....	111
9.5.3	Drawdown uncertainty analysis	114
9.5.4	Groundwater allocation.....	117
9.5.5	Knowledge prioritisation recommendations	117
9.6	Modelling assumptions and limitations	118
10.	Assessment of potential impacts.....	119
11.	Groundwater monitoring.....	121
11.1	Baseline groundwater monitoring, sampling, and analysis	121
11.1.1	Mine operation monitoring	121
11.1.2	Groundwater monitoring program.....	121
11.2	Groundwater monitoring and modelling reviews	123

12.	Site-wide water balance model	124
13.	Conclusion and recommendations	125
13.1	Conclusion.....	125
13.2	Recommendations	126
14.	References	127

Appendices

Appendix A. Mapbook

Appendix B. Surface water chemistry

Appendix C. Bore and drilling logs

Appendix D. Summary tables of production bores, monitoring bores, pressure loggers, and VWP's

Appendix E. Pumping test plots

Appendix F. Aqtesolv Analysis Plots

Appendix G. Calibration hydrographs

Appendix H. Water level hydrographs

Appendix I. Model classification

Appendix J. Parameter frequency histograms

List of tables

Table 2-1:	BoM Telfer Aero Climate data (Worley, 2024c)	11
Table 2-2:	Field water quality parameters obtained from Toramah Soak (Golder, 2021)	14
Table 2-3:	Water quality parameters obtained from laboratory analyses from Toramah Soak (Golder, 2021)	14
Table 3-1:	Lithological descriptions of the main geological units encountered at the Winu study area ..	15
Table 3-2:	Description, thickness, and hydrogeological function of hydrostratigraphic units within the study area.....	20
Table 4-1:	GDE potential around the study area (using data from BoM, 2023).....	28
Table 4-2:	Active groundwater licences within the study area.....	31
Table 5-1:	Hydrogeological reports for the Winu Project	33
Table 6-1:	Summary of bores and sensors installed/deployed at Winu.....	35
Table 6-2:	Summary of bores installed at the regional borefields	36
Table 7-1:	Summary of pumping tests undertaken at the Winu Project.....	40
Table 7-2:	Step rate test results	43
Table 7-3:	Analytical solutions used in Aqtesolv Pro for each pumping test	57
Table 7-4:	Hydraulic properties of the various HSUs collated from previous studies.....	67
Table 8-1:	Annual Quality Monitoring in the Unconfined Aquifer	68
Table 8-2:	Annual Water Quality Monitoring in the Metasediment Aquifer.....	69
Table 9-1:	Conceptual hydrogeology summary	72
Table 9-2:	Numerical model updates	76
Table 9-3:	Numerical model layers.....	79
Table 9-4:	Winu Model Parameterisation.....	82

Table 9-5: Calibration targets.....	88
Table 9-6: Proposed dewatering bore locations (Water supply bores are not included in this table)	97
Table 9-7: Dewatering periods	98
Table 9-8: Proposed water supply bore locations	101
Table 9-9: Dewatering and water supply bore schedule and supply volumes	103
Table 9-10: Steady state, Transient and predictive water balance (ML/day)	107
Table 9-11: Probabilistic terminology used (from Middlemis & Peeters, 2018)	109
Table 9-12: Knowledge prioritisation recommendations.....	117
Table 10-1: Managing potential impacts to water resources and environmental receptors.....	119
Table 11-1: Baseline groundwater monitoring summary	122

List of figures

Figure 1-1: Winu site location.....	6
Figure 1-2: Winu site layout.....	8
Figure 1-3: Topography of the study area	10
Figure 2-1: Average monthly and annual rainfall (by water year) recorded at Telfer Aero (Bureau of Meteorology identification no. 13030) (Worley, 2024c)	12
Figure 2-2 Localised claypan in the Winu east area (S: 20.83, E: 121.86, WGS84)	13
Figure 3-1: Regional bedrock geology and structure (RTX, 2016).....	17
Figure 3-2: Geological lineaments (RTX, 2022) overlain on aeromagnetic data	18
Figure 3-3: Conceptual cross section through Winu	21
Figure 3-4: Groundwater level (m AHD) Winu study area	24
Figure 4-1: Potential environmental receptors and groundwater dependent ecosystems.....	30
Figure 4-2: Groundwater licences surrounding the Winu study area	32
Figure 6-1: Overview of bore locations at Winu.....	37
Figure 6-2: Overview of VWP locations at Winu.....	38
Figure 6-3: Overview of regional bores and borefield locations	39
Figure 7-1: Locations of pumping tests undertaken at the Winu Project	41
Figure 7-2: Step rate test charts for WINU0076 (test no. 1), WINU0080, WINU0706, WINU0708, WINU0910 and WINU0913	45
Figure 7-3: Step rate test data for WINU0076 (test no. 7), WINU0917, WINU0925, and WINU1305	46
Figure 7-4: Maximum displacement during WINU0076 CRT (2019)	47
Figure 7-5: Maximum displacement during WINU0080 CRT	48
Figure 7-6: Maximum displacement during WINU0706 CRT (Golder, 2022a).....	49
Figure 7-7: Maximum displacement during WINU0708 CRT (Golder, 2022a).....	50
Figure 7-8: Maximum displacement during WINU0910 CRT (Golder, 2022b).....	51
Figure 7-9: Maximum displacement during WINU0913 CRT (Golder, 2022c).....	52
Figure 7-10: Maximum displacement during WINU0076 CRT (2023)	53
Figure 7-11: Maximum displacement during WINU0917 CRT	54
Figure 7-12: Maximum displacement during WINU0925 CRT	55
Figure 7-13: Maximum displacement during WINU1305 CRT	56
Figure 7-14: Cross section of VWP locations in relation to WINU0076 pumping test.....	64
Figure 8-1: Piper diagram with bores classified by aquifer	70
Figure 9-1: Winu hydrogeological conceptualisation	75
Figure 9-2: Winu numerical model domain and Voronoi mesh discretisation	80
Figure 9-3: Numerical Model construction and layers.....	81
Figure 9-4: Model parameter ranges (Kh and Sy).....	83

Figure 9-5: Model boundary condition assignment.....	86
Figure 9-6: Calibration statistics (groundwater level and drawdown)	89
Figure 9-7: Simulated water table elevation (steady state)	91
Figure 9-8: Observed vs modelled groundwater levels in monitoring bores.....	92
Figure 9-9: Simulated drawdown at the end of each pumping test	93
Figure 9-10: Kh and Kv values derived from calibration	94
Figure 9-11: Ss values derived from calibration.	95
Figure 9-12: Sy Values derived from calibration	95
Figure 9-13: Dewatering and supply bores around the proposed Winu pit	99
Figure 9-14: Dewatering and target modelled drawdown (cross-section looking north).....	100
Figure 9-15: Predicted groundwater supply volume.....	105
Figure 9-16: Water table drawdown due to dewatering at LoM	106
Figure 9-17: Transient water balance for calibration and predictive modelling	108
Figure 9-18: Parameter frequency histograms for PPIES workflow realisations.....	110
Figure 9-19: RMS and SRMS of individual realisations (no-flow barriers).....	111
Figure 9-20: Predictive uncertainty classes for annual mine dewatering rates.....	112
Figure 9-21: Dewatering rate deviation from the median probability (P50).....	113
Figure 9-22: Probability of 2 m drawdown exceedance during life of mine (No-flow barriers).....	115
Figure 9-23: Probability of 2 m drawdown exceedance during life of mine (Partial flow barriers)	116
Figure 12-1: Median annual site water balance for the HFB 1E-5 (ML/year).....	124

Executive summary

Rio Tinto Winu Pty Limited (RTC) (100% owned by Rio Tinto) is planning to develop a copper-gold mine and associated infrastructure based on the Winu deposit, located approximately 320 km east of Port Hedland in the Pilbara region of Western Australia.

As groundwater supply represents a critical resource for the planned development, characterisation of the local and regional aquifer systems is a key component of the initial baseline assessment in the Winu Project area.

This H3 hydrogeological report presents the findings of the hydrogeological investigations, the derived hydrogeological conceptualisation, and the results of groundwater modelling completed to assess the potential impact of mine dewatering.

Groundwater assessments between 2018 to 2024 has provided an understanding of the local hydrogeology and allowed the development of a robust conceptual and numerical groundwater model.

The numerical groundwater model provides LOM dewatering rates, including a probabilistic assessment of model uncertainty, using the approach based on Middlemis and Peeters (2023). The key outcomes are:

- It is likely (P50) that:
 - a. predicted dewatering requirements range from 80 to 250 L/s and averages at 105 L/s over LoM
 - b. the project water balance is positive (i.e. net excess) for most years and excess water management will be required
 - c. up to 0.57 GL/a makeup water will be required in some years (after Year 17).
- It is unlikely (P33 and P67) that:
 - a. inflow to the open pit ranges by greater or less than 10% from predicted inflows based on parameter uncertainty
 - b. the project water balance is slightly positive (i.e. net excess) for most years and excess water management will be required
 - c. makeup water will be required after Year 13.
- It is very unlikely (P10 and P90) that:
 - a. predicted dewatering requirements range by greater than 40% from predicted inflows
 - b. up to 2 GL/a makeup water may be required in some years
 - c. that the groundwater regime will be impacted by more than 2 m drawdown:
 - i. beyond 15 km of open pit mining of CB_6
 - ii. no sensitive receptors will be impacted, including the regional Soaks (during mining).

Parallel hydrogeological investigation work has identified the Rimfire Borefield area as potentially suitable for supplying up to 2.8 GL/a of makeup water.



The numerical model predicts little to no drawdown impacts away from the mine area or anywhere near identified receptors as a result of dewatering and the pumping of Rimfire at 2.8 GL/a over the full LoM (conservative assumption).

Effective water management planning around mine dewatering and water supply pumping (as well as excess water management) for the project will require a groundwater licence (GWL) allocation of 7.82 GL/a. This will cover the predicted total groundwater abstraction for the peak water use years.

Total groundwater allocation will be much less than this in many years. Ongoing dewatering operation (and ongoing model validation/recalibration efforts) may necessitate some changes to predicted dewatering/water supply requirements.

Acronyms and abbreviations

Acronyms and abbreviations	Definition
BoM	Bureau of Meteorology
BTOC	Below top of casing
CRT	Constant-rate test
DO	Dissolved oxygen
DoW	Department of Water
DWER	Department of Water and Environmental Regulation
EC	Electrical conductivity
EPZ	Enhanced permeability zone
EVT	Evapotranspiration
GDE	Groundwater Dependent Ecosystem
GL/a	Gigalitre per annum
GWL	Groundwater licence
HSU	Hydrostratigraphic unit
IDE	Inflow Dependent Ecosystem
Kh	Horizontal hydraulic conductivity (m/d)
Kv	Vertical hydraulic conductivity (m/d)
m BGL	Metre below ground level
mg/L	Milligram per litre
ORP	Oxidation-reduction potential
Pre-min mafic sill	Pre-mineralisation mafic sill
RC	Reverse circulation
RTC	Rio Tinto Winu Pty Limited
S	Storage (dimensionless)
SRT	Step-rate test
Ss	Specific storage (1/m)
Sy	Specific yield (dimensionless)
TA	Total alkalinity (mg/L)
TDF	Thorny Devil Fault
TSF	Tailings storage facility
VWP	Vibrating wire piezometer
WRL	Waste rock landform

1. Introduction

1.1 Overview

Rio Tinto Winu Pty Limited (RTC) (100% owned by Rio Tinto) is planning to develop a coppergold mine and associated infrastructure based on the Winu deposit, located approximately 320 km east of Port Hedland in the Pilbara region of Western Australia.

The Winu Project encompasses a vein and breccia-hosted copper and gold deposit discovered by Rio Tinto Exploration (RTX) in 2017. The ore body is situated below the water table and will be mined from an open cut pit, with planned depth of ~450 m BGL.

The Winu Project (the Project) is located on land where native title is held by the Nyangumarta and Martu peoples.

As groundwater supply represents a critical resource for the planned development, characterisation of the local and regional aquifer systems is a key component of the baseline assessment in the Winu Project area.

Worley was engaged by RTC to support hydrogeological investigations and improve understanding of groundwater resources and potential impacts associated with the Winu Project.

Development of the project will require water management activities to be implemented, including:

- Dewatering and potential depressurisation to enable mining below water-table
- Water supply, proposed to be taken from a combination of bores (borefields) in the immediate and regional Winu area Surplus water management, where dewatering exceeds demand for peak periods.

This H3 hydrogeological report presents the findings of the hydrogeological investigations, the derived hydrogeological conceptualisation, and the results of groundwater modelling completed to assess the potential impact of mine dewatering and recovery post-closure.

1.2 Key objectives

The key objectives of this assessment were:

- Refine the hydrogeological conceptualisation of the Winu Project area
- Support the application of a 5C abstraction license, for up to 7.82 GL/a for the duration of mining
- Inform the Water Management Plan for the life of the Project (LoP)
- Inform the regulatory project approval process for the Project

1.3 Scope of assessment

To meet the objectives outlined in Section 1.2, the follow scope of works has been completed:

- Review and consideration of historic hydrogeological assessments of the project area
- A field hydrogeological investigation program involving drilling and pump testing of production bores and monitoring bores,
- Development and refinement of a hydrogeological conceptualisation for the Project area
- Development of a new numerical model for estimation of dewatering rates and impact assessment
- Identification of groundwater management strategies and monitoring requirements

This report has been prepared according to the requirements of the Department of Water and Environmental Regulation (DWER) Policy 5.12 for detailed hydrogeological assessment (H3).

1.4 Project location and setting

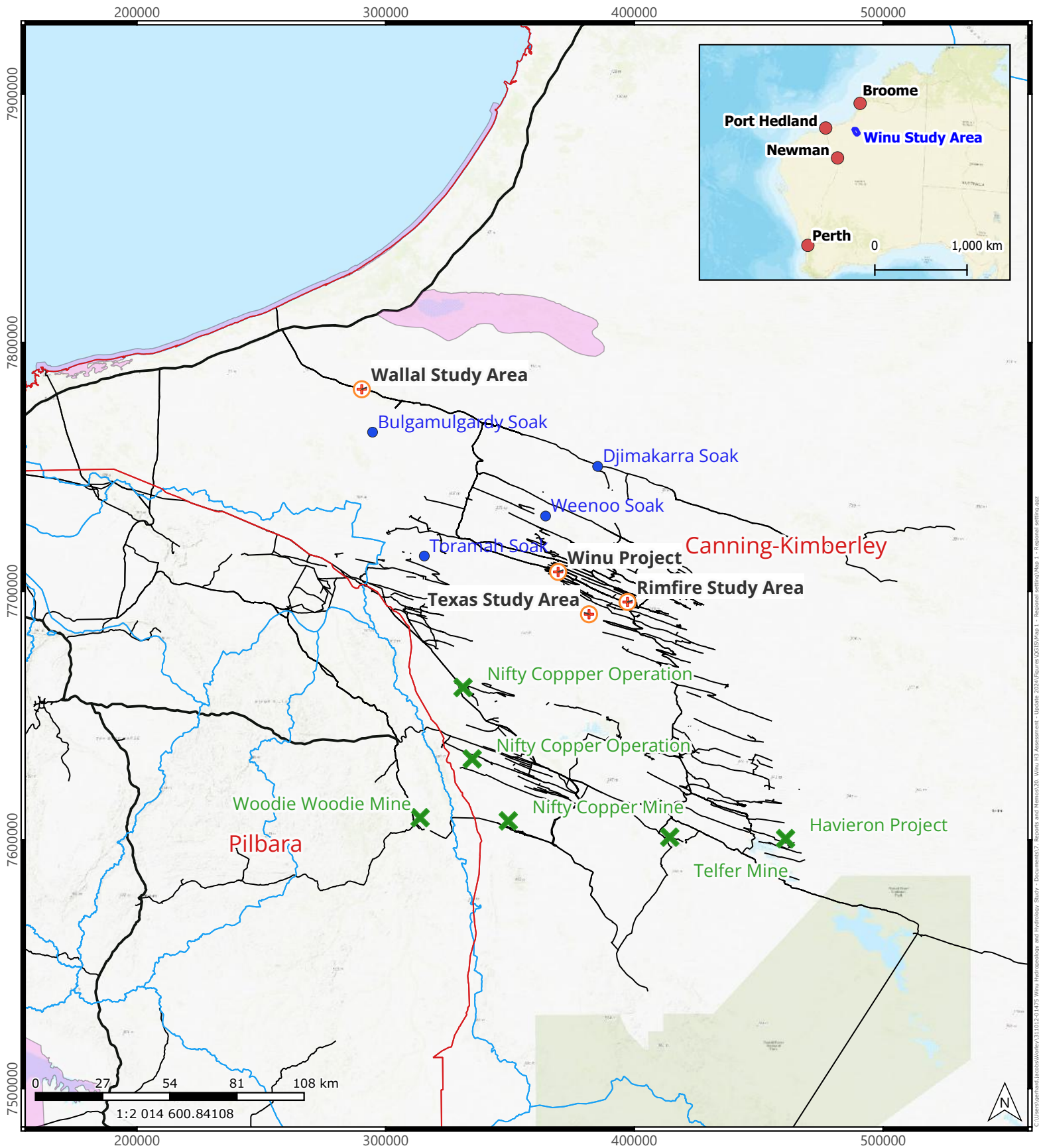
The Winu project is situated in the Great Sandy Desert within the Canning-Kimberley Groundwater Management area (Figure 1-1). The Project covers 37,354 ha area across multiple tenements.

The Project is within the Nyangumarta People Exclusive Native Title determination (WAD6281/1998), which includes the Nyangumarta Warrarn Indigenous Protection Area. The aerodrome is located to the south within the Martu Ngurrara native Title determination (WAD6110/1998) (Map 1, Appendix A).

Pastoral activity is active in the nearby coastal areas, primarily cattle stations including Wallall Downs, Pardoo station, and Eighty-Mile station.

The nearest Aboriginal Communities are Warralong (~220 km west of Winu); Punmu (~205 km southeast of Winu); and Yandaringa (~185 km north of Winu) (Department of Planning, Lands and Heritage, 2020).

Operating mines surrounding Winu include Woodie manganese (110 km southwest), Telfer gold mine (120 km south-southeast) and Havieron gold mine is under development (150 km southeast).



Legend

- Mining_Receptors
- WRIMS - Groundwater Areas
- Ramsar Sites
- Soaks
- Site Locations
- Regional catchment
- Road_Network
 - Local Road
 - State Road
 - Winu Tracks
- ESRI Topo

Regional Setting

Winu Hydrology/Hydrogeology Study

Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	1-1

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 15/05/2024, 14:35

References

Consultant



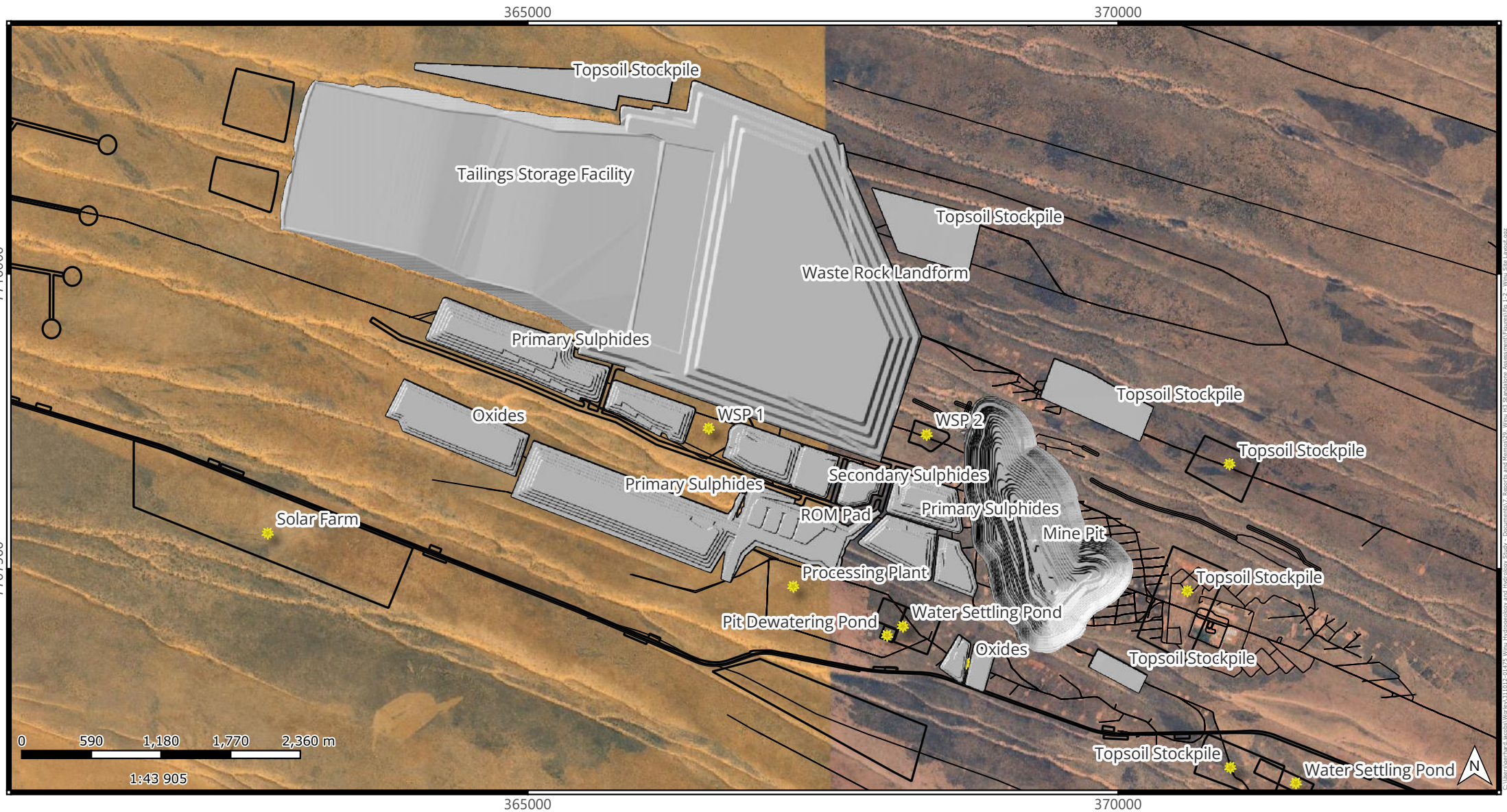
Client

RioTinto

1.4.1 Proposed mining operation

The Winu project will incorporate both mining and mineral processing on site. The proposed layout for mining infrastructure and excavated materials is shown in Figure 1-2 and mining operations will require the construction and development of:

- Processing plant
- An opencut mine pit
- Waste rock landforms (WRLs), tailings storage facilities (TSFs), and landfill
- Access roads
- Aerodrome
- Administration buildings
- Accommodation camp
- Stockpile and laydown areas
- Water supply borefield(s), dewatering bores and monitoring bores
- Water transfer infrastructure and excess water disposal facilities
- Fuel storage facilities



Legend

- Unused
- Site Infrastructure
- Proposed Mine Layout
- Winu Tracks

Proposed Site Layout

Winu Hydrology/Hydrogeology Study		
Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	1-2
Notes:		References
Project CRS: GDA94 / MGA zone 51		-
Last Saved: 26/07/2024, 09:34		
Consultant		Client

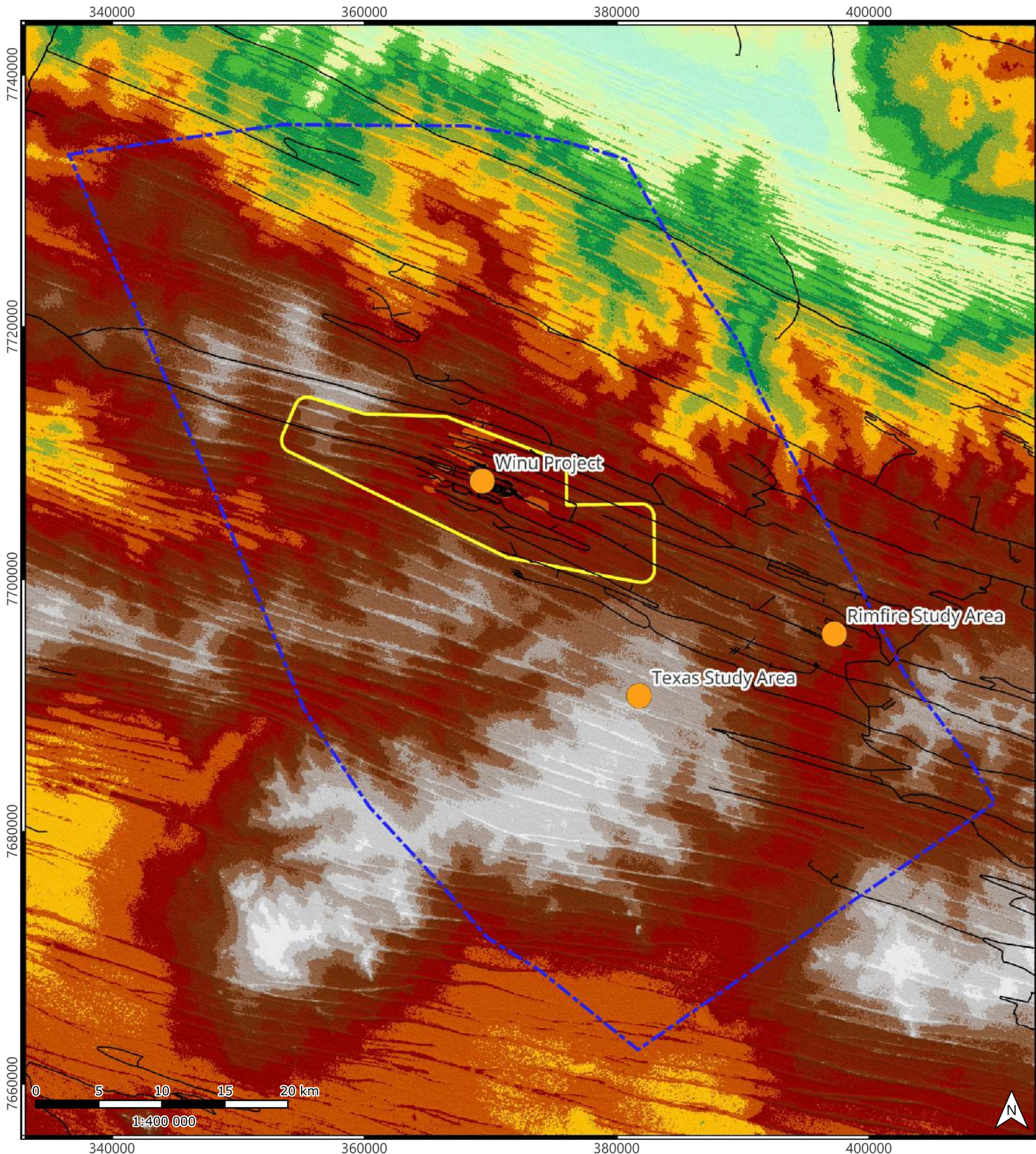
© Worley Pty Ltd While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

1.4.2 Topography

The area comprises flat to gently undulating red sand plains, with occasional clay pans and gravel pisolite cover. Narrow longitudinal dunes, oriented in a west-northwest to east-southeast direction, occur throughout the area. The dunes are typically 5 to 15 m high, with a width of between 30 to 50 m.

Surface elevations surrounding Winu are relatively planar and gently slope in a north-westerly direction towards the Indian Ocean coastline. Topography ranges between 245 to 300 m AHD (Figure 1-3).

A combination of LiDAR data and elevation data from the Shuttle Radar Topography Mission (SRTM- spatial resolution of 1-arc second, approximately 30 m) were used for the larger study area.



Legend

- Site Locations
- Winu Model Boundary
- Winu Tracks
- LiDAR Data Extent

Elevation (m AHD)

- ≤ 180
- 180 - 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240

- 240 - 250
- 250 - 260
- 260 - 270
- 270 - 280
- 280 - 290
- 290 - 300
- 300 - 310
- 310 - 320
- > 320

Topography

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 1-3
-----------------------------	----------------------------	-------------------

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 13/05/2024, 16:44

References

Consultant



Client

RioTinto

2. Climate

2.1 Rainfall, temperature and evaporation

The Project is located in an arid environment within the Great Sandy Desert bioregion of Western Australia, which can experience high intensity rainfall events often associated with cyclonic activity, typically between the months of December and April.

The nearest BoM rainfall station Telfer Aero (ID: 13030) is located 100 km south of the Winu (Map 2, Appendix A), where daily rainfall data has been recorded from January 1974 to the present.

Figure 2-1 presents the annual rainfall by water year (October to September) and monthly rainfall totals over the same period. The overall average annual rainfall (by water year) is 362 mm. Higher rainfall was recorded for the period from 2000 to 2019 (average 393 mm), before again trending to the lower long-term average (362 mm) since 2019 (Worley, 2024c).

Variability in annual rainfall experienced in the region is substantial, with some years annual totals occurring practically in one or two months.

Key climatic information from the BoM database is presented Table 2-1.

Table 2-1: BoM Telfer Aero Climate data (Worley, 2024c)

Parameter	Value
Mean annual rainfall	362 mm/y
Average evaporation	4,125 mm/y
Average maximum and minimum temperature in January	36.5 °C and 21.1 °C
Average maximum and minimum temperature in July	18.6 °C and 5.5 °C

The average maximum and minimum temperatures in January are 36.5 °C and 21.1 °C respectively, and the average maximum and minimum temperature in July are 18.6 °C and 5.5 °C respectively.

Average evaporation between 1974 and 1995 (recorded at the Telfer Aero weather station) was 4,125 mm/yr, which is approximately 10 times higher than the average annual rainfall.

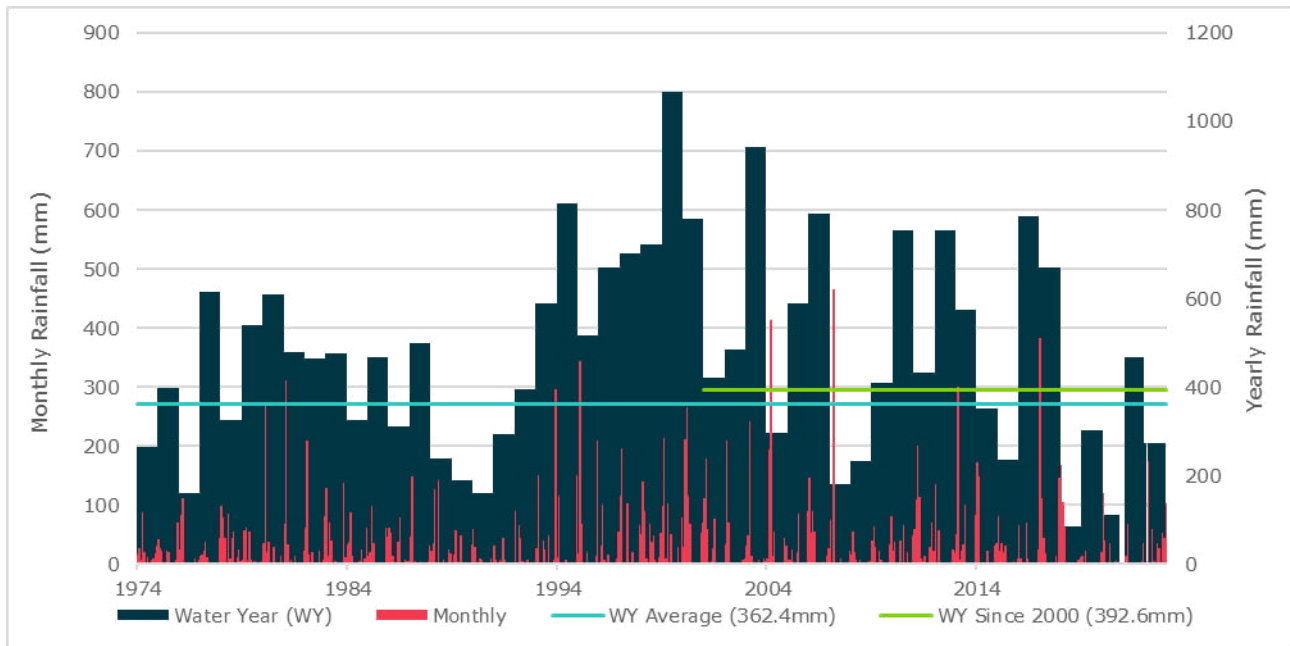


Figure 2-1: Average monthly and annual rainfall (by water year) recorded at Telfer Aero (Bureau of Meteorology identification no. 13030) (Worley, 2024c)

2.2 Hydrology

2.2.1 Surface water features and drainage

With the dune dominated topography across the Winu area and aeolian sand cover extending to depths of 10 m BGL, there are no clearly defined surface water courses.

However, internal drainage systems have resulted in the formation of several claypans across the region, which are likely associated with localised areas of ephemeral, perched water tables which express at surface after high rainfall events (Figure 2-2).

Surface water features are otherwise sparsely located in the region surrounding Winu (Map 3, Appendix A). These include:

- Soaks: Weenoo, Toramah, Djimakarra and Bulgamulgardy Soaks
- Claypans: South-east of Winu mining area
- Oakover River located approximately 100 km west of Winu
- Mandora Salt Marsh Ramsar wetland area located over 100 km north of Winu
- Lake Waukarlycarly located approximately 60 km south of Winu
- Wallal and Percival palaeovalley systems (WASANT, 2012)



Figure 2-2 Localised claypan in the Winu east area (S: 20.83, E: 121.86, WGS84)

2.2.2 Surface water quality

With the ephemeral nature of surface water at Winu, no surface water quality data has been collected within the Winu Project area. However, in May 2021 Golder (Golder, 2022a) undertook water sampling at the Toramah Soak (54 km west of the Winu Project). The soak was dry during the time of sampling, however shallow groundwater was collected from a hand-augered hole at a depth of 0.72 m.

The appearance of the soaks and their physical setting is analogous to those of the claypans which occur to the west and south of the study area and may provide an indication of surface/shallow groundwater quality data for the Winu area, although with the large distances between Toramah Soak and the Project area, there may also be significant differences in various water quality parameters.

Consistent with the previous conceptualisation reported in Golder (2022), these surface water features are interpreted as localised features formed by surface water runoff, separate from the much deeper regional water table.

Field water quality parameters obtained from the Toramah Soak are presented in Table 2-2 and key parameters from the laboratory analyses are provided in Table 2-3. Laboratory analytical reports are provided in Appendix B.

Table 2-2: Field water quality parameters obtained from Toramah Soak (Golder, 2021)

Field Parameter	Unit	Value
Temperature	°C	26.4
pH	pH Unit	9.6
Electrical Conductivity (EC)	µS/cm	11.5
Total Dissolved Solids (TDS)	mg/L	7,286
Oxygen Reduction Potential (ORP)	mV	48.1
Dissolved Oxygen (%)	%	22.2
Dissolved Oxygen (mg/L)	mg/L	1.71

Table 2-3: Water quality parameters obtained from laboratory analyses from Toramah Soak (Golder, 2021)

Parameter	Unit	Value
pH	pH unit	9.42
EC (@ 25°C)	µS/cm	11,800
TDS (@ 180°C)	mg/L	8,370
Suspended solids	mg/L	94,700
Turbidity	NTU	46,800
Calcium	mg/L	2
Magnesium	mg/L	<1
Sodium	mg/L	2,450
Potassium	mg/L	431
Total Alkalinity as CaCO ₃	mg/L	3,350
Sulfate as SO ₄ (turbidimetric)	mg/L	997
Chloride	mg/L	1930

In summary, the results show:

- Relatively high salinity (saline to highly saline) likely as a result of evapoconcentration of the surface water and shallow groundwater
- Sodium-chloride/carbonate hydrochemical type, with negligible calcium/magnesium content
- High alkalinity/bicarbonate concentrations
- Basic pH value (9.4 pH) compared to groundwater at Winu (which typically ranges between pH 7 and 8)
- Elevated concentrations of aluminium and iron (total dissolved metals)

3. Hydrogeology

3.1 Geological Overview

3.1.1 Regional geology

The Winu study area is situated within the Anketell Shelf subdivision of the Canning Basin, which comprises metasedimentary and igneous intrusive rocks.

The Winu project area is located along the eastern margin of the Anketell fault, which forms a distinct structural boundary separating the stratigraphic units of the Barnicarndy Graben (previously named Waukarlycarly Embayment by GSWA in 2021) in the west, to those of the Anketell Shelf in the east.

Regional tectonic movement and development of the present-day Anketell Shelf and Barnicarndy Graben created structural, brittle deformations within the Proterozoic basement (metasediments). The brittle deformations are inferred to have enhanced permeability in both the fresh and weathered metasediments (Golder, 2022a).

A broad scale bedrock geology and structural map of the north-eastern Paterson Province encompassing the Winu project area has been produced by RTX (2016) and is shown Figure 3-1.

3.1.2 Lithology

There are six (6) key identified geological units at Winu. These are described in Table 3-1 from surface to deepest (youngest to oldest), with typical unit thicknesses based on drilling data acquired during the field campaigns. Bore logs of the hydrogeological bores completed to date are included in Appendix C.

Table 3-1: Lithological descriptions of the main geological units encountered at the Winu study area

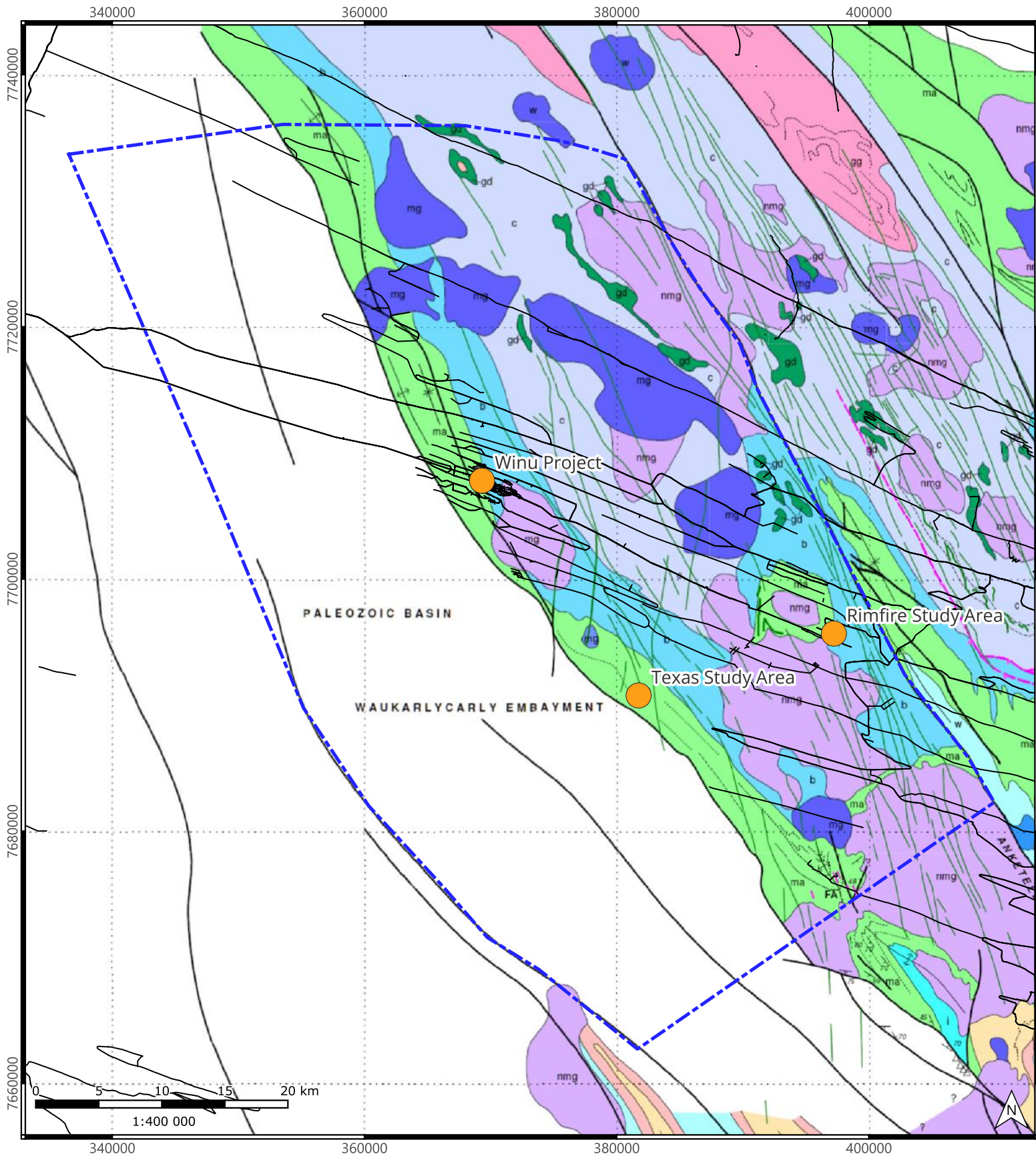
Lithology	Thickness (m)	Description
Quaternary aeolian sand	0 to 10	Very fine to medium grained aeolian sand, typically reddish-brown, well sorted, minor silt
Unconfined sandstone and silcrete	10 to 30	Silty sandstone with high silt content reducing with depth, quartz sand grains, colour ranges between white to pink, fine to coarse grained, poorly sorted, subangular to subrounded grains Silcrete and hematitic silcrete (ferricrete) typically occur within the top 10 to 20 m of the interval, colour ranges between white to reddish brown
Permian Mudstone	0 to 500	Very fine, reduced to oxidised Mudstone, present to the west of the main Winu area. Regional interpretations of Czarnota et al. (2009), report the depth to basement to the west of the Anketell Shelf as generally less than 250 m, whilst the interpretation by Alavi (2013) notes a depth of up to 500 m. This unit pinches out to the east and is a discontinuous, low permeability unit, incorporating clay, claystone, diamictite, and conglomerate (fine-grained, matrix supported) facies

Lithology	Thickness (m)	Description
Mafic intrusions within the Proterozoic metasediments	5 to 40	Black to grey, fine grained, slightly weathered to fresh, hornblende phenocrysts, micaceous/schistose in some intervals
Granite and felsic intrusions within the Proterozoic metasediments	>100	Moderately weathered to highly weathered granite/felsic intervals, typically occurring between 20 and 80 m BGL, light brown to tan, occurs as variably consolidated sandy silt comprising quartz and feldspar grains, little to no biotite visible, fines content reducing with depth as weathering decreases. Fresh granite underneath the weathered horizon.
Proterozoic metasediment	> 300	Moderately weathered to fresh metasedimentary intervals, medium grained, dark grey, biotitic, Metasiltstones and Metasandstones

3.1.3 Geological lineaments

In structural (or fractured rock) aquifers, groundwater is stored in the fractures, joints, bedding planes and cavities of the rock mass. RTX (2022) produced a regional structural dataset delineating lineaments around the Paterson region, based on interpretation of drilling and geophysical data and mapped local and regional structures (faults, dykes etc). These structures have been overlain on a regional aeromagnetic dataset which show a strong correlation with several magnetic zones and lineaments (Figure 3-2).

These lineaments generally show a strong northwest to southeast trend, with minor faults cross cutting major structures. Lineaments likely comprise faults and fractures which have the potential to store and convey water. Previous studies (Advisian, 2022a) and (Advisian, 2023d) show a correlation between structures and higher yielding bores.



Legend

- Site Locations
- Winu Model Boundary
- Winu Tracks

nmg	Non-magnetic granitoid
mg	Magnetic granitoid
gd	Gabbro/diorite sill
w	WILKI FORMATION + Kaliranu beds
g	GARDENS FORMATION
p	PUNTA PUNTA FORMATION
m	MALU FORMATION
i	ISDELL FORMATION
b	BROADHURST FORMATION
c	COOLBRO FORMATION
gg	Granulite/gneiss

Bedrock Geology and Structure

Winu Hydrology/Hydrogeology Study

Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	3-1

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 14/05/2024, 11:17

References

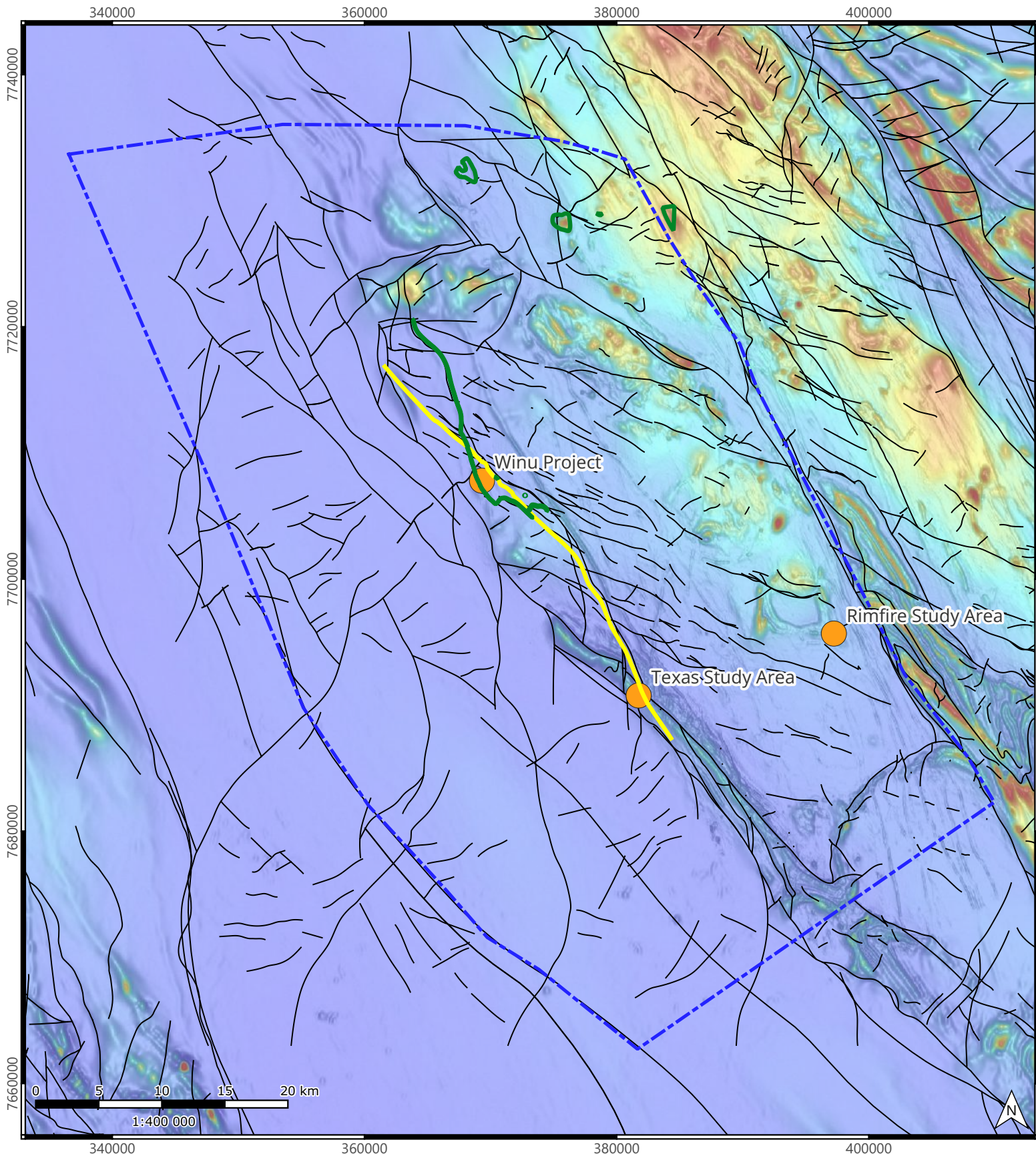
RTX, 2016

Consultant



Client

RioTinto



Legend

Site Locations

Winu Model Boundary

Thorny Devil Fault

Pre-min Mafic Sill

Paterson Structure March 2022

citadel_regional_tmi_rtp_vsun_psc_FULL RES

Band 1 (Red)

Band 2 (Green)

Band 3 (Blue)

Geological Lineaments

Winu Hydrology/Hydrogeology Study

Project No.
311012-01475

Client
Rio Tinto Copper

Figure No.
3-2

Notes:

Project CRS: GDA94 / MGA zone 51

Last Saved: 21/05/2024, 13:11

References

RTX, 2022

Consultant

worley
consulting

Client

RioTinto

3.2 Hydrostratigraphic units and geological structural features

With the results from drilling programs between 2019 and 2024 the study area has been divided into seven (7) hydrostratigraphic units (HSU) based on lithology and their hydrogeological function.

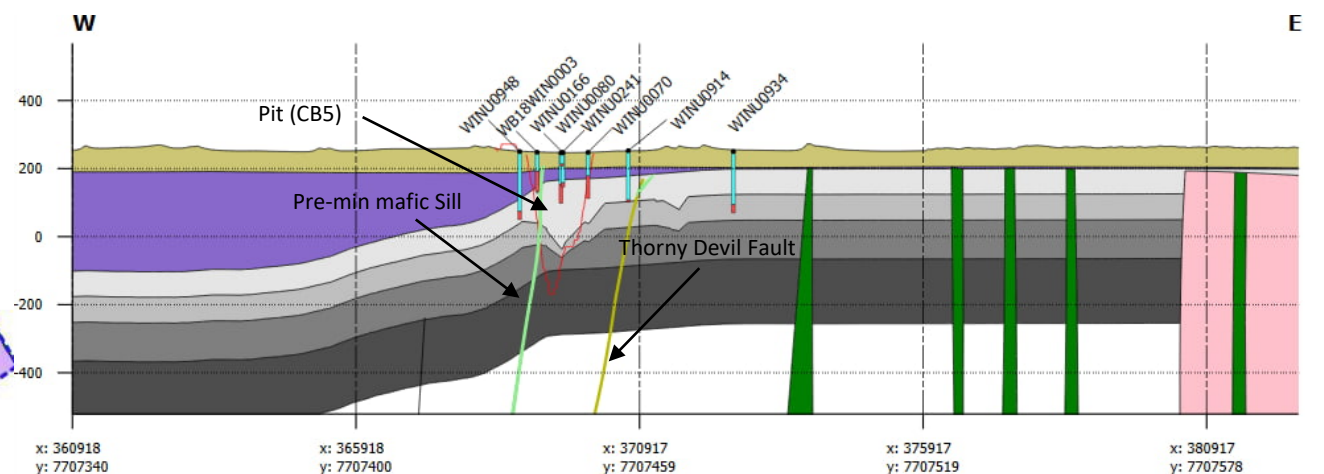
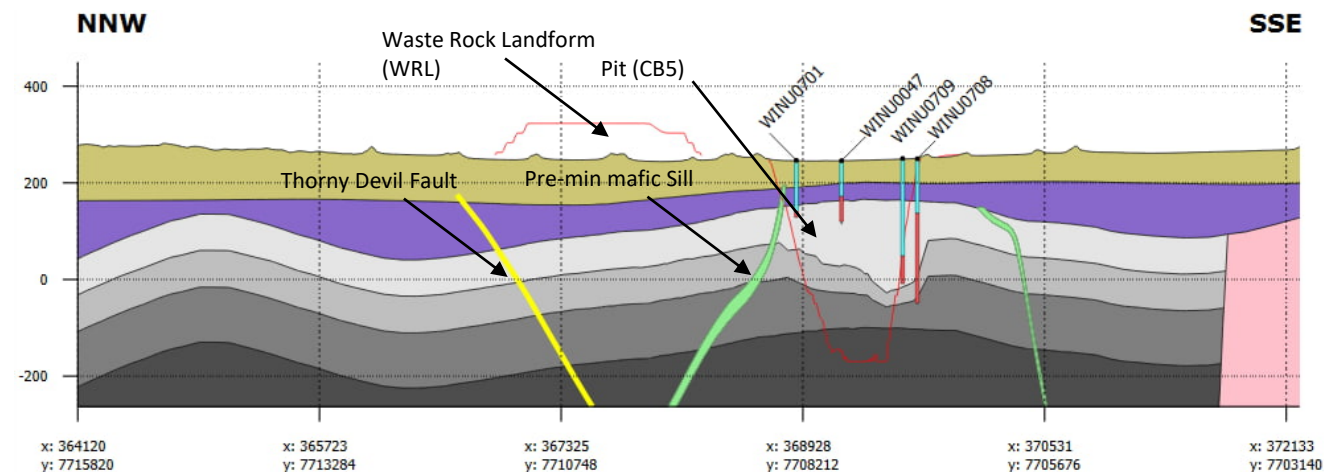
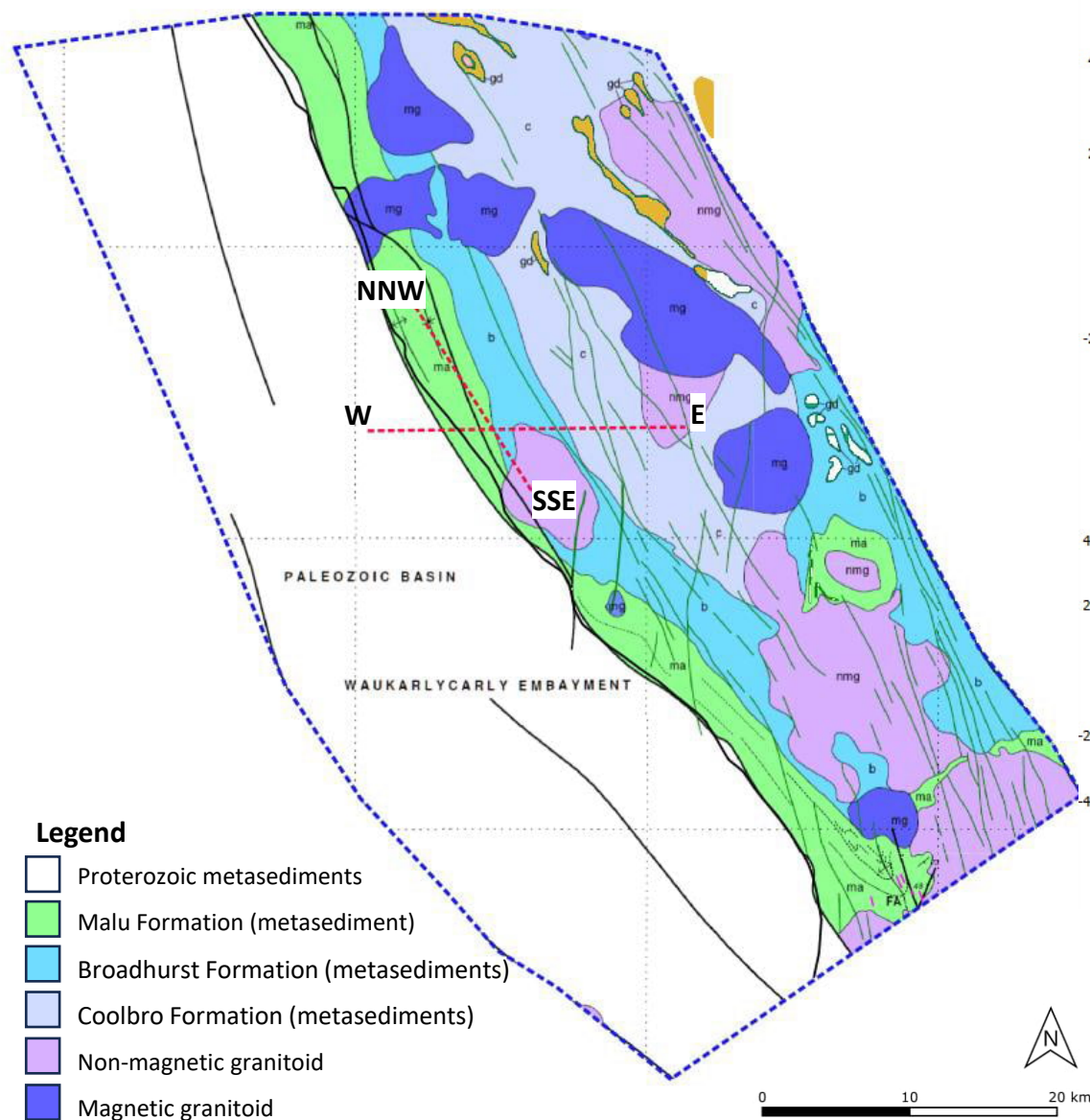
The lithologies intersected at Winu are:

- Quaternary aeolian sands generally 5 to 10 m thick, however, can be up to 30 m thick under dunes and largely unsaturated
- Silcrete/ferricrete up to 20 m thick and largely unsaturated
- Unconfined Sandstone up to 60 m thick – partially saturated. The water table near Winu occurs around 50 to 60 metres below ground level (m bgl), near the base of the unconfined aquifer.
 - Department of Water (DoW, 2012) describes this aquifer as the Wallal Aquifer (unconfined) groundwater resource, largely unsaturated
 - Referred to herein as the “Unconfined Sandstone aquifer”
- Permian Mudstone occurs to the west. Regional interpretations of Czarnota et al. (2009), report the depth to basement to the west of the Anketell Shelf as generally less than 250 m, whilst the interpretation by Alavi (2013) notes a depth of up to 500 m.
 - This unit pinches out to the east and is a discontinuous, low permeability confining unit (aquitard), incorporating clay, claystone, diamictite, and conglomerate (fine-grained, matrix supported) facies.
- Proterozoic metasediments include metasilstone and metasandstone, typically thicker than 300 m, classified as a fractured rock aquifer and includes both an upper ‘weathered’ and lower ‘fresh’ (unweathered) profiles. Secondary porosity and permeability occur in the metasediments due to weathering, fracturing, and faulting.
 - Mafic intrusive units encountered at several locations are considered relatively sparsely distributed and unlikely to act as significant confining units. However, locally, they may behave as partially impermeable flow barriers and partly compartmentalise groundwater flow.
- Granitoid igneous intrusions surround Winu to the north, northeast, and south hosted within the Proterozoic metasediments. These are interpreted to act as a low permeability facies and inhibit groundwater flow in the metasediment aquifer, where present.
- As discussed in Section 3.1.3, lineaments likely comprising faults and fractures which have the potential to store and convey water are the primary water supply targets in the Winu area.
- The current hydrostratigraphic interpretation of the hydrogeological units in the Winu area is summarised in Table 3-2.

A conceptual cross section across the Winu area, showing the spatial configuration of the various units, is included in Figure 3-3.

Table 3-2: Description, thickness, and hydrogeological function of hydrostratigraphic units within the study area

Hydrostratigraphic unit (HSU)	Lithology	Thickness (m)	Hydrogeological function	Description
Quaternary aeolian sand	Silty sand, very fine to medium grained	0 to 10	Unsaturated	Occurs over majority of the study area, unsaturated except following periods of increased rainfall
Silcrete/ferricrete	Silcretised sandstone with variable ferricrete	10-30	Unsaturated	Occurs over majority of the study area, unsaturated
Sandstone	Fine to medium grained sandstone	10 to 30	Unconfined sedimentary aquifer	Variable spatial coverage and thickness, partially saturated
Permian Mudstone	Mudstone, claystone, diamictite	0 to 500	Sedimentary aquitard	Discontinuous, low permeability confining unit
Mafic intrusions	Slightly weathered to fresh, hornblende phenocrysts, micaceous/schistose in some intervals.	5 - 40	Intrusive aquitard	These are interpreted to act as a low permeability facies and presumably inhibit groundwater flow in the metasediment aquifer,
Proterozoic metasediment	Moderately to highly weathered metasediment	20 to 80	Fractured aquifer	Divided into different zones due to faulting and weathering. The fresh and weathered zones are inferred to act as a fractured aquifer.
	Slightly weathered to fresh metasediment, massive, fine to coarse grained	> 300		
Granite	Slightly weathered to fresh, granite, generally occurs as quartz, feldspar, and biotite in a matrix	> 100	Intrusive aquitard	These are interpreted to function as a low permeability facies and presumably inhibit groundwater flow in the metasediment aquifer



Scale: 1:88,000
Vertical exaggeration: 6x

0m 2000m

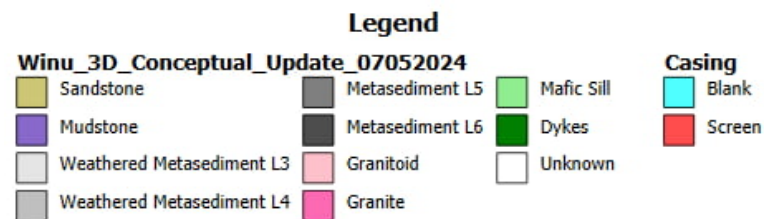


Figure 3-3 Conceptual cross section through Winu

3.3 Groundwater recharge

Recharge to groundwater occurs episodically, mainly in association with cyclonic events where sufficient rainfall has infiltrated into the surficial sediments to overcome the high rates of evapotranspiration.

Groundwater levels measured in WIDI0020 (unconfined sandstone aquifer) and WIDI0016 (unconfined metasediment aquifer) did not show a groundwater level response to cyclonic events since 2019, although the depth to groundwater (50 m to 60 m at these wells) means it will require a very large rainfall event to induce direct rainfall recharge to the aquifer at Winu.

The shallower groundwater encountered regionally (between 5 to 20 m BGL to the south of Rimfire) and absence of a confining layer, means that recharge to the aquifer system is more likely in these areas.

Satellite imagery indicates potential outcrop/subcrop toward the southeast of the Rimfire area which may provide a source of recharge for the groundwater system. The Percival Palaeovalley (Bell, Kilgour, English, Woodgate, & Lewis, 2012) situated immediately south of Rimfire may also provide another source of diffuse groundwater recharge.

Mean and median long-term recharge rate estimates for the metasediment aquifer (assuming a recharge area approximately 15 km to the southeast of Winu) range between 1.5 mm/a (0.4% of annual rainfall) and 8.7 mm/a (2.4% of annual rainfall) depending on the assumptions made about aquifer thickness and porosity (aquifer assumed to be 100 m to 200 m thick with 5-10% porosity).

3.3.1 Groundwater isotope study

Isotope studies have been carried out by Innovative Groundwater Solutions at Winu on behalf of Rio Tinto (IGS, 2021). Isotope samples were collected from 15 bores in the metasediment aquifer and five bores in the unconfined aquifer, and were analysed for tritium, stable isotopes (O-18/deuterium), carbon-14, and strontium $^{87}\text{Sr}/^{86}\text{Sr}$, which were analysed in specialist laboratories.

The results were evaluated to estimate groundwater residence times and likely recharge mechanisms to the aquifers.

Isotope-estimated ages suggest younger groundwater, indicating recharge may be actively locally occurring. IGS (2021) concluded:

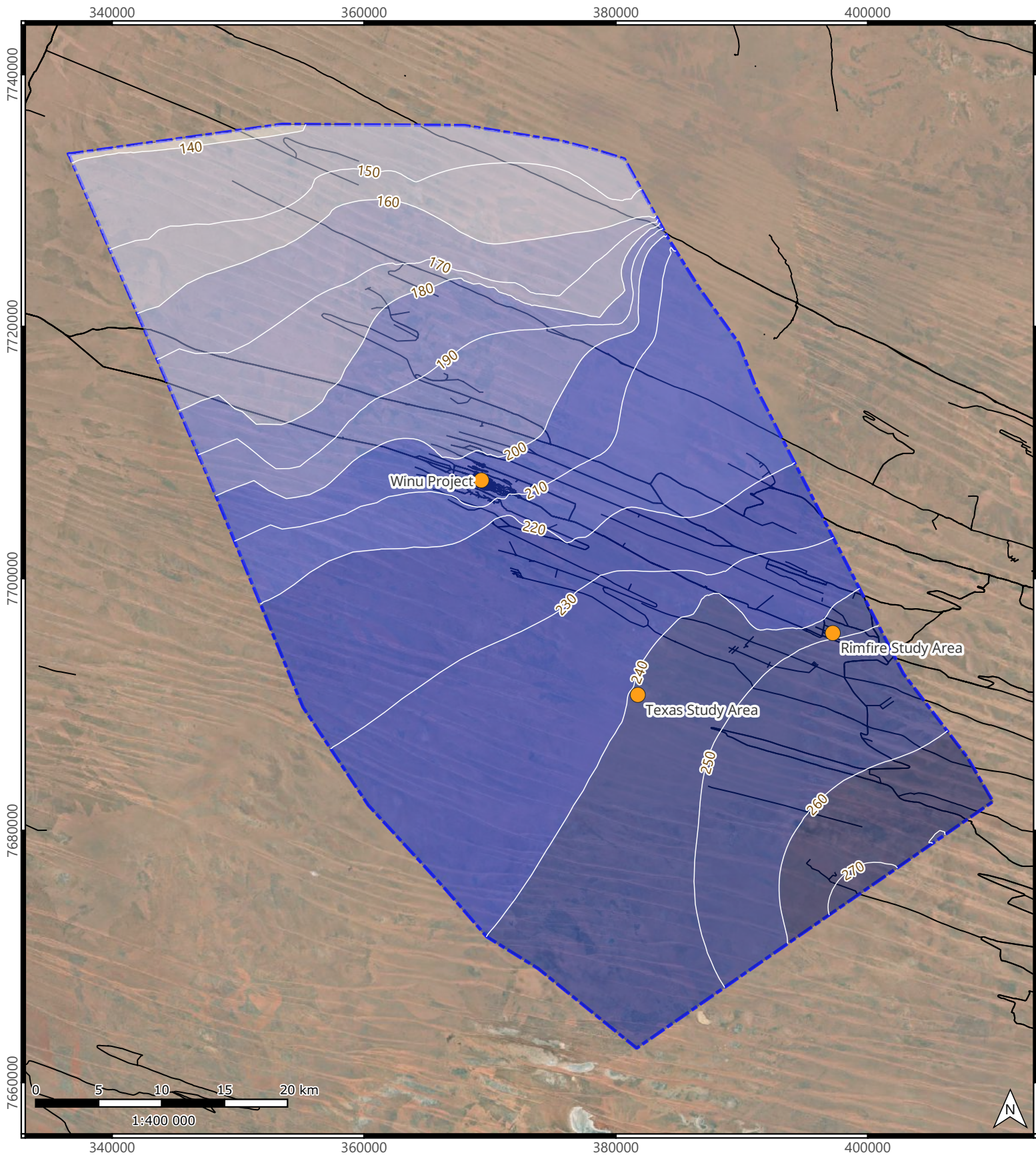
- Residence times of groundwater in the Permian sandstone formation are between 60 and 500 years
- Metasediment aquifer groundwater residence times range between 1,600 years and 10,100 years
- Some mixing of older groundwater with newer groundwater is evident, suggesting that upward leakage from the metasediments aquifer into the unconfined aquifer may be occurring in some locations.

3.4 Groundwater levels and flow directions

Groundwater flow directions are inferred from measured groundwater levels from the observation bores at Winu, Winu aerodrome, Rimfire and Texas areas (Figure 3-4)

The water level data suggest:

- A deep regional water table occurs in unconfined sandstones, with limited saturated thickness observed at Winu, which is situated on the basement high. Little information is available on regional groundwater levels in the unconfined aquifer surrounding Winu.
- A separate unconfined to confined groundwater flow system exists within the metasediments aquifer, with north-westerly throughflow, confined by the 'Permian' mudstone strata at Winu (where present).
- Upward leakage through the mudstone (through silty, weathered, or thin mudstones) is possible from the metasediment aquifer to the unconfined sandstone aquifer, where upward hydraulic gradient from metasediments is present. The IGS (2021) report suggests this is occurring based on isotope analysis from some groundwater bores (WINU0214, WINU0216, and WINU0261).
- Large granitoid intrusions have been mapped using regional gravity survey data within the Proterozoic basement and are assumed to inhibit groundwater flow in the metasediment aquifer where present.
- Regional groundwater flow is in an NNW direction towards the coastline (Indian Ocean), based on available groundwater level data from both aquifers.
- The groundwater gradient across the study area is approximately 0.0016 (i.e., 1.6 m per 1000 m).
- Groundwater levels fluctuate between 252 m AHD (WINU0946) to the southeast (Texas) and 173 m AHD (WINU0928) to the northwest (Winu North).
- Shallow groundwater levels to the southeast (3.82 m BGL) at AKD10 appear to correlate with the occurrence of the Percival Palaeovalley. The Palaeovalley is the lowest topographical feature in the vicinity. The current conceptualisation indicates that AKD10 is situated within a perched watertable correlated to the palaeochannel; and is disconnected from the regional metasediment aquifer.



Legend

- Site Locations
- Winu Model Boundary
- Winu Tracks

Groundwater Level (m AHD)

- <= 140
- 140 - 160
- 160 - 180
- 180 - 200
- 200 - 220
- 220 - 240
- 240 - 260
- > 260

Winu Groundwater Levels (m AHD)

Winu Hydrology/Hydrogeology Study

Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	3-4

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 15/05/2024, 13:44

References

Consultant



Client

RioTinto

3.5 Discharge and losses

The discharge mechanisms within the study area could occur through:

- Lateral outflow
- Evaporation and evapotranspiration
- Groundwater abstraction

Lateral outflow is expected to be the main mechanism of groundwater loss from the area. Using the following parameters, an estimated daily outflow flux (Q) from the study area was calculated using Darcy's law as being 77 m³/d/km, whereby:

$$Q = K * I * A$$

- **K:** Bulk hydraulic conductivity of 0.24 m/d
- **I:** Groundwater gradient of 0.0016 (i.e., 2.5 m decrease over 1000 m)
- **A:** Cross sectional area of 200,000 m² (aquifer saturated thickness of 200 m, length of 1 km)

Evaporation and evapotranspiration (EVT) losses are minor in comparison to lateral outflow due to groundwater levels in the study area generally being below 20 m BGL, well below the likely extinction depth of the EVT processes.

Approximately 2 km south of the study area, coincident with the Percival Palaeovalley (within vicinity of bore AKD10), EVT losses are likely to be present due to the occurrence of shallow groundwater, approximately 4 m BGL. The potential EVT rate is an order of magnitude higher than rainfall, and most of the rainfall will be removed by this process, with the potential exception of rainfall produced during cyclonic events.

The main losses via groundwater abstraction for mining purposes will be the Winu project, when in operation. No other mining operations are known to extract groundwater in the immediate vicinity.

3.6 Groundwater surface water interaction

No significant groundwater surface water interaction is likely to occur within the study area based on the observed water levels >20 m BGL and the absence of any surface hydrological features (i.e., soaks and claypans).

This may change toward the east where groundwater level in bore AKD10 (taken on 21/3/2023) is 3.82 m BTOC. The shallow groundwater occurrence is currently poorly understood; however, it is considered likely a combination of low topography and potentially perched groundwater levels within the Percival Palaeovalley (Bell, Kilgour, English, Woodgate, & Lewis, 2012), or alternatively close to regional recharge area(s).

Groundwater surface water interaction is likely to be spatially constrained to areas with shallow groundwater levels (below 5 m BGL), and temporally constrained during and immediately following periods of intense rainfall and/or cyclonic events.

3.7 Compartmentalisation

Golder (2022a) and IGS (2021) imply that salinity contrasts could not be correlated to any specific features/structures or compartmentalisation. Groundwater salinity patterns at Winu are more predominantly related to depth, with increasing residence times at depth producing higher concentrations.

However, the aquifer testing results indicate that groundwater flow is influenced by linear features, suggestive of at least partial compartmentalisation, characterised by both flow and no-flow boundaries. These boundaries, such as the pre-min mafic sill and the TDF, create distinct compartments within the aquifer system, resulting in significant groundwater level disparities of up to 10 meters observed during testing (WINU0917).

4. Existing groundwater use

4.1 Onsite groundwater use at Winu

There are currently seven (7) active groundwater abstraction sites (operational bores) at Winu with a combined use of approximately 0.06 GL/a (60,000 kL/a) (Worley, 2024b). The total abstraction entitlement available under groundwater license GWL201165(7) is 0.3 GL/a (300,000 kL/a).

Aside from pumping tests, abstracted groundwater is being used at Winu for:

- Potable water supply for the accommodation camp
- Dust suppression and earthworks
- Road construction and maintenance
- Drilling operations and bore construction
- General operation

4.2 Other groundwater users

4.2.1 Pastoral

The online Water Information Reporting (WIR) tool provided by the Department of Water and Environmental Regulation (DWER) for public domain bores did not list any that are used to supply pastoral stations.

Pastoral activity occurs in the nearby coastal areas, primarily cattle stations which include Wallal Downs, Pardoo station, and Eighty-mile station approximately 180 – 200 km northwest.

4.2.2 Mining – third parties

Aside from the local development of the Winu project, the closest third-party mines to Winu are (Map 4, Appendix A):

- Nifty Copper Mine, operated by Cyprium Metals Ltd (110 km south-west)
- Telfer Mine, operated by Newcrest Mining Ltd (120 km south-southeast)
- Havieron Project, JV between Newcrest Mining Ltd and Greatland Pty Ltd (140 km south-east)
- Woodie Woodie Mine, operated by Pilbara Manganese Pty Ltd (110 km south-west)

4.2.3 Aboriginal communities

The nearest Aboriginal communities are Warralong (~220 km west of Winu); Punmu (~205 km southeast of Winu); and Yandaringya (~185 km north of Winu) (Department of Planning, Lands and Heritage, 2020).

No other Aboriginal communities are known to exist near Winu. There are no nearby Aboriginal communities utilising groundwater other than the Kunawarritji Aboriginal Corporation, noted as being 250 km southeast of Winu (Golder, 2022a).

4.2.4 Environmental receptors

The online Groundwater Dependent Ecosystem Atlas (GDE Atlas) tool hosted by BoM was used to identify potential GDEs (aquatic, terrestrial, or subterranean) in proximity to the Winu study area. No mapped or known GDE were identified within the model domain. The closest GDEs are located 25 to 35 km away from the Winu Project (Figure 4-1), with these GDE areas rated as having a low GDE potential, with an IDE likelihood of 3, 4 & 8.

The Inflow Dependent Ecosystem (IDE) rating describes the likelihood of an ecosystem using a source of water aside from rainfall, with ratings between 1 (low) and 10 (high), where a value between 6 (low) and 10 (high), indicates a landscape that is most likely to be accessing additional water sources., such as high soil moisture or shallow groundwater.

A likelihood value of 6 indicates a landscape that is marginally more likely to be accessing an additional source of water than relying solely on rainfall. A value of less than 6 represents a landscape that is more likely to rely solely on rainfall and is therefore not considered inflow dependent.

The Weenoo and Djimaracka Soaks, located 23 km and 45 km northwest of the Winu mine area respectively, were also assessed for GDE potential. Based on the studies undertaken by (Golder, 2022a), these soaks are fed by infiltrated rainfall and surface water runoff collected in topographic depressions and are not groundwater dependent.

A summary table of the GDE areas is provided in Table 4-1. The location of the GDE areas, soaks, and palaeovalley systems are shown in Figure 4-1.

Table 4-1: GDE potential around the study area (using data from BoM, 2023)

GDE ID No.	Distance from Winu (km)	Description	GDE Potential	IDE Likelihood	River Region
1	26	Gravelly sandplains and occasional sand dunes supporting hard spinifex grasslands.	Low	4	Sandy Desert
2	27	Gravelly sandplains and occasional sand dunes supporting hard spinifex grasslands.	Low	3	De Grey River
3	35	Mosaic: Hummock grasslands, low tree steppe; eucalypts over feathertop between dunes / Hummock grasslands, patchy shrub steppe; Acacia pachycarpa over	Low	8	Sandy Desert

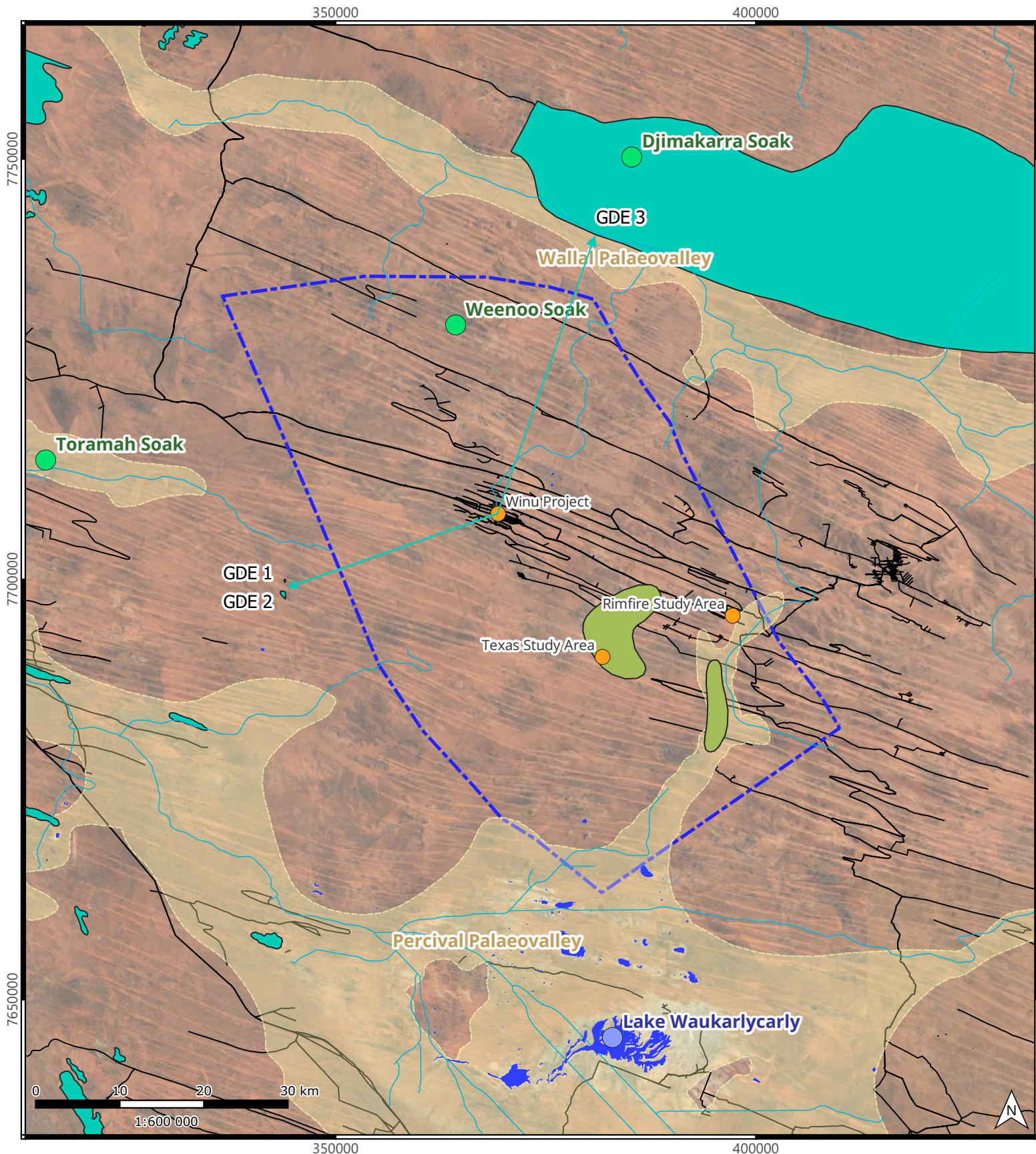
Biota Environmental Sciences, (2022) completed a subterranean fauna desktop study and basic survey to assess the likelihood that stygobitic fauna (stygofauna: aquatic subterranean fauna) or troglobitic fauna (troglofauna: air-breathing fauna above water table) occur within the study area.



The study was based on collated information from government databases, previous sampling and publicly available information. The basic survey also involved low intensity sampling for troglofauna and stygofauna within the study area to verify the findings of the desktop study.

No troglobitic or stygobitic fauna were found at Winu to date. The Biota Environmental Sciences (2022) report concluded that it is unlikely that subterranean fauna occur in most geological units of the study area.

Recent sampling at Texas and Rimfire has found indications of stygofauna, however, further work is required to understand the species and potential habitats.



Legend

- Site Locations
- Lake Waukarlycarly
- Soaks
- Winu Model Boundary
- Winu Tracks
- Surface Drainage
- WASANT Palaeovalleys 2012
- Terrestrial_GDE
- Claypan Occurrence Area
- Waterbody

Potential Environmental Receptors

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 4-1
-----------------------------	----------------------------	-------------------

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 21/05/2024, 15:07

References

Consultant



Client

Rio Tinto

4.3 Abstraction and licensing

There are five (5) active (5C) groundwater licences within the study area, of which four (4) licences are issued to Rio Tinto Exploration Pty Ltd (licence 201165 is utilised by RTC at Winu). A summary of the active licences is presented in Table 4-2, and shown spatially in Figure 4-2.

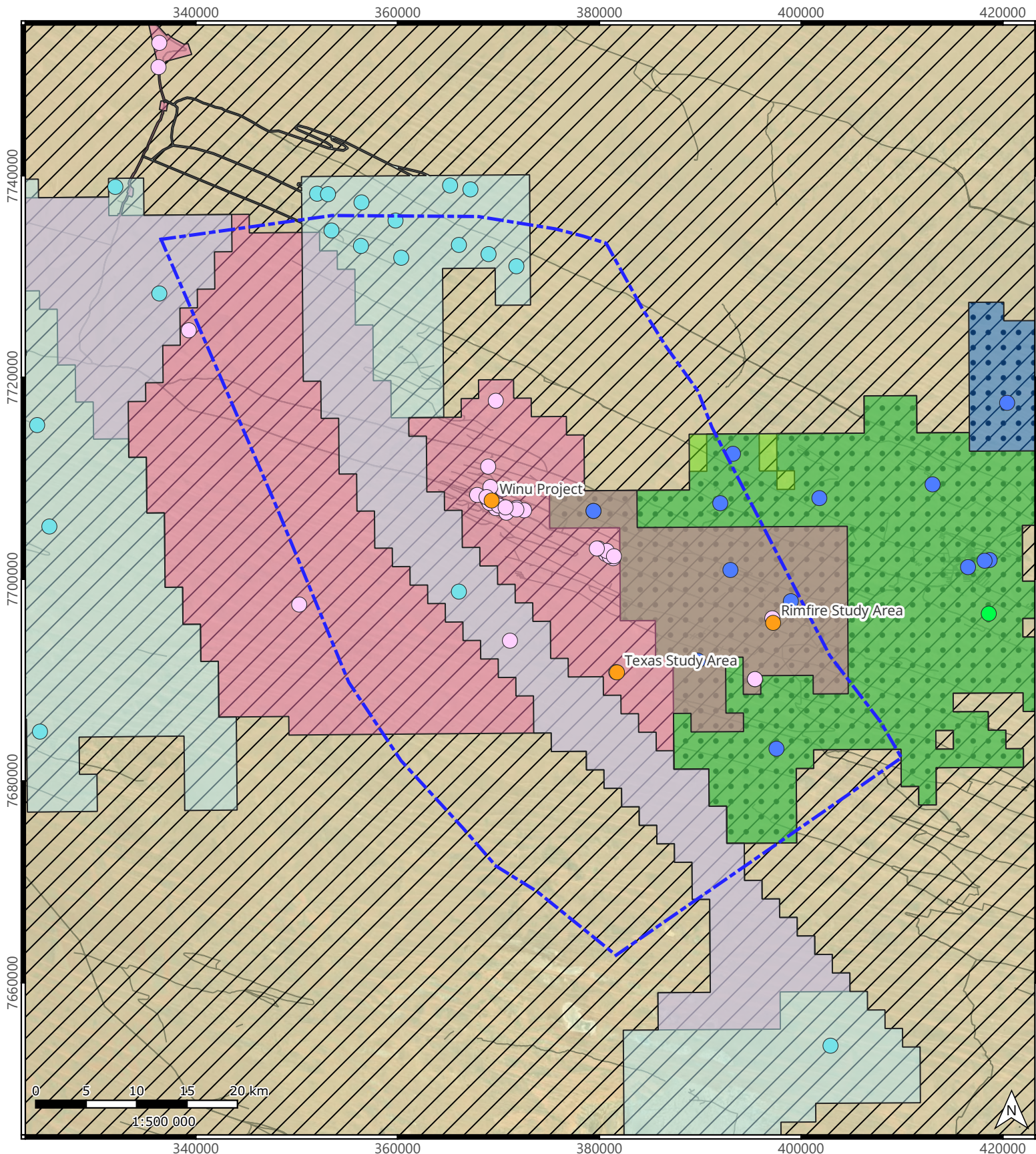
Groundwater abstraction from these licences has been permitted within the Canning – Wallal, and Canning – Grant aquifers.

The total allocation for all five (5) active licences across both aquifers amounts to 0.35185 GL. Of this, 0.3515 GL is allocated to the Canning – Wallal aquifer, and the remaining 0.00035 GL is allocated to the Canning – Grant aquifer.

Although groundwater licences 179796 and 200009 are situated within the Winu study area, given the low annual allocation (0.00035 GL/a and 0.0015 GL/a respectively) they are unlikely to have any discernible impact on groundwater levels within the model domain.

Table 4-2: Active groundwater licences within the study area

Licence number	Licensed party	Issue date	Expiry date	Licensed aquifer	Annual allocation (GL)
179796	New Standard Onshore Pty Ltd	18/09/2014	17/09/2024	Canning – Grant	0.00035
200009	Rio Tinto Exploration Pty Limited	22/06/2017	21/06/2027	Canning – Wallal	0.0015
201165	Rio Tinto Exploration Pty Limited (Winu)	18/12/2023	17/12/2025	Canning – Wallal	0.3
204033	Rio Tinto Exploration Pty Limited	16/09/2021	15/09/2031	Canning – Wallal	0.02
206212	Rio Tinto Exploration Pty Limited	9/08/2021	8/08/2031	Canning – Wallal	0.03



Legend

- Site Locations
- Winu Model Boundary
- Winu Tracks

Groundwater Licence

- 179796
- 200009
- 201165
- 204033
- 206212

Licensed Drawpoint

- 200009
- 201165
- 204033
- 206212

Groundwater Licences

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 4-2
-----------------------------	----------------------------	-------------------

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 15/05/2024, 14:24

References

-

Consultant



Client

RioTinto

5. Groundwater investigations

Hydrogeological investigation for the Winu Project were undertaken by Golder Associates between 2019 and 2022, and Advisian (rebranded as Worley Consulting) between 2022 and 2024.

Hydrogeological investigations included:

- Drilling
- Logging of lithology
- Bore installation and development of monitoring and production bores
- Water quality sampling
- Aquifer testing (slug tests and pumping tests)
- Groundwater level monitoring

The reports describing the hydrogeological investigations completed for the Winu Project is listed on Table 5-1.

Table 5-1: Hydrogeological reports for the Winu Project

Author	Date	Title	Reference
Golder	2020	2020 Winu Hydrogeological Field Investigation	(Golder, 2020)
Golder	2021	Winu regional water supply options and selection of drillhole investigation sites	(Golder, 2021)
Golder	2022	H3 Hydrogeological Assessment of the Winu Project	(Golder, 2022a)
Advisian/Worley*	2022	Winu Dewatering Strategy and Groundwater Supply Update 2022	(Advisian, 2022a)
Advisian/Worley	2022	Winu Hydrogeological Factual Field Report	(Advisian, 2022b)
Advisian/Worley	2023	Rimfire Bore Redesign for 26D.	(Advisian, 2023a)
Advisian/Worley	2023	Rimfire target identification based on RC drilling results.	(Advisian, 2023b)
Advisian/Worley	2023	Winu Annual Aquifer Review	(Advisian, 2023c)
Advisian/Worley	2023	Texas target identification based on RC drilling results	(Advisian, 2023d)
Advisian/Worley	2023	Rimfire H2 Assessment	(Advisian, 2023e)
Advisian/Worley	2023	Texas H3 Assessment	(Advisian, 2023f)
Advisian/Worley	2023	Rimfire and Texas Phase 2 – 2024	(Advisian, 2023g)
Advisian/Worley	2024	Solute Transport Modelling (Groundwater), Quarry and Pond Options	(Advisian, 2024)
Advisian/Worley	2024	Winu Baseline Groundwater Monitoring Plan – Update 2024	(Worley, 2024a)
Advisian/Worley	2024	Winu Annual Aquifer review, 1 st January 2023 to 31 ST December 2023.	(Worley, 2024b)
Advisian/Worley	2024	Winu Operational Surface Water Management Plan Update 2023	(Worley, 2024c)
Advisian/Worley	2024	Winu Water Balance Update 2024	(Worley, 2025)

Table notes

*In late 2023 Advisian was rebranded as Worley Consulting

6. Drilling

Water bore installations and hydrogeological investigations at Winu commenced in 2018 to identify a project water supply. The exploratory drilling around Winu is presented on Table 6-1 and shown spatially in Figure 6-1 and Figure 6-2.

Regional field investigations were undertaken at Wallal, Rimfire and Texas in 2022 and 2023 and included installations of bores, and pumping tests. The regional bores are summarised on Table 6-1 and shown spatially in Figure 6-3.

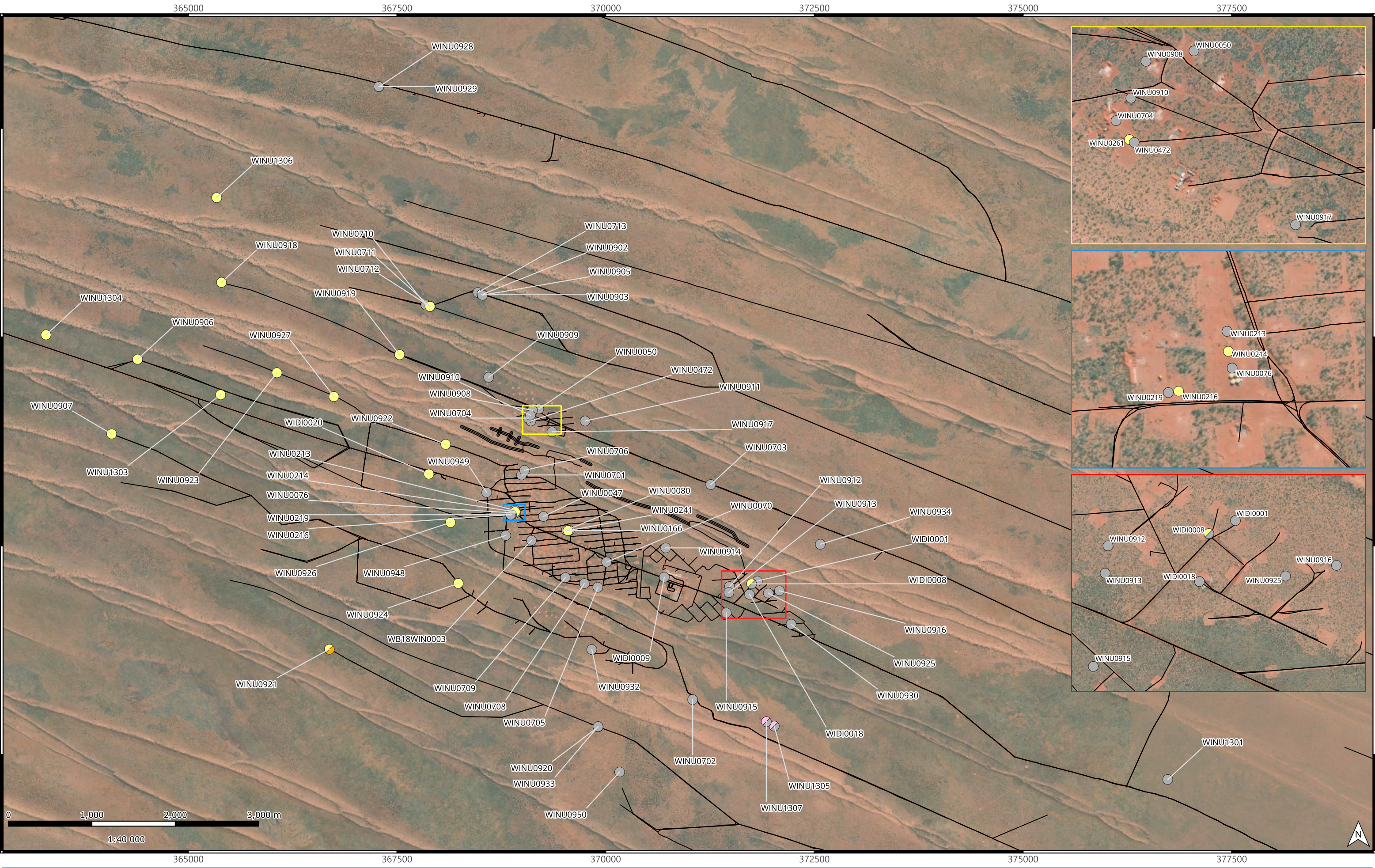
All bore logs are shown in Appendix C.

Table 6-1: Summary of bores and sensors installed/deployed at Winu

Borefield/ Area	Bore/ sensor type	Screened aquifer	No. of bores/ sensors	Comments
Winu	22 production bores (7 equipped for abstraction, 15 used as monitoring)	Confined metasediment	16	-
		Unconfined metasediment/ granite	1	WINU1305, Winu South aquifer
		Unconfined sandstone/ metasediment	1	WIDI0009, was constructed in October 2018 prior to current 26D license, bore was drilled for early water supply for exploration activities
		Unconfined sandstone	1	WIDI0020
		Unconfined metasediment	3	WIDI0008 & WIDI0016 & WINU0925
	50 monitoring bores	Unconfined sandstone	20	-
		Confined metasediment	26	-
		Unconfined metasediment	3	-
		Unconfined metasediment/ granite	1	Winu South aquifer
	22 vibrating wire piezometer arrays, comprised of 79 sensors	Aeolian sands	1	-
		Unconfined sandstone	5	-
		Permian mudstone	33	-
		Confined metasediment	40	-
	1 barometric pressure logger	-	-	-

Table 6-2: Summary of bores installed at the regional borefields

Borefield	Bore/ sensor type	Screened aquifer	No. of bores/ sensors	Comments
Wallal	1 production bore	Wallal Sandstone	1	WINU0936
	3 monitoring bores	Wallal Sandstone	2	WINU0935, WINU0938
		Lower Callawa	1	WINU0937
Rimfire	1 production bore	Granite/metasediment	1	WINU0942
	3 monitoring bores	Granite	1	WINU0940
		Granite/metasediment	2	WINU0941, WINU0943
Texas	1 production bore	Metasediment	1	WINU0944
	3 monitoring bores	Metasediment	3	WINU0945, WINU0946, WINU0947



Legend

●

Screened Aquifer

●

Metasediment

●

Granite/Metasediment

●

Permian Sst.

●

Permian Sst./Metasediment

●

Permian Sst./Mudstone

—

Winu Tracks

Winu Bore Locations

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475

Notes: Project CRS: GDA94 / MGA zone 51
Last Saved: 21/05/2024, 14:07

Client

Rio Tinto Copper

References

Figure No. 6-1

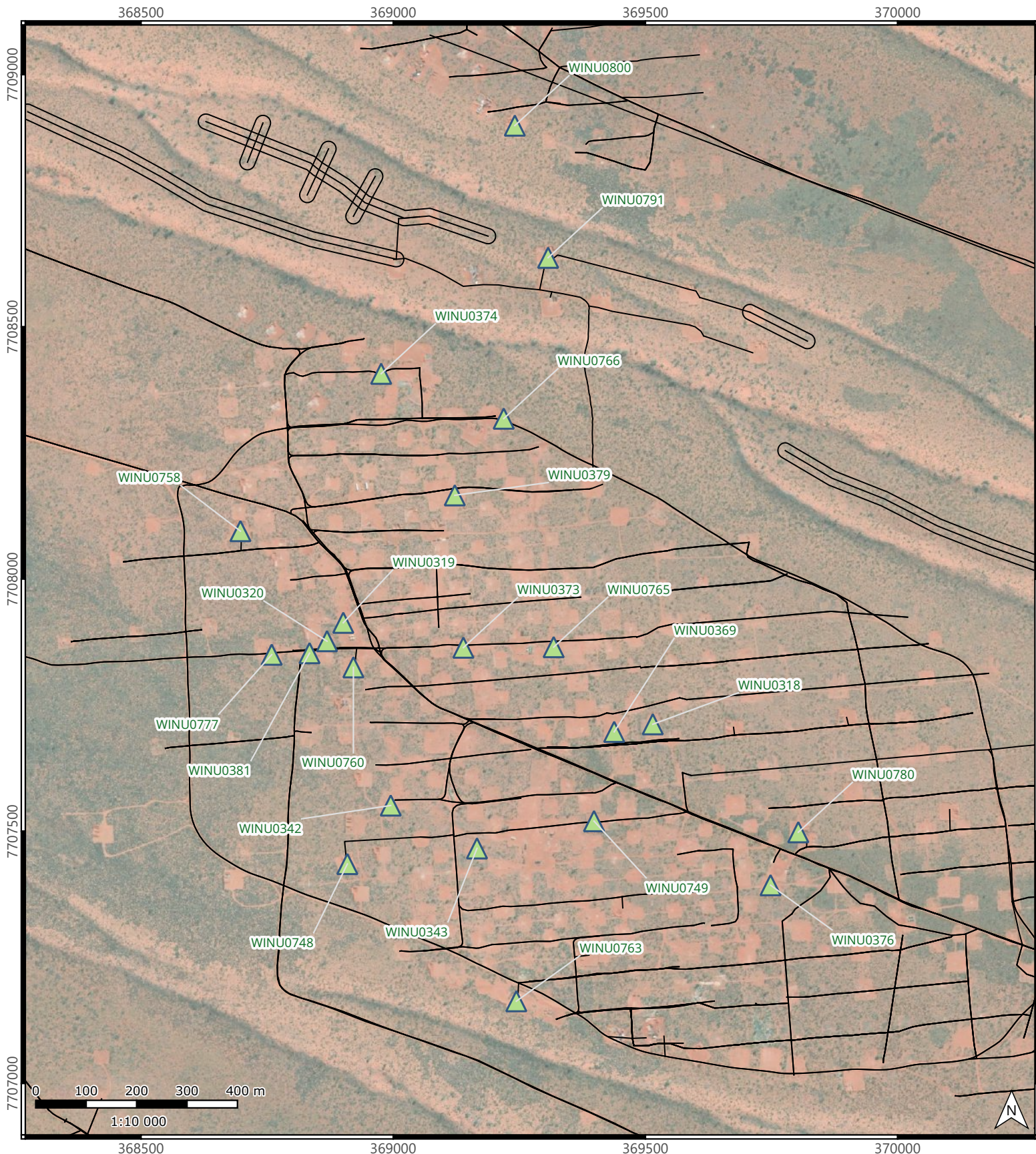
Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Model Boundary
- Winu Tracks
- ▲ VWP

Winu VWP Locations

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 6-2
-----------------------------	----------------------------	-------------------

Notes:
 Project CRS: GDA94 / MGA zone 51
 Last Saved: 21/05/2024, 14:13

References

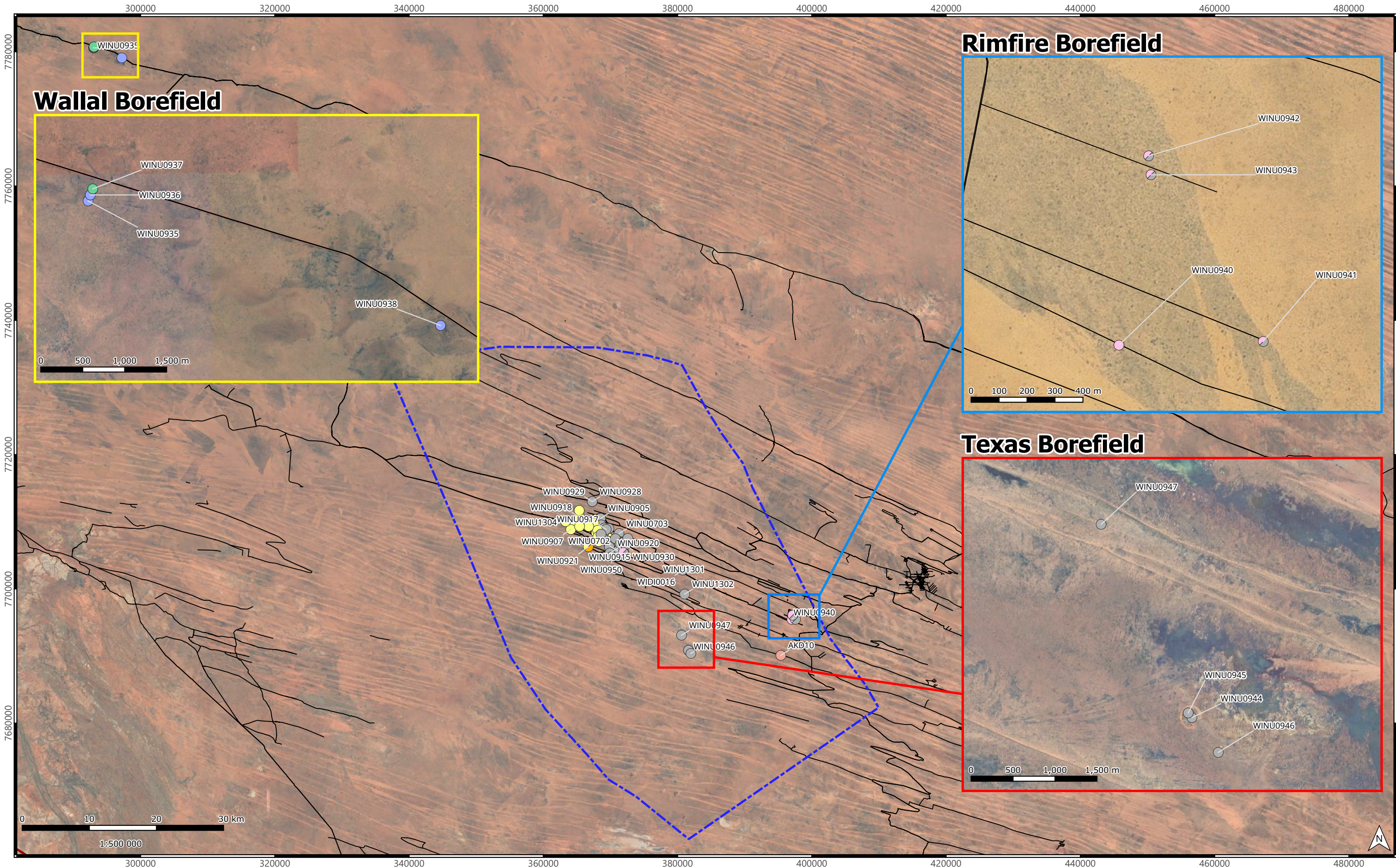
-

Consultant



Client

RioTinto



- Legend**
- Winu Tracks
 - Winu Model Boundary
 - Screened Aquifer
 - Granite
 - Metasediment
 - Granite / Metasediment
 - Permian Sandstone
 - Permian Sandstone/Metasediment
 - Permian Sst/Mudstone transition
 - Wallal Sandstones - Wallal
 - Lower Callawa - Wallal
 - Unknown

Regional Bore Locations

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 6-3
Notes: Project CRS: GDA94 / MGA zone 51 Last Saved: 21/05/2024, 14:30	References -	

Consultant

worley
consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

7. Test pumping

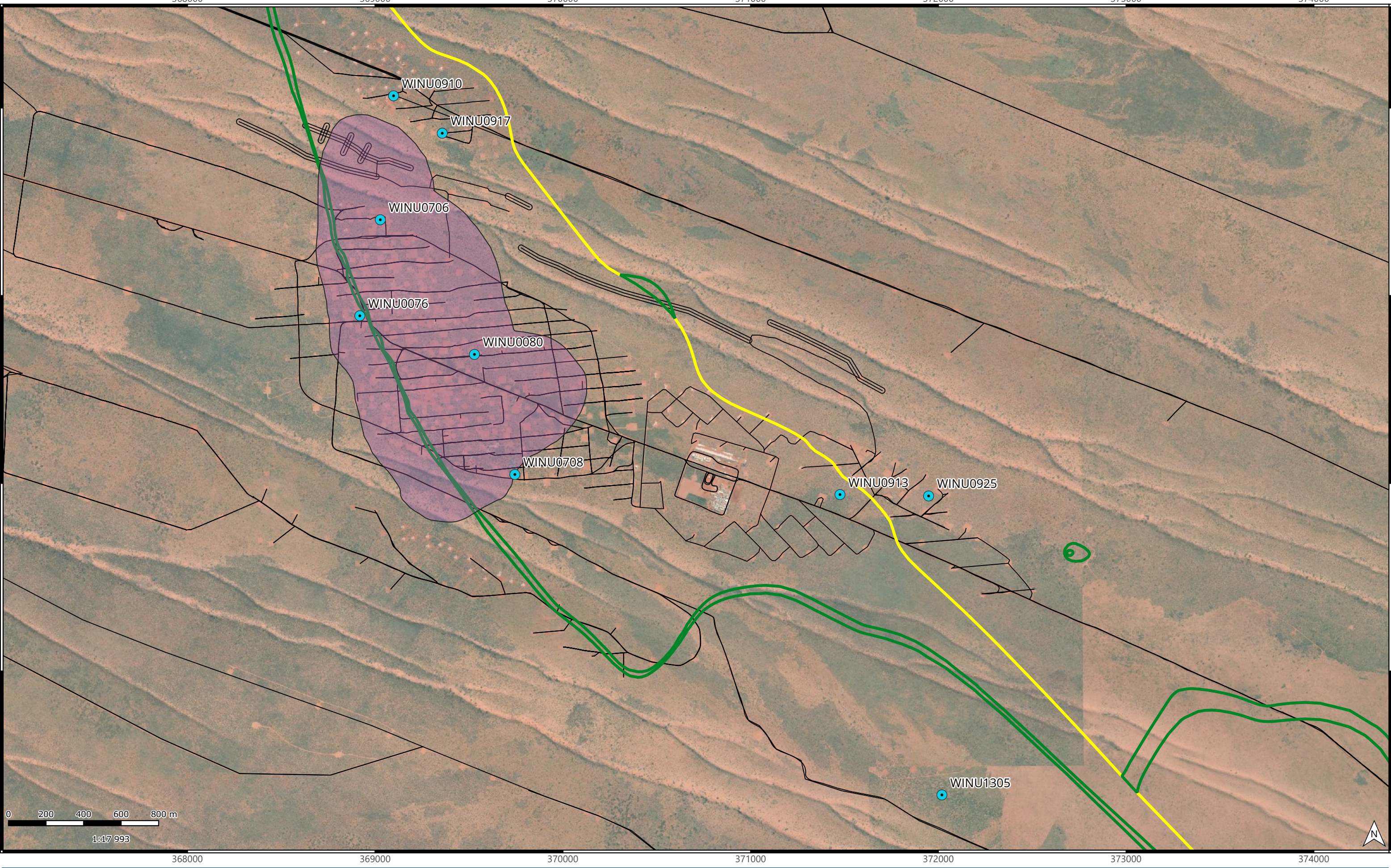
7.1 Pumping test locations

The key dates and details for each pumping test is summarised on Table 7-1. The locations of the tested bores are shown spatially in Figure 7-1 and bore logs are presented in Appendix C.

Table 7-1: Summary of pumping tests undertaken at the Winu Project

Test no.	Bore ID	CRT start date/time	CRT end date/time	CRT rate (L/s)	Pumping duration (days)	No. days recovery (95%)	Max drawdown in the PB (m)
1	WINU0076	19/09/2019	22/09/2019	15.6	3.8	2	17.3
2	WINU0080	23/10/2019 09:00	28/10/2019 07:00	9.2	4.9	1	15.7
3	WINU0706	12/02/2021 12:00	20/02/2021 12:00	13	8	3	103.6
4	WINU0708	17/03/2021 10:00	26/03/2021 8:00	8	9	3	104.42
5	WINU0910	24/11/2021	17/12/2021	36	25	5	67.85
6	WINU0913	15/04/2022	14/05/2022	9	31	3	94.66
7	WINU0917*	25/10/2023 10:00	8/11/2023 10:00	50	14	12	35.04
8	WINU0076	23/11/2023 11:00	12/12/2023 11:00	26	19	5	25.13
9	WINU0925	27/02/2024 11:00	29/02/2024 16:10	4	2.2 (53 hours)	1	59.15
10	WINU1305	30/03/2024 14:00	29/04/2024 14:00	27	30	15	27.76

*WINU0917 also tested in June 2023, however test failed after 2 days and was re-tested



Legend

Main Map

Bore Master_20240503

Production

Production

Winu Pit Outline

954964~2 — entities

Winu Model Boundary

Winu Tracks

ESRI Satellite

Winu Test Pumping Locations

Winu Hydrology/Hydrogeology Study

Project No.
311012-01475

Notes:
Project CRS: GDA94 / MGA zone 51
Last Saved: 26/07/2024, 10:52

Client
Rio Tinto Copper

References
-

Figure No.
7-1

Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

7.2 Step rate tests (SRT)

Prior to each step rate test (SRT), a calibration test was carried out at each production bore to ensure correct operation of equipment. Following the calibration test and after suitable water level recovery, a formal SRT was carried out using 4 or 5 progressively increasing pumping steps (rates), with a duration of between 30 and 100 minutes.

Manual water level measurements and logger data were collected from the production bore during the SRT and also during the recovery phase for some of the bores. Details of the SRT steps and observations are provided in Table 7-2 and plots of observed drawdown during each SRT and recovery are presented in Figure 7-2 to Figure 7-3. The results from the SRT were used to select an initial pumping rate for each constant rate test (CRT).

Table 7-2: Step rate test results

Test no.	Bore ID	SWL at start of test (m BRL)	Pump inlet depth (m BRL)	Step	Pumping rate, Q (L/s)	Duration of step (mins)	PWL at end of step (m BRL)	Total drawdown (m)	Step drawdown (m)
1	WINU0076	50.29	82	1	1.5	30	49.27	1.02	1.02
				2	3	30	48.46	1.83	0.81
				3	5	30	47.33	2.96	1.13
				4	7	30	46.77	3.52	0.56
2	WINU0080	49.8	92	1	2.5	30	51.87	2.07	2.07
				2	5	30	55.13	5.33	3.26
				3	7.5	30	58.86	9.06	3.73
				4	9.6	30	62.75	12.95	3.89
3	WINU0706	53.32	141	1	6	90	70.62	17.30	17.30
				2	9	90	84.44	31.12	13.82
				3	12	90	107.38	54.06	22.94
				4	15	25	133.92	80.60	26.54
					12	65	110.58	57.26	-23.34
				5	13.5	90	127.20	73.88	16.62
4	WINU0708	51.68	191	1	5	100	87.97	36.29	36.29
				2	6	100	98.25	46.57	10.28
				3	8	100	118.66	66.98	20.41
				4	10	180	159.38	107.70	40.72
5	WINU0910	54.51	182.4	1	10	100	62.71	8.20	8.20
				2	20	100	75.03	20.52	12.32
				3	30	100	93.70	39.19	18.67
				4	40	100	114.47	59.96	20.77

				5	45	100	126.86	72.35	12.39
6	WINU0913	44.1	183.1	1	4	100	62.84	18.74	18.74
				2	6	100	75.38	31.28	12.54
				3	8	100	91.32	47.22	15.94
				4	10	100	109.24	65.14	17.92
				5	12	100	160.43	116.33	51.19
7	WINU0076	51.69	113	1	15	100	60.5	8.81	8.81
				2	20	100	64.86	13.17	4.36
				3	25	100	69.99	18.30	5.13
				4	28	100	73.68	21.99	3.69
8	WINU0917	55.70	167.5	1	20	100	61.88	6.18	6.18
				2	30	100	66.54	10.84	4.66
				3	40	100	72.90	17.02	6.36
				4	50	100	77.96	22.26	5.06
				5	52	5	79.02	23.32	1.06
9	WINU0925	45.81	113	1	3	100	77.66	31.85	31.85
				2	4	100	95.82	50.01	18.16
				3	5	100	126.77	80.96	30.95
				4	6	54	176.21	130.4	49.44
10	WINU1305	46.55	142.5	1	15	100	49.95	3.4	3.4
				2	20	100	52.17	5.62	2.22
				3	25	100	54.51	7.96	2.34
				4	28.5	100	56.83	10.28	2.32

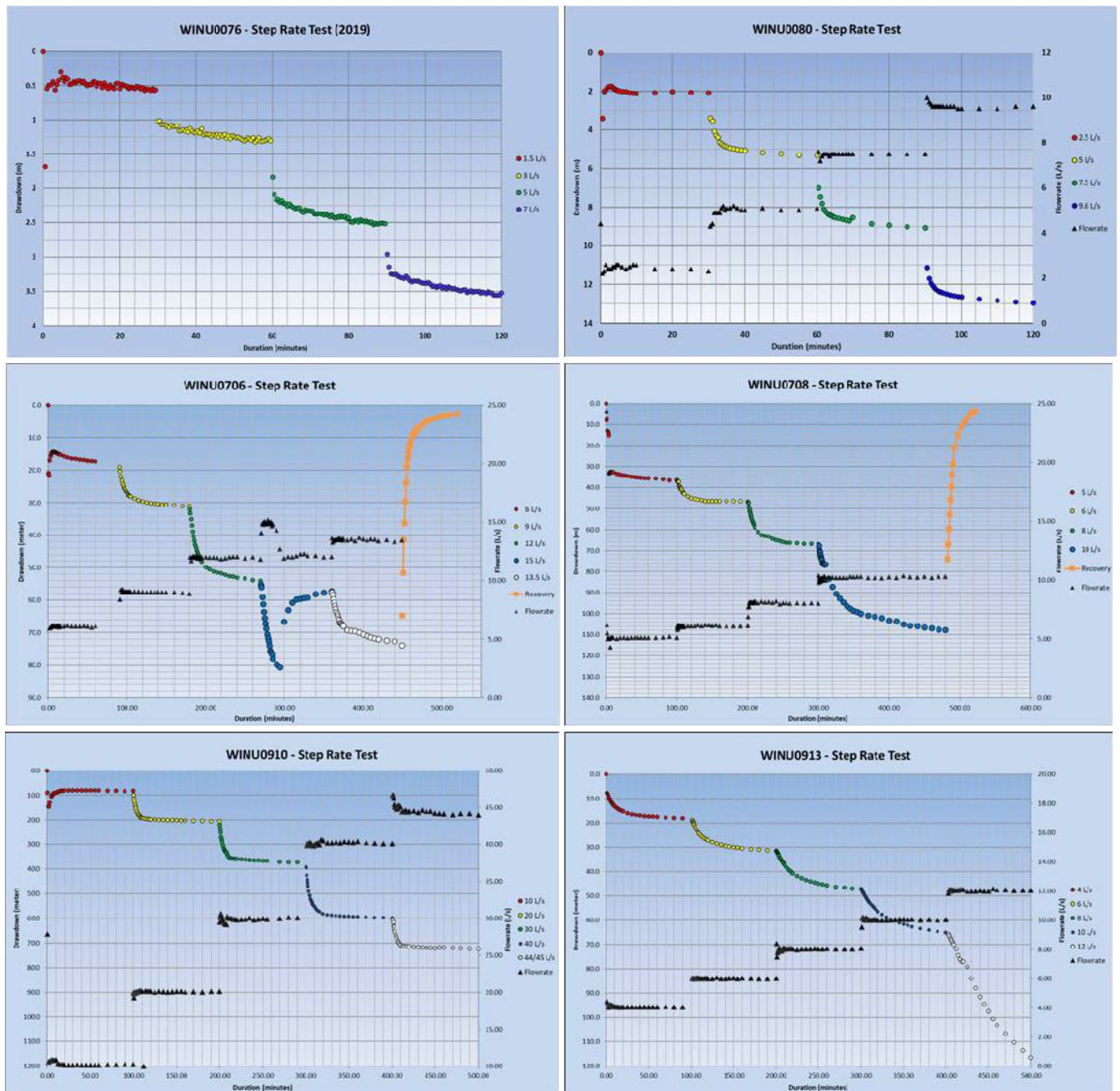


Figure 7-2: Step rate test charts for WINU0076 (test no. 1), WINU0080, WINU0706, WINU0708, WINU0910 and WINU0913

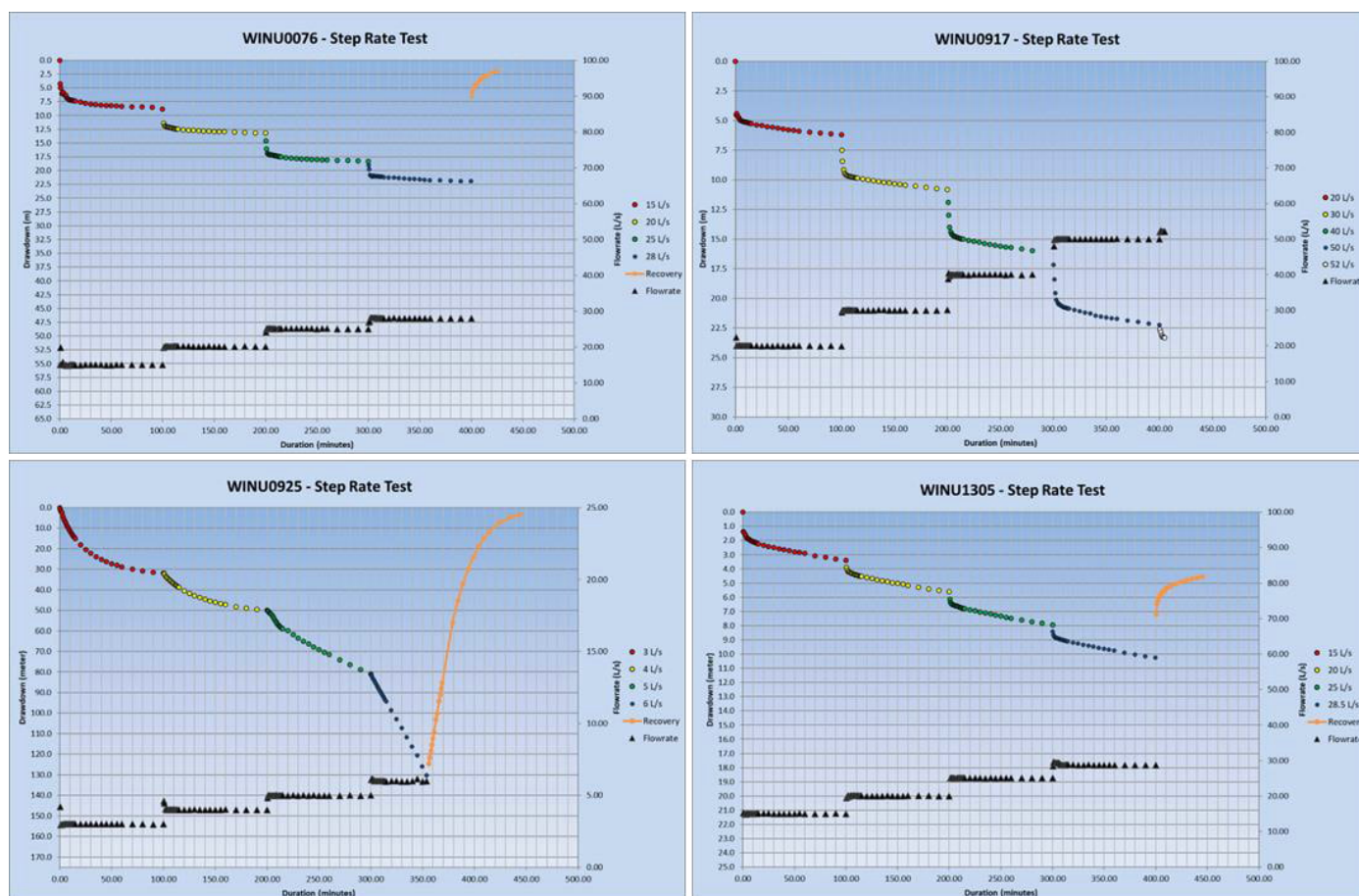


Figure 7-3: Step rate test data for WINU0076 (test no. 7), WINU0917, WINU0925, and WINU1305

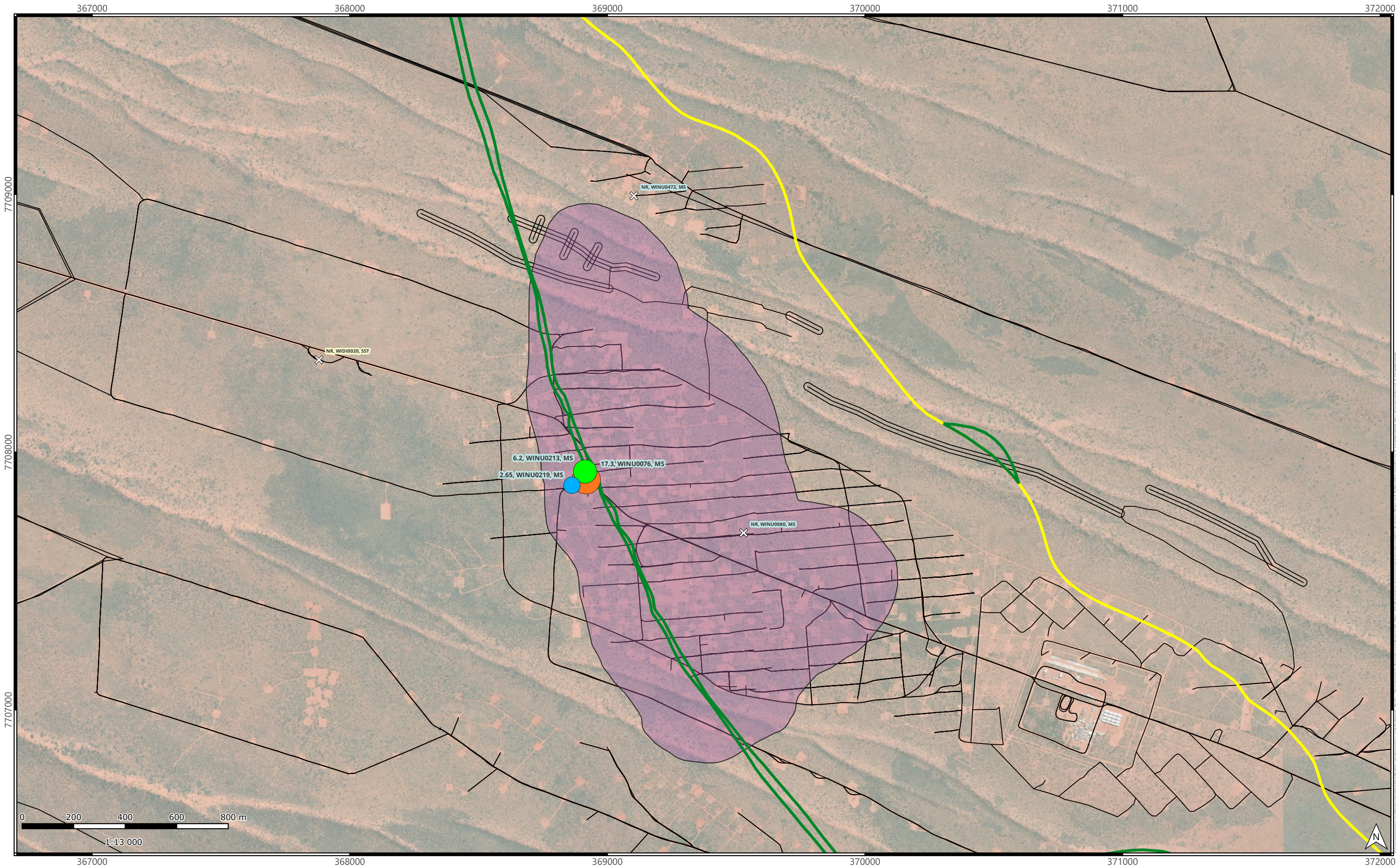
7.3 Constant rate tests (CRT)

The aim of the CRT was to evaluate the performance of the bore over a multi-day test and to stress the surrounding aquifer to allow estimation of the hydraulic properties of the aquifer system.

Upon cessation of the CRT, water level in the production bore was left to recover to a minimum of 95% of pretest levels, where timing permitted.

Water level changes during the CRT were recorded in the pumped bore and at multiple monitoring locations using a combination of pressure loggers, VWP, and manual water level measurements.

The maximum drawdown at each monitoring location is shown in Figure 7-4 to Figure 7-13. The maximum drawdown observed at each production bore at the end of pumping is tabulated on Table 7-1.



Legend

Winu Tracks

Winu Pit Outline

Thorny Devil Fault (95 m AHD)

Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

⌘ No Response (NR)

0 - 1

1 - 5

5 - 10

10 - 20

> 20

WINU0076 Pumping Test Drawdown (2019)

Winu Hydrology/Hydrogeology Study		
Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	7-4
Notes:	References	
Project CRS: GDA94 / MGA zone 51	-	
Last Saved: 12/07/2024, 10:19		

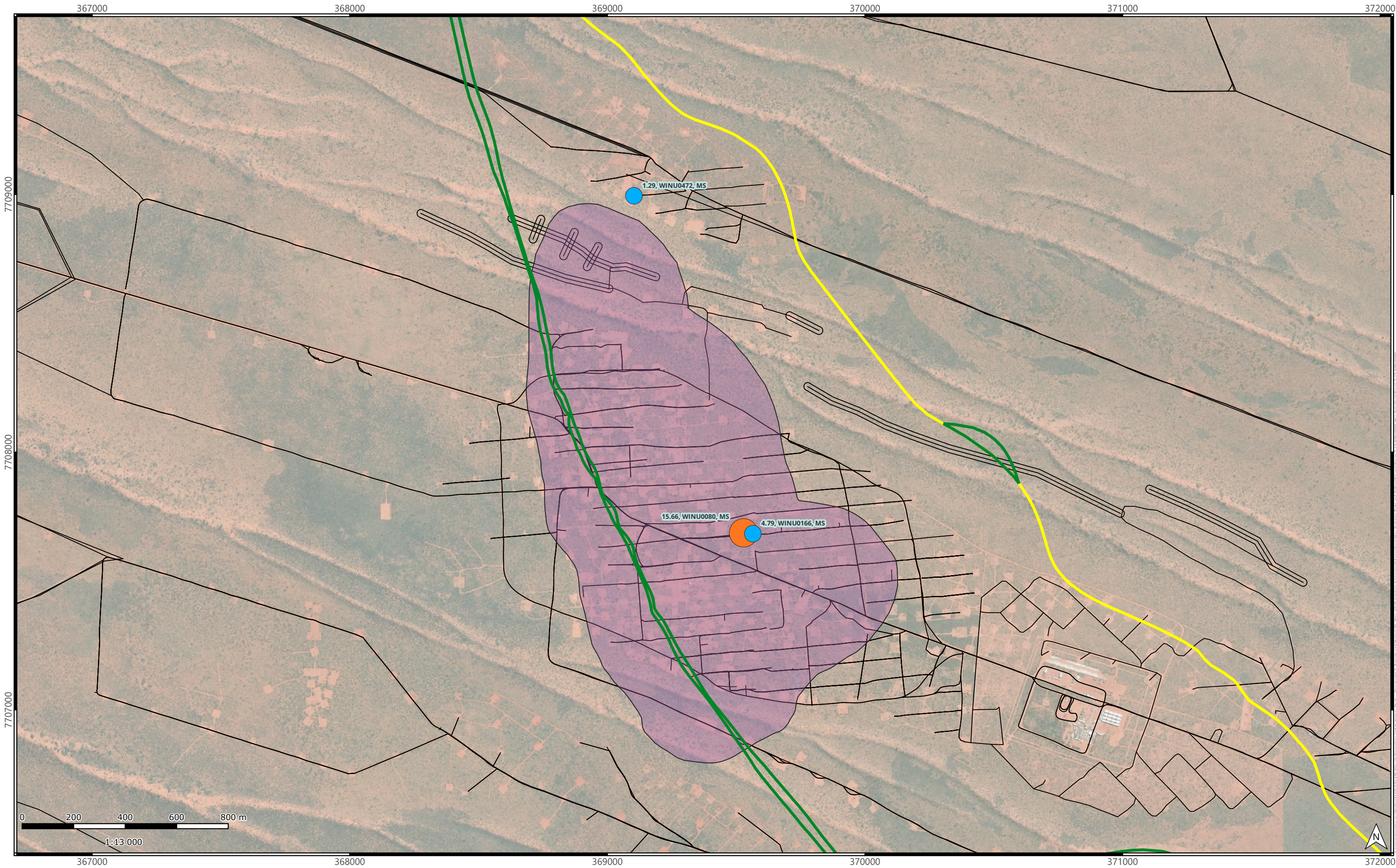
Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

Winu Tracks

Winu Pit Outline

Thorny Devil Fault (95 m AHD)

Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

⌘ No Response (NR)

0 - 1

1 - 5

5 - 10

10 - 20

> 20

WINU0080 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study		
Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	7-5
Notes:	References	
Project CRS: GDA94 / MGA zone 51	-	
Last Saved: 12/07/2024, 10:26		

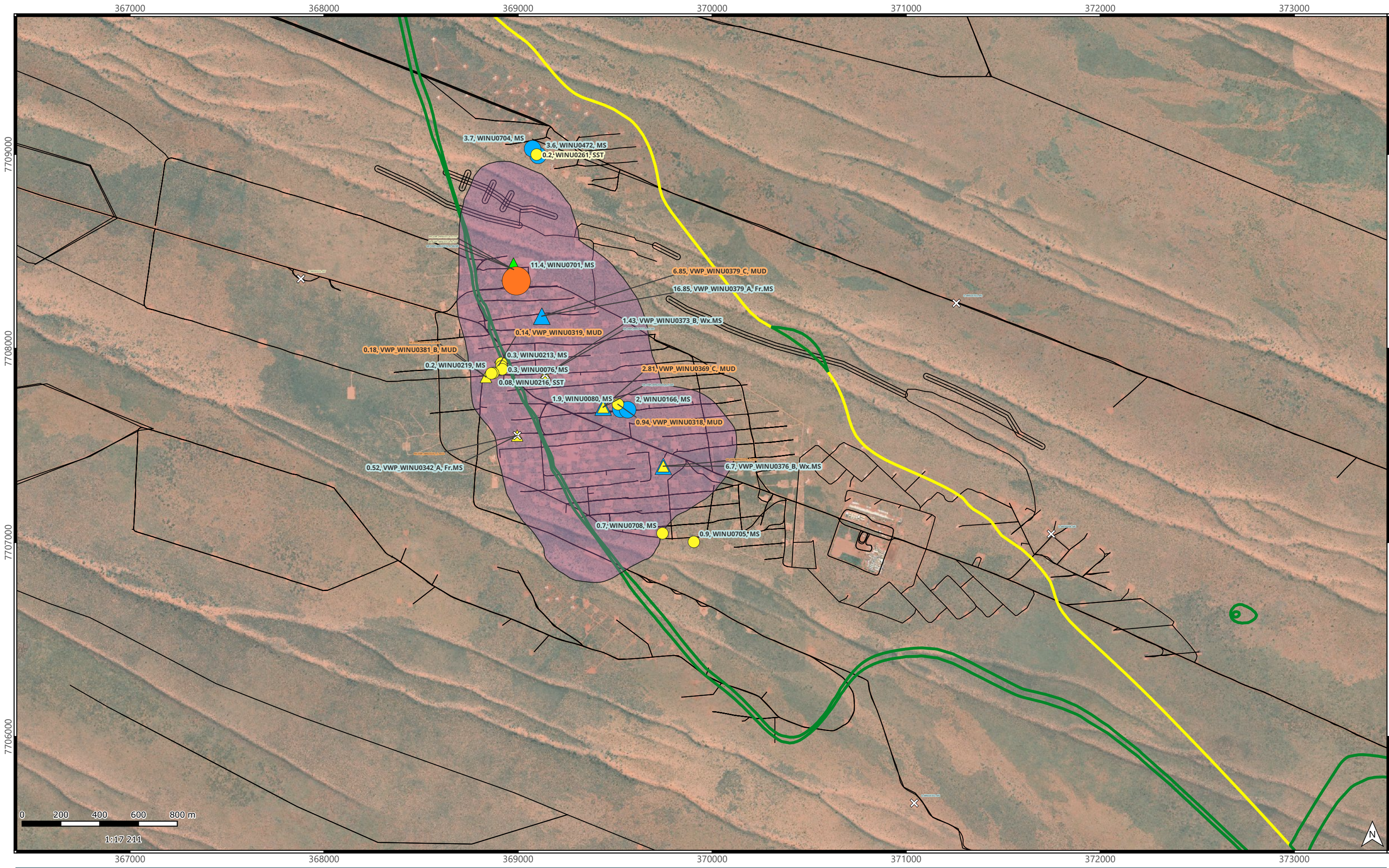
Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Tracks
- Site Locations
- Winu Pit Outline
- Winu Model Boundary
- Thorny Devil Fault (95 m AHD)
- Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

⊗	No Response (NR)
●	0 - 1
●	1 - 5
●	5 - 10
●	10 - 20
●	> 20

VWP Drawdown (m)

⊗	No Response (NR)
▲	0 - 1
▲	1 - 5
▲	5 - 10
▲	10 - 20
▲	> 20

WINU0706 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475

Notes: Project CRS: GDA94 / MGA zone 51
Last Saved: 29/07/2024, 14:58

Client

Rio Tinto Copper

References

Figure No. 7-6

Consultant

worley
consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Tracks
- Site Locations
- Winu Pit Outline
- Winu Model Boundary
- Thorny Devil Fault (95 m AHD)
- Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

VWP Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

WINU0708 Pumping Test Drawdown
Winu Hydrology/Hydrogeology Study
Project No. 311012-01475
Notes: Project CRS: GDA94 / MGA zone 51
Last Saved: 29/07/2024, 13:47

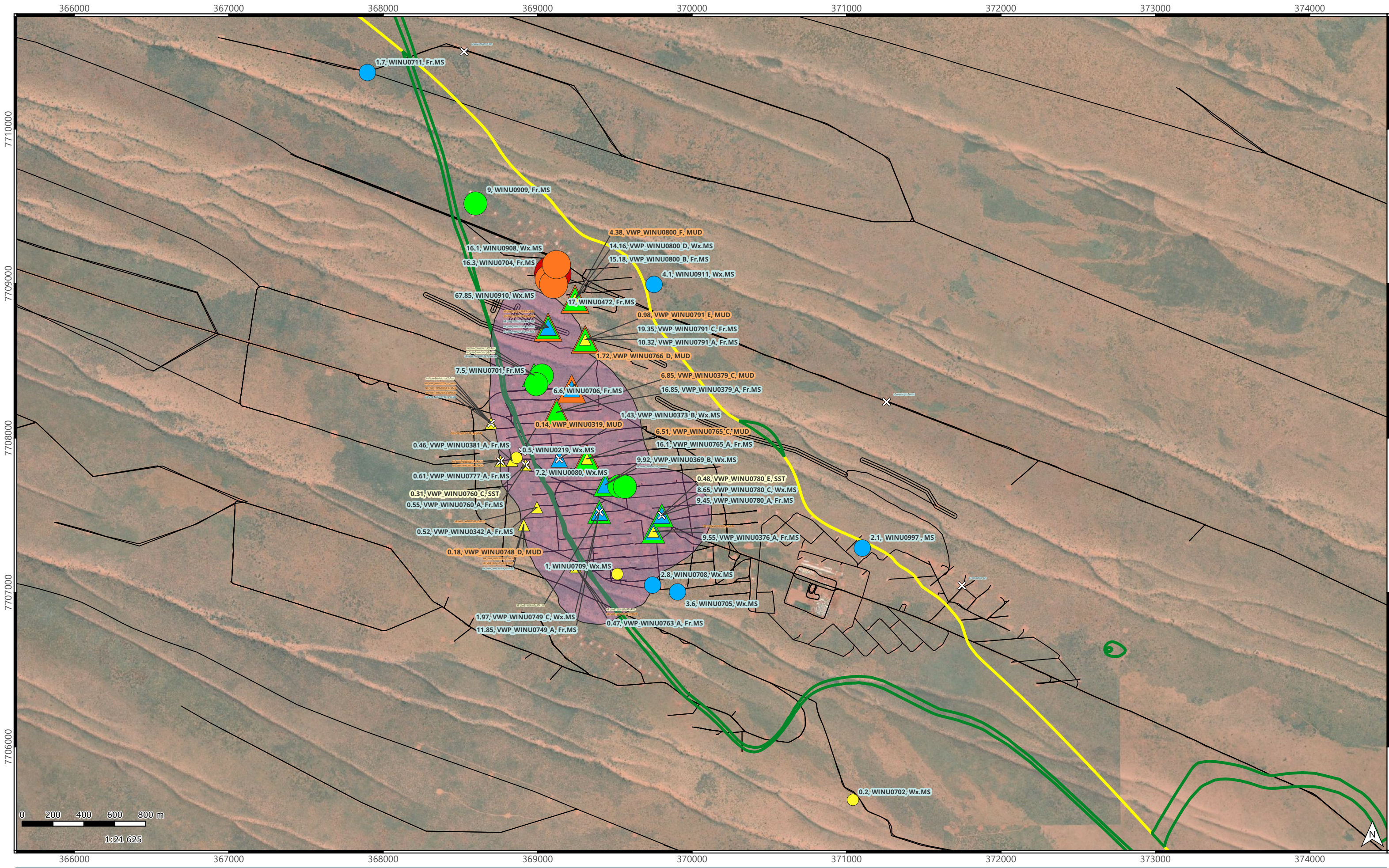
Client
Rio Tinto Copper
References

Figure No. 7-7

Consultant
worley
consulting

Client
RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

Winu Tracks

Site Locations

Winu Pit Outline

Winu Model Boundary

Thorny Devil Fault (95 m AHD)

Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

⊗ No Response (NR)

● 0 - 1

● 1 - 5

● 5 - 10

● 10 - 20

● > 20

VWP Drawdown (m)

⊗ No Response (NR)

▲ 0 - 1

▲ 1 - 5

▲ 5 - 10

▲ 10 - 20

▲ > 20

WINU0910 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study		Figure No. 7-8
Project No. 311012-01475	Client Rio Tinto Copper	
Notes: Project CRS: GDA94 / MGA zone 51 Last Saved: 29/07/2024, 14:58	References -	

Consultant



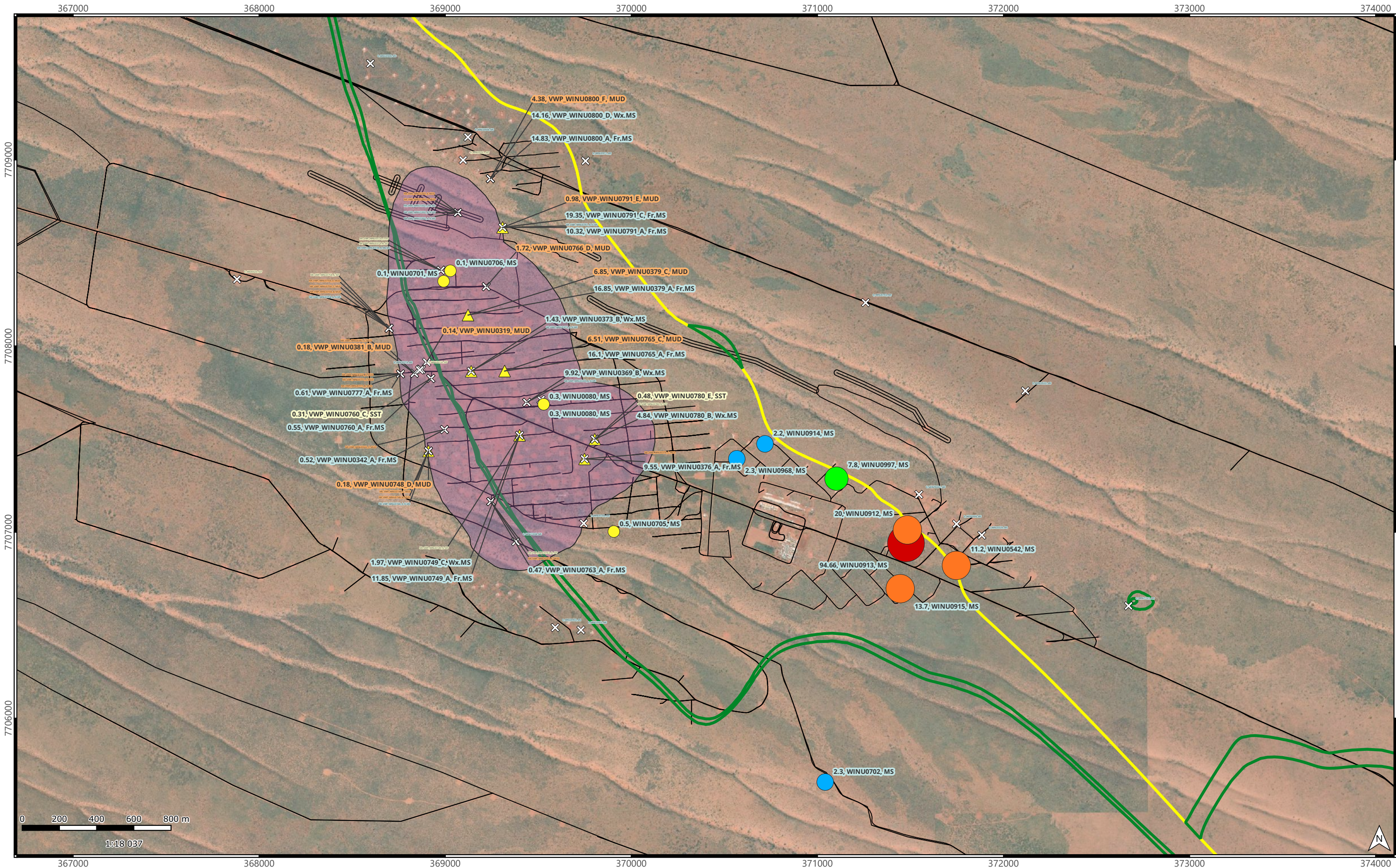
worley consulting

Client



RioTinto

© Worley Pty Ltd While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Tracks
- Site Locations
- Winu Pit Outline
- Winu Model Boundary
- Thorny Devil Fault (95 m AHD)
- Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

VWP Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

WINU0913 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study		Figure No.
Project No.	Client	7-9
311012-01475	Rio Tinto Copper	
Notes:	References	
Project CRS: GDA94 / MGA zone 51	-	
Last Saved: 29/07/2024, 14:59		

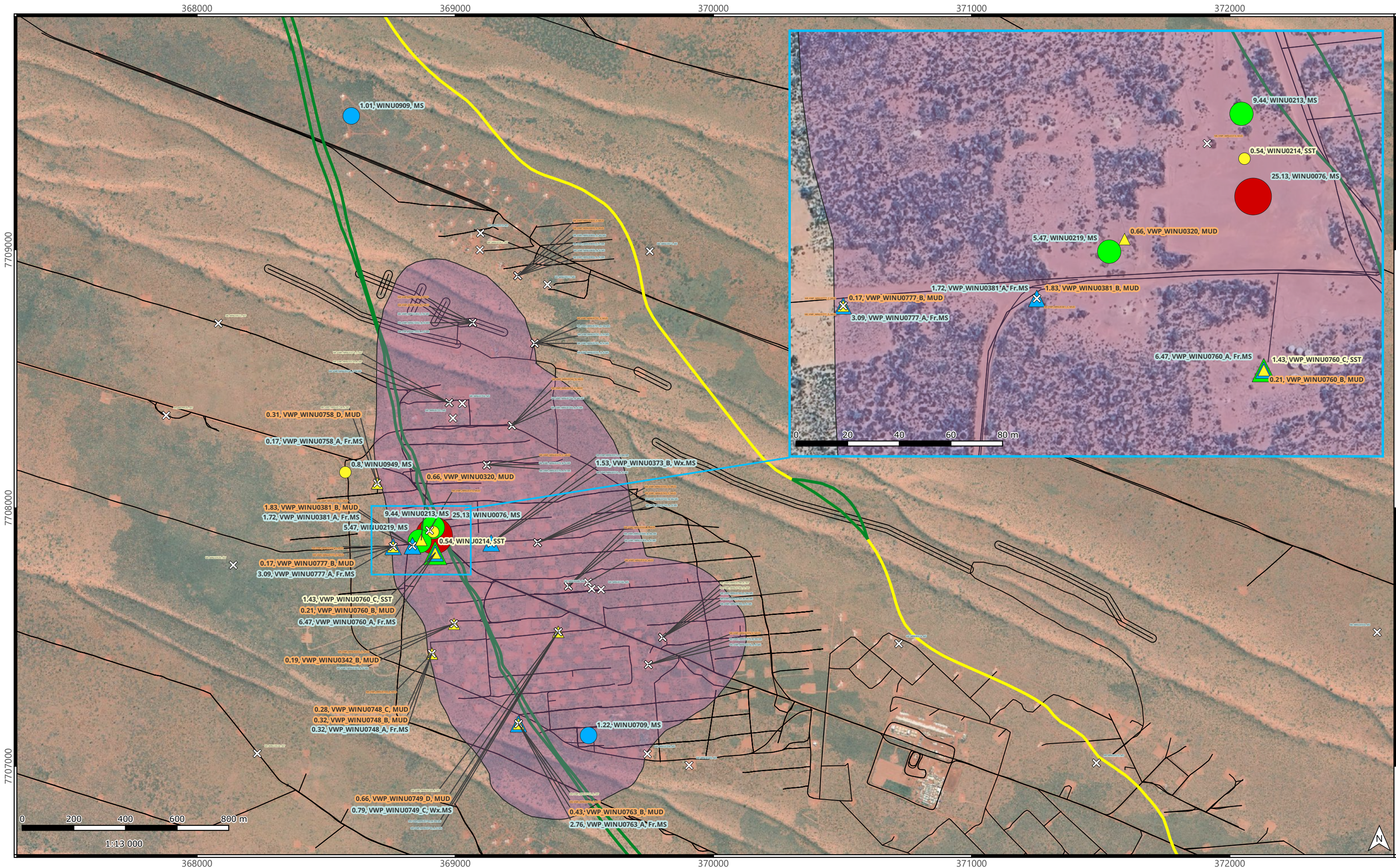
Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Tracks
 - Site Locations
 - Winu Pit Outline
 - Winu Model Boundary
 - Thorny Devil Fault (95 m AHD)
 - Pre-Min Mafic Sill (95 m AHD)
- | Bore Drawdown (m) | VWP Drawdown (m) |
|--------------------|--------------------|
| ⊗ No Response (NR) | ⊗ No Response (NR) |
| ● 0 - 1 | ▲ 0 - 1 |
| ● 1 - 5 | ▲ 1 - 5 |
| ● 5 - 10 | ▲ 5 - 10 |
| ● 10 - 20 | ▲ 10 - 20 |
| ● > 20 | ▲ > 20 |

WINU0076 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study

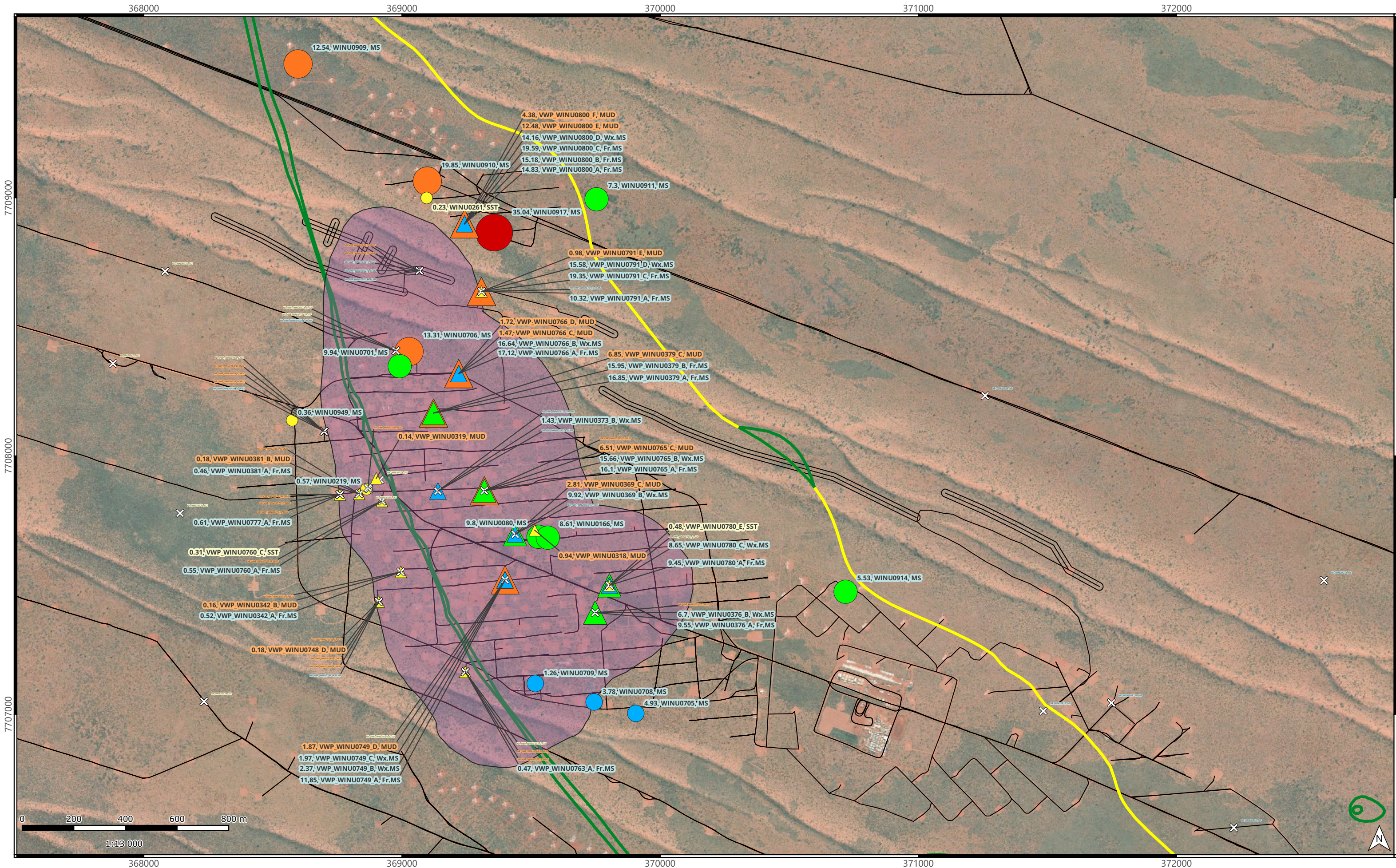
Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	7-10
Notes:	References	
Project CRS: GDA94 / MGA zone 51	-	
Last Saved: 22/05/2024, 15:17		

Consultant

worley
consulting

Client

RioTinto



Legend

— Winu Tracks

● Site Locations

▭ Winu Pit Outline

▭ Winu Model Boundary

▭ Thorny Devil Fault (95 m AHD)

▭ Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

⊗ No Response (NR)

● 0 - 1

● 1 - 5

● 5 - 10

● 10 - 20

● > 20

VWP Drawdown (m)

⊗ No Response (NR)

▲ 0 - 1

▲ 1 - 5

▲ 5 - 10

▲ 10 - 20

▲ > 20

WINU0917 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study		
Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	7-11
Notes:	References	
Project CRS: GDA94 / MGA zone 51	-	
Last Saved: 22/05/2024, 14:44		

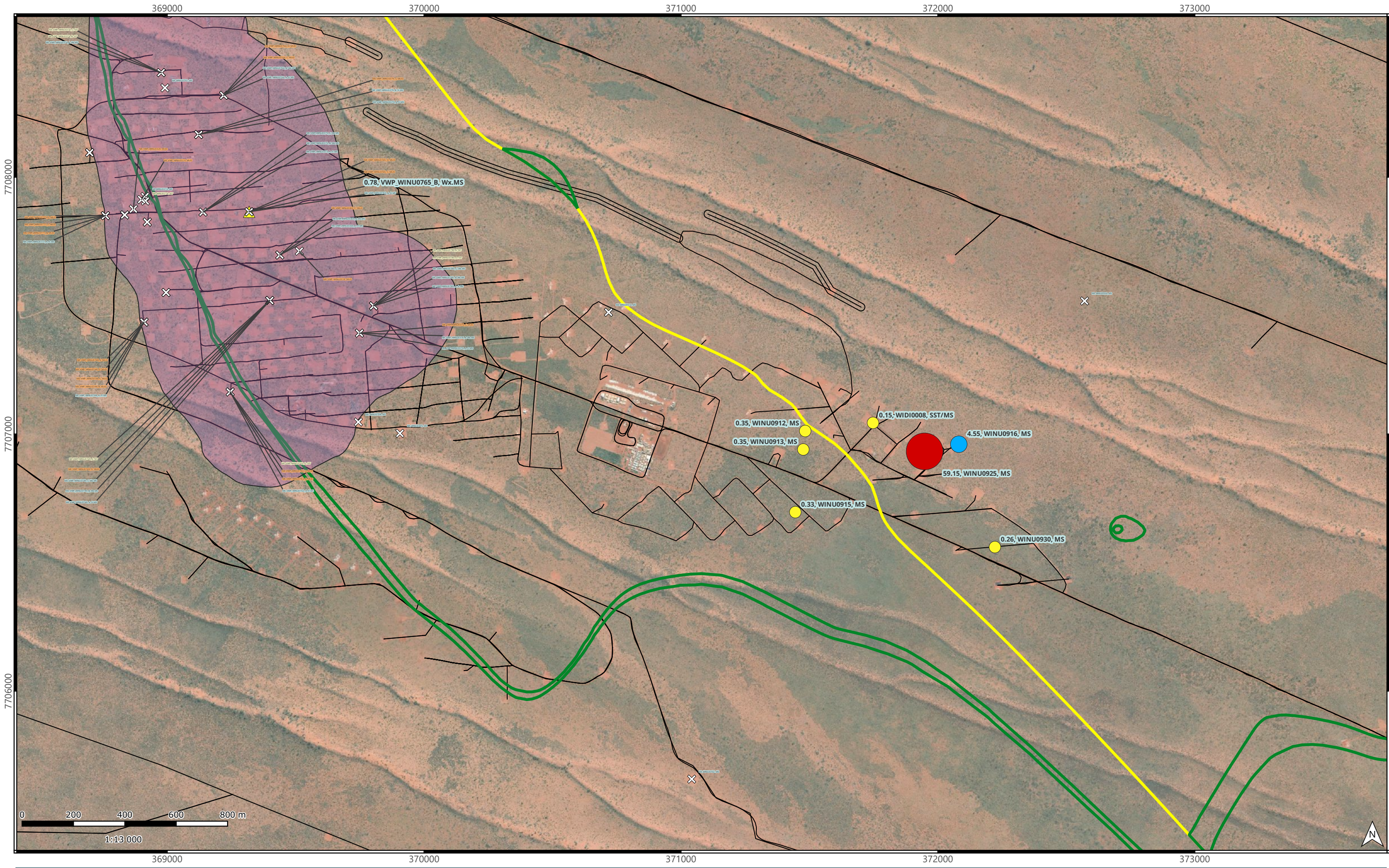
Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Tracks
- Site Locations
- Winu Pit Outline
- Winu Model Boundary
- Thorny Devil Fault (95 m AHD)
- Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

VWP Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

WINU0925 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study		
Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	7-12
Notes:	References	
Project CRS: GDA94 / MGA zone 51	-	
Last Saved: 22/05/2024, 15:27		

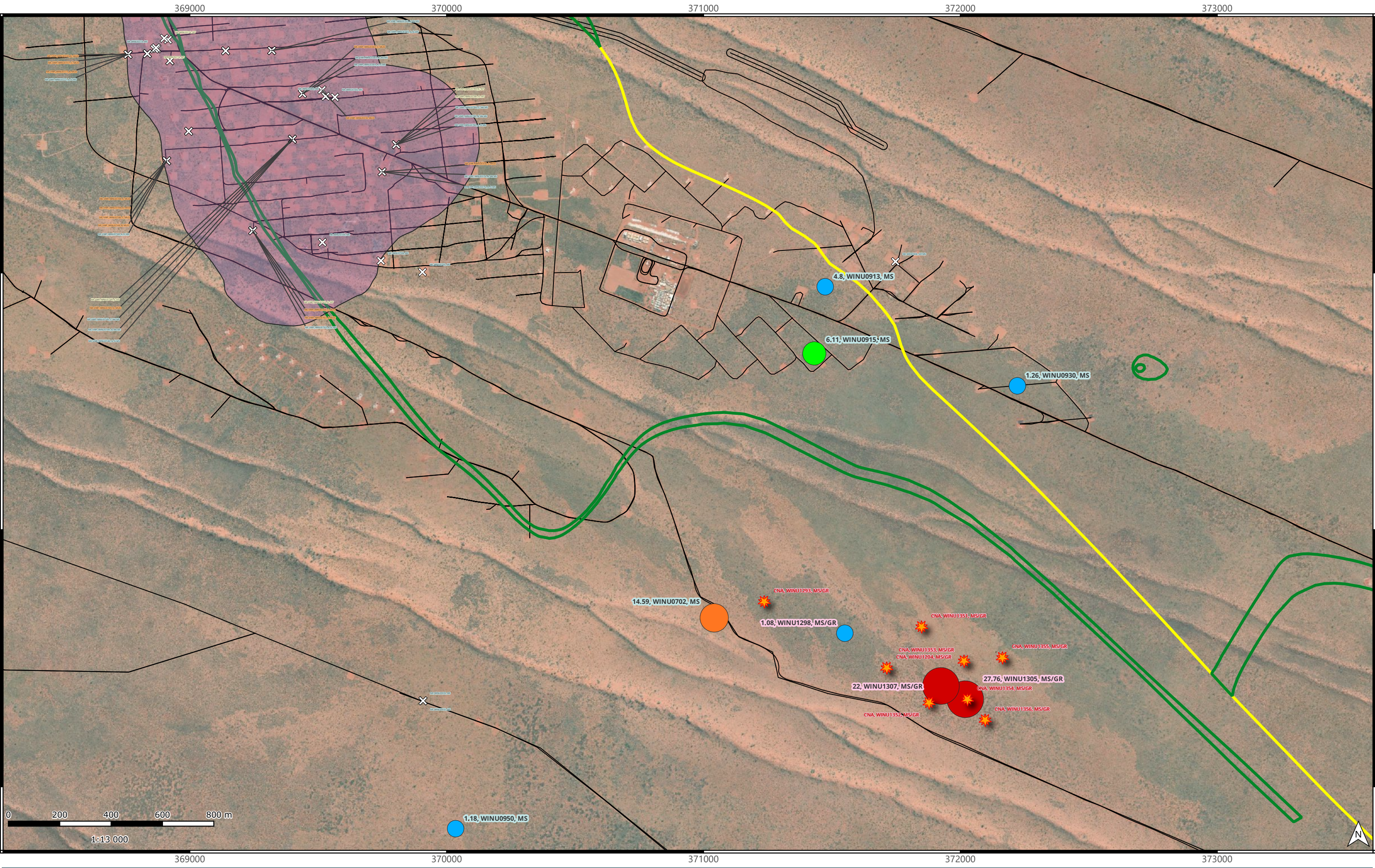
Consultant

worley consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



Legend

- Winu Tracks
- Site Locations
- Winu Pit Outline
- Winu Model Boundary
- Thorny Devil Fault (95 m AHD)
- Pre-Min Mafic Sill (95 m AHD)

Bore Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

VWP Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

WINU1305 Pumping Test Drawdown

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475
Notes: Project CRS: GDA94 / MGA zone 51
Last Saved: 22/05/2024, 15:47

Client Rio Tinto Copper
References -

Figure No. 7-13

Consultant

Client

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

7.4 Test results and interpretation

The pumping and recovery data collected during the CRT were analysed using Aqtesolv Pro software (Duffield, 2007) to estimate aquifer parameters. Data for each test was analysed using a range of analytic solutions which are summarised on Table 7-3 and shown in Appendix F.

Table 7-3: Analytical solutions used in Aqtesolv Pro for each pumping test

Test no.	Bore ID	Analyses used
1	WINU0076	Not applicable
2	WINU0080	Not applicable
3	WINU0706	Theis (1935, confined), Theis Recovery (1935, confined)
4	WINU0708	Hantush-Jacob (1964. Leaky-confined), Theis (1935, confined), Theis Recovery (1935, confined)
5	WINU0910	Theis (1935, confined), Theis Recovery (1935, confined), Cooper-Jacob (1946, confined)
6	WINU0913	Theis (1935, confined), Theis Recovery (1935, confined), Cooper-Jacob (1946, confined)
7	WINU0917	Hantush-Jacob (1964. Leaky-confined)
8	WINU0076	Moench dual-porosity (1984)
9	WINU0925	Moench dual-porosity (1984)
10	WINU1305	Barker dual-porosity (1988)

An analysis and interpretation of each pumping test is summarised below.

7.4.1 WINU0076 (2019)

- All drawdown observed in bores located to the west of the pre-min mafic sill, with limited bores available for monitoring at the time of testing.
- Very limited to no drawdown was observed to the east of the pre-min mafic sill in the main drill area, this would support the conceptualisation of the no-flow properties of the pre-min mafic sill in areas where cross cutting secondary (late time) faulting is not present.
- Drawdown observed in the upper layers indicate that some leakage has occurred through the mudstone layer, which is only 16 m thick within the vicinity of the production bore.

7.4.2 WINU0080

- Drawdown observed in the main drill area and to the north (WINU0472)
- No drawdown observed to the west of the pre-min mafic sill

7.4.3 WINU0706

- Transmissivity calculated for monitored bores and VWP range widely, between 11 and 176 m²/d (Hydraulic conductivity (K), between 0.06 and 0.9 m/d) in both weathered and fresh metasediments screened bores.
- K for monitored bores screened within the fresh metasediments is typically <0.5 m/d, except for WINU0704 (K = 0.9 m/d), where high yielding faults/broken ground were encountered.

- The K values calculated for monitored bores screened within the weathered metasediments is typically higher and likely to be more representative of the bulk aquifer properties than for bores screened in the fresh metasediments.
- Typically, there was either no drawdown or a subdued response observed at the VWPs installed in the overlying Permian mudstone/claystone units.
- A strong NNW-SSE preferential flow pathway is present within the metasediments (likely controlled by fault zone broken ground and brittle deformation associated with folding) in the mine area and toward the north of the mine area.
- A diminished aquifer response observed on the western side of the mine area could be a result of one or multiple features including:
 - Pre-mineralised mafic structures acting as a hydraulic barrier (with some connectivity in the north).
 - A series of northerly trending dykes interpreted by Rio Tinto.
 - Anisotropy associated with orientation of dominant flow paths within the aquifer, associated with faulting and fractured/broken metasediments.

7.4.4 WINU0708

- Transmissivity ranges from 5.5 to 328 m²/d ($K = 0.02$ to 1.3 m/d) in both weathered and fresh metasediments screened bores.
- Strong propagation of drawdown to the north-northwest, with drawdown observed north of the dunes in WINU0704 and WINU0472. As was the case for WINU0706, this is along strike of the dominant structural features modelled by Rio Tinto (likely controlled by fault zone broken ground and brittle deformation associated with folding).
- No drawdown was observed to the south-east at WINU0702, and north-east at WINU0703, indicating less hydraulic connectivity in fresh metasediments in these directions away from the mine area.
- Distance-drawdown data indicate a weakly linear relationship in the NNW strike from WINU0708 (PB02) with clear discrepancies in drawdown and distance from the pumped bore. Little to no response was observed to the west.
- Calculation of transmissivity/storage coefficient was not possible using distance-drawdown methods for WINU0708 and monitored bores due to only a weak trend.
- Typically, no drawdown or a subdued drawdown response was observed for VWPs installed in the overlying Permian mudstone/claystone.
- One VWP installed in the unconfined sandstone (WINU0374C) did respond to test pumping, where no mudstone is present (i.e., metasediments are unconfined).
- A subdued drawdown response was observed on the western side of the mine area, which could be a result of one or multiple features including:
 - Pre-mineralised mafic sill acting as a hydraulic barrier (with some hydraulic connectivity in the north).
 - Series of northerly trending near-vertical dykes interpreted by Rio Tinto.

- Anisotropy associated with orientation of dominant flow paths within the aquifer, associated with faulting and fractured/broken metasediments.
- Potential for the higher-transmissivity zone west of WINU0708 to diminish drawdown responses to the west in WINU0709, which showed no response to pumping despite being only 234 m away from the production bore.

7.4.5 WINU0910

- CRT analysis of bores screened in the fresh metasediment aquifer gave transmissivity values ranging between 117.8 m²/d and 170.7 m²/d with an average of 142.2 m²/d (K = 0.8 to 1.1 m/d, average = 0.95 m/d) whereas monitoring bores screened in the weathered metasediments (WINU0911, WINU0705 and WINU0166) gave higher overall transmissivity values between 96.8 m²/d and 288.9 m²/d with an average of 228.8 m²/d (K = 0.6 to 1.9 m/d, average = 1.5 m/d).
- A key observation in the CRT was a hydraulic connection between the overlying mudstone and metasediment aquifer. VWP (e.g., WINU0765_C) installed in mudstone showed depressurisation during test pumping. Deeper VWPs installed in the mudstone responded earlier and indicated more depressurisation than the shallower sensors, indicating that dewatering of the metasediment aquifer creates a downward hydraulic gradient in the Permian mudstone.
- Bores installed in the unconfined sandstone aquifer did not show any significant response to the CRT pumping. This indicates that the Permian mudstone acts as a confining unit. A small response was observed in VWP_WINU0760_C (0.1 m drawdown), which is likely a response at the base of the sandstone (where the sandstone is not fully unconfined) and the drawdown mimics the mudstone drawdown response.
- Nested VWP sites present different reactions to the CRT pumping. Hydraulic heads vary between sites as to whether it is upward or downward. Nested well site 2 (WINU0261, WINU0704, WINU0472) switched from an upwards gradient from the metasediments to a downward gradient pressure from the sandstone after the CRT. Almost all VWPs showed upward head gradients from the metasediments. WINU0748 and WINU0749 are the only two VWPs which have downward head gradient from the mudstones.
- Hydraulic connection within the Winu Far North, Winu North (EPZ), and Winu Mine areas was observed on the west side of Thorny Devil Fault (TDF) and east side of the mafic sill. WINU0711 located on the west side of the TDF responded to the CRT pumping with an estimated drawdown of 1.7 m while WINU0905 located on the east of the TDF did not record any drawdown.
- Although strong NNW-SSE preferential flow is observed within the metasediments (likely controlled by the fault zone and deformation associated with folding) no boundary condition affect was observed in any of the VWP or monitoring bore responses.
- A diminished drawdown is observed in the bores located to the west of the Winu Mine Area which is interpreted as a barrier effect of the mafic sill. Relatively small drawdowns observed on the west of the sill may result in part from east-west cross-cutting faults.
- It is observed that hydraulic connection between the EPZ and Ngapakarra exists. Open hole WINU0997 located in the Ngapakarra area gave 2.1 m of drawdown during CRT.

- It is difficult to estimate the role of Thorny Devil Fault due to lack of monitoring bores installed in or on eastern side of the fault.
- Low calculated well efficiency for WINU0910 (EPZ-PB01) has been interpreted by Golder to be attributed to well losses associated with non-laminar aquifer flow from discrete fracture zones.
- WINU0910 has a slightly higher well efficiency compared to previous production bores tested at Winu because of the improved bore design (stainless steel screens with increased per cent open area and no gravel pack).
- A strong NNW-SEE preferential flow path is present within the metasediments aquifer (likely controlled by fault zone broken ground and brittle deformation associated with folding) in the mine area and to the north of the mine (EPZ).
- Drilling and test pumping of WINU0910 has confirmed the existence of the EPZ north of the Winu Mine area. WINU0910 achieved a maximum pumping rate of 45 L/s in the SRT and a yield of 36 L/s in the CRT. This is the highest sustained rate a production bore has achieved at Winu at the time of testing.
- Hydraulic conductivities (K) of the metasediments aquifer are similar to previous hydraulic testing estimates. Fresh metasediments have K values of around 1 m/d which increase to up to 2 m/d where the metasediments are weathered.
- Test pumping has confirmed that the mafic sill is a partial barrier to groundwater flow with drawdown primarily observed on the eastern side of the sill. Several east-west structures cross-cut the sill, resulting in partial connection. This has implications for future dewatering strategies for the open pit, whereby dewatering bores will be required on either side of the mafic sill.
- Drawdown was observed at great distances from WINU0910 at Winu Far North and Winu South, which has not been observed in previous pumping tests. Structures north of Winu and south of Winu are poorly understood and more work is required to understand connection and hydraulic parameters in these areas.
- Typically, there was either no drawdown or a subdued response observed in the overlying unconfined sandstone aquifer, reinforcing the mudstone unit at Winu as a confining unit.
- Vertical connection between the metasediments aquifer and mudstone unit was observed during the CRT, with vertical leakage from the mudstone. This was identified by drawdown observed in VWPs set in the mudstone but also the delayed yield drawdown curves in the metasediments aquifer monitoring bore data.
- The nature of the Thorny Devil Fault as either a barrier or conduit is inconclusive from the WINU0910 pumping test. Hydraulic connection along the Thorny Devil Fault was observed on the western (hanging wall) side of the fault, suggesting hydraulic connection along the strike of the fault, however connection across the fault cannot be determined due to limited monitoring bores to the east of the Thorny Devil Fault.

7.4.6 WINU0913

- CRT analysis of bores screened in the metasediment aquifer gave transmissivity values ranging between 7.2 m²/d and 115.7 m²/d with a geometric mean value of 33.4 m²/d (K = 0.04 to 0.73 m/d, geometric mean = 0.21 m/d).
- Drawdown analysis indicates the existence of a hydraulic boundary in the vicinity of WINU0913. Also, the lack of drawdown observed in the bores located on the east side of the TDF shows that TDF acts as a hydraulic boundary for the metasediment aquifer.
- Bores installed in the unconfined sandstone aquifer and mudstone aquitard did not show any significant response to the CRT pumping. This indicates that the Permian mudstone acts as a confining unit for the monitored area.
- Fluctuations recorded during the recovery test in the vicinity of water supply bores are interpreted to be independent of the CRT.
- No response was observed in any of the VWPs installed in the Winu mine area. Similar to the monitoring bores, some VWPs installed in the vicinity of site's water supply bores recorded depressurization independent of the CRT.
- Hydraulic connection within the Ngapakarra area was observed on the west side of the TDF, and east side of the mafic sill. WINU0702 located approximately 1 km to the south of WINU0913 responded to the CRT pumping with an estimated drawdown of 2.3 m while MONT0001 and WINU0539 located 400 m away from WINU0913 and east of the TDF did not record any drawdown.
- It is observed that hydraulic connection only exists between the Ngapakarra and Winu South areas. WINU0702 is the only bore presenting drawdown among the bores located out of Ngapakarra area.
- WINU0913 achieved a maximum pumping rate of 12 L/s in the SRT and a yield of 9 L/s in the CRT.
- Approximately 23.62 ML of groundwater was discharged from the aquifer during the test including calibration, SRT and CRT periods.
- Well losses in WINU0913 have been interpreted by Golder to be attributed to non-laminar aquifer flow from discrete fracture zones.
- WINU0913 has a similar well efficiency but lower yield compared to WINU0910 and previous production bores tested at Winu.
- A strong NNW-SSE preferential flow direction has been observed within the metasediment aquifer (likely controlled by fault zone broken ground and brittle deformation associated with folding) on the west side of the TDF in the Ngapakarra area.
- Hydraulic conductivity (K) values of the metasediment aquifer are lower compared to previous hydraulic testing estimates. The metasediments have average K values of around 0.2 m/day in the Ngapakarra area.
- Although drawdown was observed at further distances from WINU0913 at Winu South (~1350 m from WINU0913), closer bores to the east of WINU0913 and TDF did not respond to the

CRT. This indicates that the preferential flow direction is likely associated with TDF structural deformations on the west and that the TDF represents a no flow boundary.

- Typically, there was either no drawdown or a subdued response observed in the overlying unconfined sandstone aquifer, reinforcing the Permian mudstone being a confining unit.
- Vertical connection between the metasediment aquifer and the mudstone unit above was not observed during the CRT in the Ngapakarra area. Hydraulic connection along the TDF was observed on the western (hanging wall) side of the fault, suggesting hydraulic connection along the strike of the fault, however connection across the fault does not exist.
- Water quality laboratory results showed a relatively stable condition for each parameter over the duration of test pumping.

7.4.7 WINU0917

- Hydraulic conductivity estimates generally range between 0.9 to 1.5 m/d, and a specific storage of between 6.7×10^{-7} to 2.0×10^{-5} m⁻¹.
- A no-flow boundary was simulated to facilitate adequate drawdown distribution along and adjacent to the TDF (i.e., around production bore, and SE at WINU0914).
- The 10 m drawdown cone extended approximately 1 km north and 1.5 km south, with 2 – 5 m drawdown observed up to 2 km south in bore WINU0705.
- Bores and VWP's located to the west of the pre-min mafic sill (within 1.5 km) indicated drawdown of less than 1 m.
- No drawdown is observed to the north and east of the TDF, except for WINU0911. (WINU0911 located 400 m away had 7.3 m of drawdown, while WINU0910 located 330 m away had 19.8 m of drawdown).
 - WINU0911 intersects the TDF, however is screened on the east of the TDF, likely resulting in a connection through the drilling processes and gravel installation explaining the response to abstraction from the west of the TDF.
- Test pumping of WINU0917 enforces the conceptualisation of no flow boundaries (pre-min mafic sill and the TDF) and compartmentalisation, with the partial connection/leakage due to secondary faulting.
- WINU0909 and WINU0709, which are located approximately 50-70 m east of the mafic sill, both reacted to pumping at WINU0917. Both bores also reacted during the WINU0076 pumping test.
 - Given the reaction of these bores in both pumping tests, it is likely that a hydraulic connection exists between the area to the west of the mafic sill (including the 50-70 m corridor east of the sill) with the area north of the pit (around WINU0917) via the vicinity of WINU0909, close to the intersection of the mafic sill and the TDF. This is likely due to the major east west late time faulting.
- A strong NNW-SSE preferential flow is observed, based on the drawdown responses recorded north of the production bore (WINU0909), the south of the pit (WINU0705), and along the TDF (WINU0914). These flows are mostly driven by local faulting within the mineralisation zone, therefore small inconsistencies with drawdown are observed.
- Recovery data show a very slow recovery after the multi day CRT, with water level reaching a 95% recovery after 12 days, indication slow recharge and that water was likely supplied out of storage.

- WINU0261, screened within the unconfined sandstone aquifer, recorded 0.23 m of drawdown, indicating that some leakage is likely occurring through the mudstone layer, which is only 11 m thick within the vicinity of the production bore.
- A drawdown response of 5.5 m at WINU0914 (1.95 km) suggests that the TDF is likely acting as a flow barrier, therefore extending the drawdown against the barrier to the south. No drawdown at WINU0903, WINU0905, WINU0703 and WINU0912, supports the concept of a flow barrier toward the east.

7.4.8 WINU0076 (2023)

- Fracture hydraulic conductivity estimates generally range between 1.6 to 2 m/d, and a fracture specific storage of between 5.7×10^{-7} to 1.0×10^{-5} m⁻¹.
- A no-flow boundary was simulated within Aqtesolv (representing the pre-mineralisation mafic sill) to facilitate adequate drawdown distribution adjacent to the pre-min mafic sill (i.e., at WINU0909, WINU0709).
- Most drawdown is observed in bores located to the west of the pre-min mafic sill, as well as in WINU0709 and WINU0909 which are located approximately 50-70 m east of the pre-min mafic sill. This is likely due to secondary east-west faulting causing leakage through the pre-min mafic sill or slight inaccuracies of the mapped structure.
- The shape of drawdown suggests anisotropic properties, with a preferential alignment toward the NW-SE.
 - Drawdown to the west (i.e., at WINU0949, WINU0219, WINU0381_A&B and WINU0758_A&B) is reduced compared to other bores of a similar distance, indicating preferential flow along strike.
 - The NW-SE drawdown orientation is likely to be aligning with mapped faults (NNW-SSE) and deformation within the pit area, as well as the mafic sill (NW-SE).
- Very limited to no drawdown was observed directly east of the pre-min mafic sill in the main drill area for all bores.
 - VWP location WINU0749_C&D within the mudstones indicated approximately 0.6 m drawdown, this is likely due to site water used from a close by location
 - VWP location WINU0373_B indicated 1.5 m drawdown within the metasediment
 - The remaining bores indicate no drawdown, this would support the conceptualisation of the no-flow properties of the pre-min mafic sill in areas where cross cutting secondary (late time) faulting is not present.
- WINU0214, screened within the unconfined sandstone aquifer, recorded 0.54 m of drawdown.
- WINU320 and WINU760_B&C, installed within the mudstone unit has responded with 0.6, 0.21 and 1.43 m drawdown.
- Drawdown observed in the upper layers indicate that some leakage has occurred through the mudstone layer, which is only 16 m thick within the vicinity of the production bore.
- Figure 7-14 is a 3D cross section from west to east through WINU0076 to showcase the locations and drawdown observed within the VWP sensors.

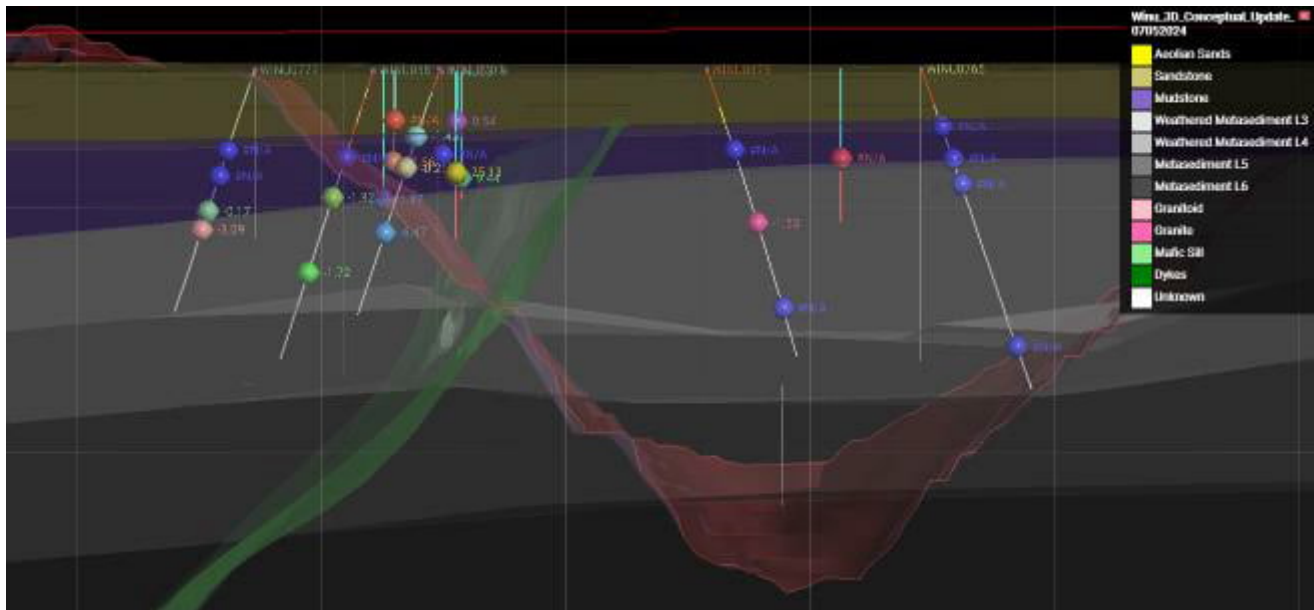


Figure 7-14: Cross section of VWP locations in relation to WINU0076 pumping test

7.4.9 WINU0925

- Fracture hydraulic conductivity estimates generally range between 0.03 to 0.04 m/d, and a fracture specific storage of between 2.0×10^{-7} to $4.4 \times 10^{-6} \text{ m}^{-1}$.
- Drawdown responses were observed on both sides of the TDF; however this is contradictory to the observations made from pumping at WINU0917 and previously tested production bore WINU0913 which suggests the TDF acts as a barrier to flow (Golder, 2022c).
 - Drawdown observed in WINU0912, WINU0913 and WINU0915 coincide with air lifting operations at WINU1305. These bores have also shown response to test pumping in WINU1305 in subsequent tests and therefore, the drawdown observed on the west of the TDF is likely not related to the pumping at WINU0925.
 - A drawdown response at WINU0702 could also be linked to airlifting of production bore WINU1305 at the time of the CRT.
- As pumping was seized after two days due to a failure with the pump equipment, limited stress on the aquifer was applied and drawdown was constrained to a small cone of influence around the production bore ($\sim 1 \text{ km}$ radius), limiting the use for reliant analysis.
- No response was observed at WINU0934, 850 m to the NE. This is thought to be due to a combination of factors, one being the short pumping duration and the other being the low hydraulic conductivities interpreted on the NE side of the TDF.

7.4.10 WINU01305

- Fracture hydraulic conductivity estimates generally range between 0.1 and 0.2 m/d, and a fracture specific storage of between 7.2×10^{-7} to $3.9 \times 10^{-5} \text{ m}^{-1}$.
- Drawdown appears to show an indication of having a westerly and northerly orientation, potentially following the geometry of the granite intrusion in the area (Figure 7-13).
- The flow dimension parameter n , was estimated to be $n=1.7$ as one of the possible interpretations using the Barker (1988) dual porosity solution, indicating a slight deviation

from the radial flow regime ($n=2$) toward a linear flow regime ($n=1$), likely as a result of preferential fracture orientations.

- Drawdown observed in bores screened within both granite and metasediment aquifers indicating a connectivity through both lithologies likely via fracture networks in the area, caused by the granitic monolith.
- Several RC holes within the immediate vicinity of WINU1305 that were being monitored either collapsed or ran dry soon after the start of the CRT; the data that was collected showed that all of the RC holes reacted with a rapid initial drawdown, and recorded part of the aquifer recovery. However, not sufficient for analysis.
- Fracture connectivity within the immediate vicinity of WINU1305 appears to be highly variable, with RC hole WINU1298 recording 1.1 m of drawdown, 500 m to the NW, while WINU0702 indicated 14.5 m of drawdown 1 km to the NW.
 - RC observation data can be highly unreliable and therefore no conclusions have been drawn from this observation.
- There appears to be a good hydraulic connection between the production bore and the Ngapakarra area south of the TDF (i.e., WINU0913, WINU0915 showed 4.8 and 6.1 m of drawdown).
 - The pre-min mafic sill is older than the granite intrusion. Therefore, the pre-min mafic sill would have been cut off in the south and are not acting as a flow barrier.
- Drawdown response NE of the TDF is subdued (i.e., at WINU0930)

7.5 Summary of key findings

- Limited aquifer responses were observed during testing of bores to the west and northeast of the mine area, and northeast of Ngapakarra. This has been interpreted to be the result of one or more of the following:
 - Pre-min mafic sill acting as a hydraulic barrier, with potentially some leakage through the southern part where it is intersected by secondary faulting.
 - Thorny Devil Fault behaving as a flow barrier to the north
 - Anisotropy associated with orientation of dominant flow paths within the aquifer, associated with secondary faulting.
 - Testing of WINU0917 has been mostly contained between these two flow barriers, indicating a level of compartmentalisation with limited storage available.
- Typically, there were small responses in the VWP installed in the Permian mudstone/claystone units overlying the tested aquifer, suggesting the mudstone layer acts as an aquitard rather than an aquiclude.
- WINU0261 and WINU214 installed in the unconfined sandstone aquifer have responded to pumping test, indicating potential leakage through thinner, poorly covered mudstone areas (10 - 15 m) within the vicinity of the proposed pit.
- NW-SE fracture networks are generally well connected within the immediate mine area, resulting in an anisotropic response to pumping that is similarly oriented.
- A good hydraulic connection exists between Winu South (WINU1305) and Ngapakarra, which likely coincides with the granite intrusion and its associated structures.

7.6 Aquifer properties compiled from studies and test pumping

A summary table of the hydraulic properties compiled from various studies (Golder, 2022, Advisian 2021a, e, f) is shown on Table 7-4.

Hydraulic parameters for the quaternary aeolian sands and silcrete/ferricrete units have not been tested at this time. Studies including the Surplus Water Management Study (Advisian, 2024), discussed potential hydraulic properties for these units; they are adopted in this study.

Table 7-4: Hydraulic properties of the various HSUs collated from previous studies

HSU	Thickness (m)	Unit Type	Material property	Units	Value	Comments
Quaternary aeolian sands (Cenozoic)	2-30	Unsaturated	Kh	m/d	5 to 20	(Advisian, 2024)
			Kv	m/d	5 to 20	
Silcrete/ferricrete	10-20	Unsaturated	Kh	m/d	0.004	
			Kv	m/d	0.004	
Unconfined sandstone	20-60	Unconfined sedimentary aquifer	Kh	m/d	1 to 10	(Golder, 2022a), (Advisian, 2022a), (Advisian, 2023e), (Advisian, 2023f)
			Kv	m/d	0.05 to 5	
			Sy	1	0.005 to 0.05	
			Ss	1/m	1.0×10^{-5} to 3.7×10^{-5}	
Permian mudstone	0-50	Sedimentary aquitard	Kh	m/d	0.001 to 0.1	
			Kv	m/d	0.0001 to 0.1	
			Sy	1	0.005 to 0.02	
			Ss	1/m	5.0×10^{-6} to 1.0×10^{-6}	
Proterozoic metasediments	0-200	Confined, weathered metasedimentary aquifer	Kh	m/d	0.05 to 10	
			Kv	m/d	0.05 to 3.25	
			Sy	1	0.005 to 0.02	
			Ss	1/m	5.0×10^{-6} to 3.7×10^{-5}	
	>300	Confined, fresh metasedimentary aquifer	Kh	m/d	0.02 to 1.1	
			Kv	m/d	0.05 to 0.8	
			Sy	1	0.002 to 0.02	
			Ss	1/m	5.0×10^{-6} to 3.0×10^{-5}	
Granitoid igneous intrusions	>300	Weathered intrusive aquitard	Kh	m/d	0.001 to 0.3	
			Kv	m/d	0.001 to 0.3	
			Sy	1	0.002 to 0.005	
			Ss	1/m	1.0×10^{-6} to 5.0×10^{-6}	
Granitoid igneous intrusions	>300	Fresh intrusive aquitard	Kh	m/d	0.0001 to 0.005	
			Kv	m/d	0.0001 to 0.005	
			Sy	1	0.001 to 0.007	
			Ss	1/m	5.0×10^{-7} to 3.0×10^{-6}	

8. Groundwater chemistry

Groundwater investigations since 2019 include a total of 106 production bores, monitoring bores, and VWPs, which target the unconfined sandstone and confined metasediment aquifers.

Field water quality parameters were recorded on all bores after completion and sampling (for laboratory analysis) has been completed on a selected number of bores.

Groundwater sampling was carried out by a combination of low flow sampling and hydrasleeves (at screen intervals). Field water quality parameters including pH, electrical conductivity (EC), temperature (Temp), dissolved oxygen (DO), oxidation-reduction potential (ORP) and total alkalinity (TA) were recorded during sampling.

8.1.1 Unconfined sandstone

The ranges of field water quality parameters of the Unconfined Sandstone Aquifers for the period from 2019 to 2023 are presented on Table 8-1.

Table 8-1: Annual Quality Monitoring in the Unconfined Aquifer

Monitoring Location	No. bores	pH				Electrical Conductivity (µS/cm)			
		Min	Max	Med	Avg	Min	Max	Med	Avg
Unconfined Sandstone Field	15	6.50	11.47	7.44	7.49	295	5,406	788	1,118
Unconfined Sandstone Lab	14	6.56	8.50	7.57	7.59	373	1,790	687	901

The results presented on Table 8-1 show groundwater in the sandstone aquifer has a generally consistent pH and a varied salinity. High EC concentrations generally correspond with low water levels in the aquifer, as occurs during periods of lower rainfall.

8.1.2 Metasediments

The field and laboratory measured water quality parameter ranges of the Metasediment Confined and Unconfined Aquifers for the period from 2019 to 2023 are presented on Table 8-2.

Table 8-2: Annual Water Quality Monitoring in the Metasediment Aquifer

Monitoring Location	No. bores	pH				Electrical Conductivity ($\mu\text{S}/\text{cm}$)			
		Min	Max	Med	Avg	Min	Max	Med	Avg
Metasediment Confined Field	27	6.62	11.6	7.62	8.04	314	8,489	2,744	3,227
Metasediment Confined Laboratory	27	4.69	11.80	7.81	8.13	321	7,130	1,460	2,093
Metasediment Unconfined Field	3	6.55	7.84	7.41	7.26	530	2,136	892	1,213
Metasediment Unconfined Laboratory	3	7.19	7.97	7.64	7.57	505	1,710	1,450	1,102

The groundwater quality results from the Confined Metasedimentary aquifer show higher salinity than the Unconfined Metasedimentary aquifer.

8.1.3 Hydrochemical types

The Piper trilinear diagram (Figure 8-1) shows that Winu hydrochemical types range from sodium-bicarbonate dominant to sodium-chloride dominant, which is common for this hydrogeological and climatic setting.

The Unconfined Sandstone aquifers hydrochemistry is variable, ranging from sodium-bicarbonate to sodium chloride type, with the majority of the samples indicating a mixed water type. This is likely due to the partial mixing between the metasediment aquifer (sodium chloride) and the unconfined sandstone aquifer (sodium-bicarbonate).

The Confined Metasediment aquifers is of the sodium-chloride type. Groundwater at the mine area has relatively higher proportions of sodium chloride compared to bores sampled further east, with a strong linear trend for major cations from sodium/potassium to increased calcium, and to a lesser extent, magnesium to the east. This is correlated with groundwater flow from recharge areas to confined sections.

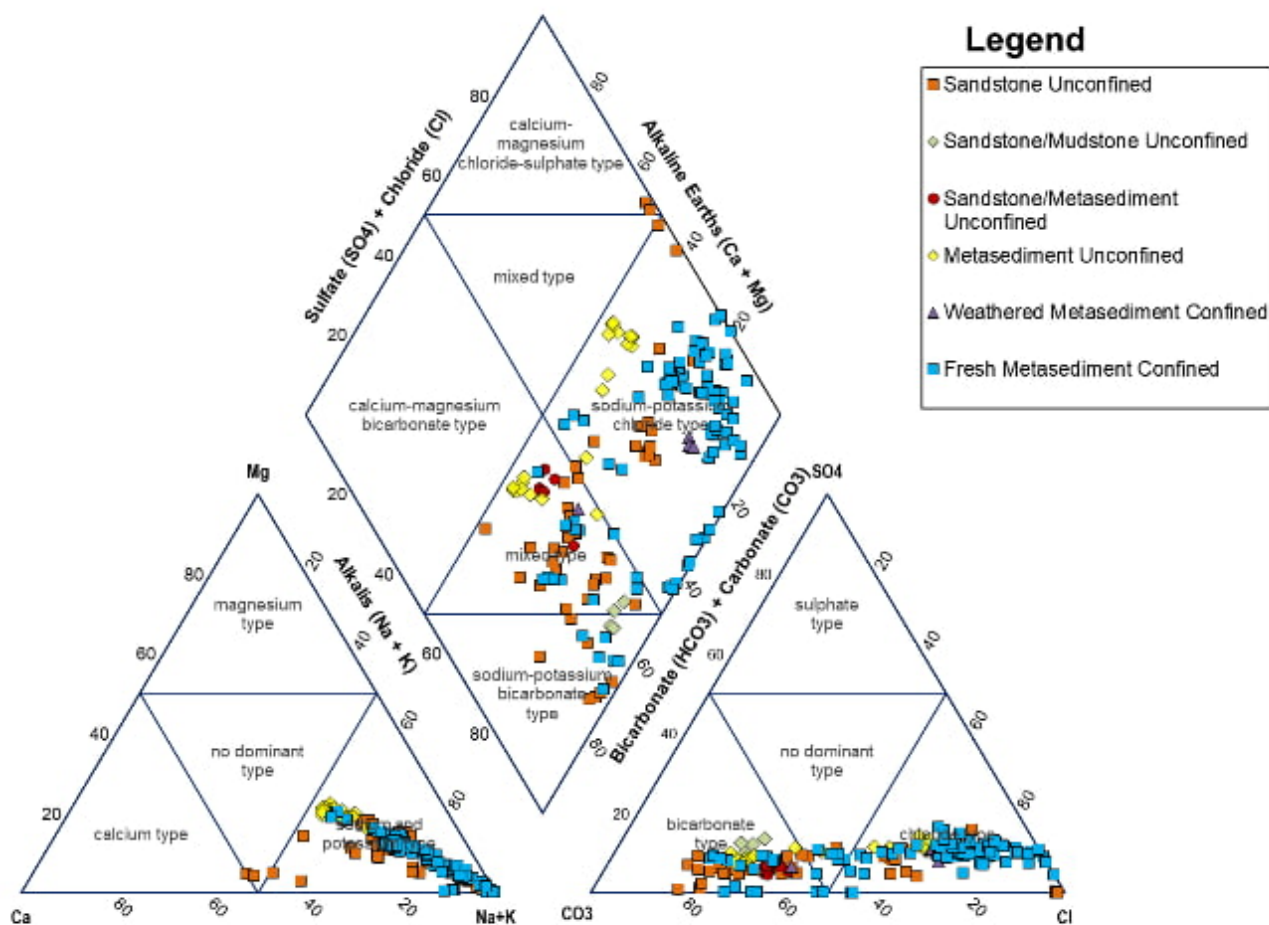


Figure 8-1: Piper diagram with bores classified by aquifer

9. Groundwater modelling

9.1 Hydrogeological conceptual model

In development of the hydrogeological conceptual model, key groundwater flow processes were identified and are presented as follows:

- The study area is considered an open hydrological system, with groundwater throughflow occurring within two main aquifer systems; the unconfined sandstone aquifer (primary porosity) and the Proterozoic metasediment aquifer (secondary/fracture porosity).
 - Within the mine area, the two aquifer systems are separated by the Permian mudstone, which is an approximately 30-40 m thick aquitard that hydraulically separates the overlying unconfined sandstone from the underlying metasediment aquifer. The mudstone unit thickness varies significantly (>200 m) toward the west, coinciding with the Anketell Fault and the Barnicarndy Graben.
 - Groundwater flow within the unconfined sandstone aquifer is in a NNW flow direction, toward the coastline (Indian Ocean).
 - Groundwater flow within the Proterozoic metasediment aquifer is both gravimetric and pressure driven, depending on the presence and thickness of the overlying Permian mudstone layer. Flow direction is also toward the NNW.
 - Upward leakage through the mudstone layer is thought to occur based on isotope interpretation (IGS, 2021) in areas where the metasediment aquifer is sufficiently pressurised, and where the mudstone is silty, weathered, or thin.
- The hydrogeological system has been divided into seven (7) hydrostratigraphic units, based on lithology and hydrogeological function. These are (from surface): aeolian sand, silcrete/ferricrete, sandstone, mudstone, mafic intrusions (dykes/sills), metasediment, and granite.
- Recharge to the groundwater system is not reliably estimated, however it is expected to occur episodically following cyclone events, when rainfall can infiltrate to depths able to overcome the high rates of evapotranspiration.
 - A potential regional groundwater recharge area is identified to the south of the Rimfire area (30 km SE of Winu). This is interpreted by an absence of a confining layer, shallow groundwater (between 5 to 20 m BGL), and several ferricrete (outcrop/subcrop) observed via satellite imagery.
 - The Percival Palaeovalley is situated to the east of the Texas area (30 km SE of Winu) and may form an additional source of groundwater recharge.
 - Recharge rates of between 0.4 to 2.4% of mean annual rainfall (1.5 and 8.7 mm respectively) are estimated from isotope studies (IGS, 2021).
- Groundwater abstraction from the study area is currently conducted only by RTC, and amounts to approximately 0.06 GL/a, which represents only 20% of the current licensed allocation of 0.3 GL/a. Groundwater abstraction is expected to increase over the life of mine to support ongoing operations.
- Groundwater within the unconfined sandstone aquifer is circum-neutral at 7.6 pH (median) but can range between 6.6 to 8.5. The median EC is 700 $\mu\text{S}/\text{cm}$ but can range between 400 to 1,800 $\mu\text{S}/\text{cm}$.

- The confined Proterozoic metasediment aquifer has groundwater with circum-neutral at 7.8 pH (median) and ranges between 4.7 to 11.8. The median EC is 1,500 $\mu\text{S}/\text{cm}$, within the 300 to 7,100 $\mu\text{S}/\text{cm}$ range.
 - The unconfined Proterozoic metasediment aquifer has slightly fresher pH, with a median EC of around 1,400 $\mu\text{S}/\text{cm}$ (ranges between 500 to 1,700 $\mu\text{S}/\text{cm}$).

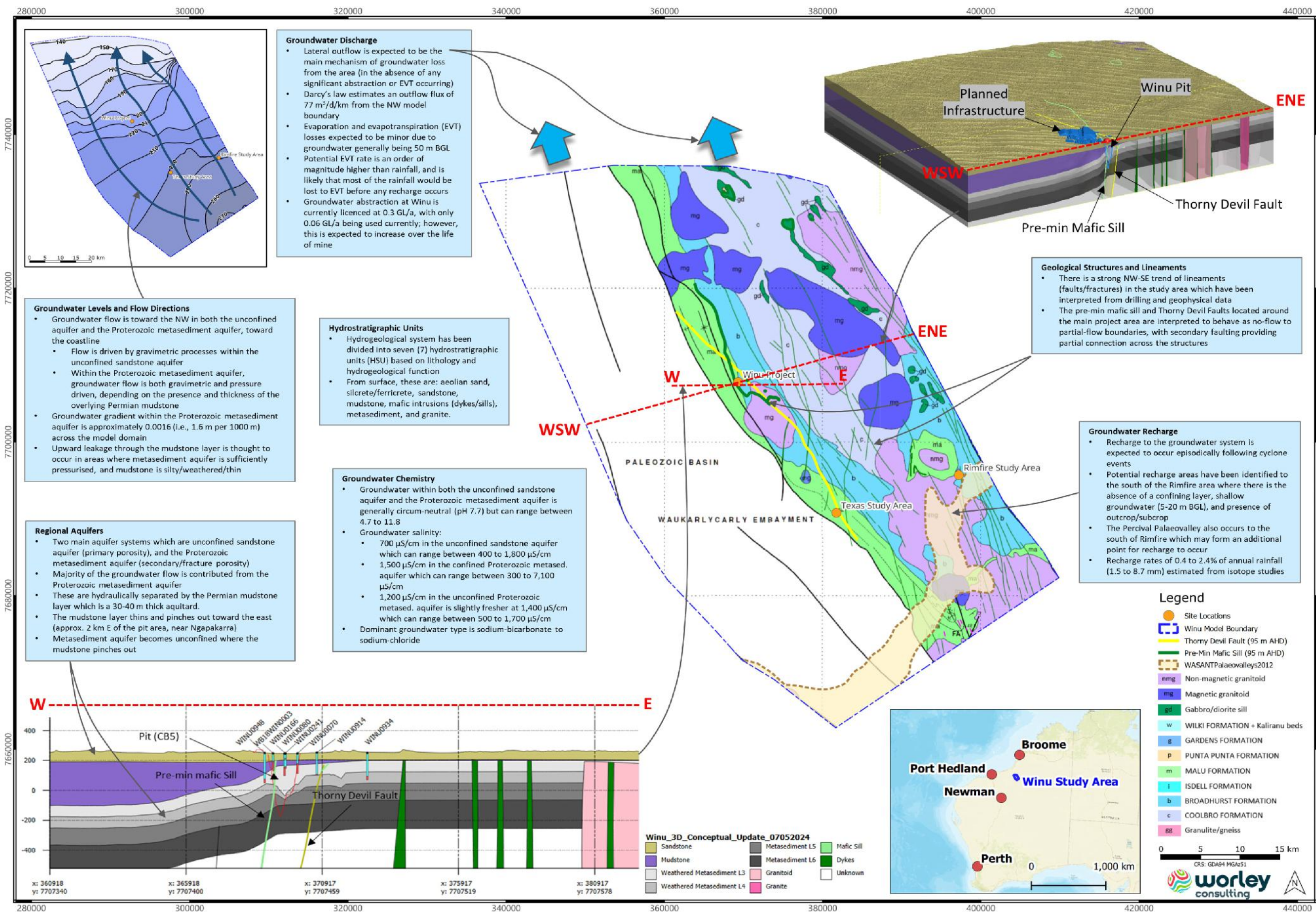
The important elements of the hydrogeological conceptualisation are summarised in Table 9-1, and are presented in Figure 9-1.

Table 9-1: Conceptual hydrogeology summary

Conceptual hydrogeology element/feature	Description				
Study domain	The numerical model boundary is aligned NW-SE and follows the general groundwater flow orientation and geological trends in the area. The total model area is 3000 km ²				
Hydrostratigraphic units (HSU)	The hydrogeological system has been divided into seven (7) hydrostratigraphic units (HSU), based on lithology and hydrogeological function.				
	These are (from surface):				
	HSU	Thickness	Hydrogeological function		
	Quaternary aeolian sand	0 to 10 m	Unsaturated		
	Silcrete/ferricrete	10 to 20 m	Unsaturated		
	Sandstone	20 to 50 m	Unconfined sedimentary aquifer		
	Permian mudstone	0 to 500 m	Aquitard		
	Mafic intrusions	5 to 40 m	Intrusive aquitard		
	Proterozoic metasediment	20 to 80 m (weathered)	Fractured aquifer		
		> 300 m (fresh)	Fractured aquifer		
Granite	> 100 m	Fractured aquifer / Intrusive aquitard			
Geological structures and lineaments	There is a strong NW-SE trend of lineaments which have been interpreted from drilling and geophysical data. The interpreted lineaments are likely to comprise of faults and fractures, which based on several pumping tests within the Winu mine area, are known to store and convey water.				
	Previous studies (Section 5), show a correlation between structures and higher yielding bores.				
Hydraulic properties	The hydraulic properties of the HSUs have been compiled from various studies (Golder, 2021a, Advisian 2021a, b, c), and include four (4) recent pumping tests undertaken at WINU0076, WINU0917, WINU0925, and WINU1305.				
	HSU	Kh (m/d)	Kv (m/d)	Sy	Ss (m ⁻¹)
	Quaternary aeolian sand	5 to 20	5 to 20	-	-
	Silcrete/ferricrete	0.004	0.004	-	-
	Sandstone	1 to 10	0.05 to 5	0.005 to 0.05	1.0x10 ⁻⁵ to 3.7x10 ⁻⁵
	Permian mudstone	0.001 to 0.1	0.0001 to 0.1	0.005 to 0.02	5.0x10 ⁻⁶ to 1.0x10 ⁻⁶

	Proterozoic metased. (weathered)	0.05 to 10	0.05 to 3.25	0.005 to 0.02	5.0×10^{-6} to 3.7×10^{-5}
	Proterozoic metased. (fresh)	0.02 to 1.1	0.05 to 0.8	0.002 to 0.02	5.0×10^{-6} to 3.0×10^{-5}
	Granitoid igneous intrusions (Weathered)	0.001 to 0.3	0.001 to 0.3	0.005 to 0.002	1.0×10^{-6} to 5.0×10^{-6}
	Granitoid igneous intrusions (fresh)	0.0001 to 0.005	0.0001 to 0.005	0.001 to 0.007	5.0×10^{-7} to 3.0×10^{-6}
Groundwater recharge	Recharge to the groundwater system cannot be accurately determined, however it is expected to occur episodically following cyclone events, where rainfall has infiltrated sufficiently to overcome the high rates of evapotranspiration. Regional groundwater recharge area around the Rimfire area (30 km SE of Winu), due to an absence of a confining layer, shallow groundwater (between 10 to 20 m BGL), and several outcrop/subcrops observed via satellite imagery The Percival Palaeovalley to the east of the Rimfire area (30 km SE of Winu) may form an additional source of groundwater recharge Recharge rates of between 0.4 to 2.4% of mean annual rainfall (1.5 to 8.7 mm) are interpreted by isotope studies (IGS, 2021)				
Groundwater discharge and abstraction	Lateral outflow is the main mechanism of groundwater loss from the area, in the absence of any significant abstraction or evapotranspiration occurring. Using Darcy's law, the outflow flux from the study area is estimated to be in the order of 77 m³/d/km Evaporation and evapotranspiration (EVT) losses are expected to be minor in comparison to lateral outflow due to groundwater levels in the study area generally being around 50 m BGL, well below the extinction depth of the EVT process (generally 5 m). The potential EVT rate is an order of magnitude higher than rainfall, and it is likely that most of the rainfall would be removed by this process before any recharge takes place, with the potential exception of rainfall produced during cyclonic events. The main discharge via groundwater abstraction will be the Winu project area, where RTC currently abstracts approximately 0.06 GL/a in support of drilling, earthworks, dust suppression, road construction, and maintenance. This represents 20% of the current licensed allocation of 0.3 GL/a. Groundwater abstraction is expected to increase over the life of mine to support pit dewatering and ore processing operations.				
Groundwater flow directions, and water levels	Groundwater levels within the study area range between 252 m AHD (WINU0946) to the SE in the Texas area, and 173 m AHD (WINU0928) to the NW in the Winu North area. Groundwater depths generally range between 20 to 50 m BGL. Groundwater flow within the unconfined sandstone aquifer is gravimetric, with regional groundwater levels indicating a NNW flow direction, toward the coastline (Indian Ocean). Groundwater flow within the Proterozoic metasediment aquifer is both gravimetric and pressure driven, depending on the presence and thickness of the overlying Permian mudstone layer. Flow direction is also toward the NNW. The groundwater gradient across the study area is approximately 0.0016 (i.e., 1.6 m per 1000 m) within the Proterozoic metasediment aquifer. Upward leakage through the mudstone layer is thought to occur based on isotope analysis (IGS, 2021) in areas where the metasediment aquifer is sufficiently pressurized, and where the mudstone is silty, weathered, or thin				
Groundwater-surface water interaction	No significant groundwater-surface water interaction is present around the Winu mine area, based on the observed water levels generally exceeding 20 m BGL, and the absence of any groundwater supported hydrological features (i.e., soaks or claypans). This may change toward the SE around the Texas area, where shallow groundwater levels have been recorded (i.e., 3.8 m BTOC at bore AKD10). The shallow groundwater occurrence is currently poorly understood, however it is considered likely to be a combination of low topography and potentially perched groundwater within the Percival Palaeovalley (WASANT,				

	2012). Groundwater-surface water interaction is likely to be spatially constrained to areas with shallow groundwater levels (below 5 m BGL), and temporally constrained during and immediately following periods of intense rainfall and/or cyclonic events.
Groundwater quality and salinity	Groundwater within the unconfined sandstone aquifer is circum-neutral at 7.6 pH (median) but can range between 6.6 to 8.5. The median EC is 700 $\mu\text{S}/\text{cm}$ (median) but can range between 400 to 1,800 $\mu\text{S}/\text{cm}$ Groundwater within the confined Proterozoic metasediment aquifer is circum-neutral at 7.8 pH (median) but can range between 4.7 to 11.8. The median EC is 1,500 $\mu\text{S}/\text{cm}$ but can range between 300 to 7,100 $\mu\text{S}/\text{cm}$ Groundwater within the unconfined Proterozoic metasediment aquifer exhibits a similar pH but is slightly fresher, with a median EC of around 1,400 $\mu\text{S}/\text{cm}$ (ranges between 500 to 1,700 $\mu\text{S}/\text{cm}$)
Environmental receptors	Three potential GDE areas have been identified within the study area using the online GDE Atlas tool (BoM), which are all situated between 25 to 35 km from the Winu mine area, and outside of the modelling domain. These are all vegetation GDE areas which support hard spinifex grasslands, hummock grasslands, and eucalypts. Shallow groundwater levels are present in the SE of the study area near bore AKD10 (3.82 m BGL) which are caused by perched groundwater supported by the presence of palaeochannel clays. It is currently interpreted to be disconnected from the regional metasediment aquifer, however this still remains to be confirmed. If it is connected, any groundwater level changes in the vicinity of the palaeochannel have an effect on the local flora and fauna. Other potential environmental receptors include the Weenoo and Djimarakka soaks, which are located 23 km and 45 km northwest of the Winu mine area respectively. These however have been assessed by Golder (2022a), and are not considered to be groundwater dependent, but instead supported by rainfall and surface water runoff.
Third-party mining operations	The closest third-party mines to Winu are: • Nifty Copper Mine, operated by Cyprium Metals Ltd (110 km south-west) • Telfer Mine, operated by Newcrest Mining Ltd (120 km south-southeast) • Havieron Project, JV between Newcrest Mining Ltd and Greatland Pty Ltd (140 km south-east) • Woodie Woodie Mine, operated by Pilbara Manganese Pty Ltd (110 km south-west)



9.2 Numerical model development

9.2.1 Background

Since 2019 and every year thereafter, the conceptual and numerical hydrogeological model has been updated as additional data is collected and the mine plan refined.

Some key model updates for Winu are summarised on Table 9-2.

Table 9-2: Numerical model updates

Groundwater Model and reference	Code	Key Change log
Golder, 2019	FEFLOW	First Model, Preliminary mine dewatering assessment (Golder, 2020)
Golder, 2020	FEFLOW	Refinement of existing 2019 model and conceptual model with new data.
Golder, 2021	FEFLOW	Refinement of the existing 2020 model, including new testing and monitoring data and refined site geological model. Finalisation of the conceptual groundwater model and independent model review (undertaken by AQ2). In addition to the previous models this model predicted mine dewatering rates, groundwater impacts and post-mine recovery.
Advisian, 2022	MODFLOW-USG	Conversion of the existing Golder, 2021 model from FEFLOW to MODFLOW-USG. The model was also updated to include the updated conceptual model, latest geological and pumping test data.
Advisian, 2023	MODFLOW-USG	The previous 2022 MODFLOW-USG model was updated to encompass the Texas bore area. The expanded model included new geological, monitoring and pumping test data. This expanded model assesses the combined impacts of Winu mine dewatering and future borefield extraction on groundwater levels.
Advisian, 2024	MODFLOW-USG	This model is a refinement of the previous 2023 model, including new monitoring data, pumping test and adjusted conceptual model from the previous model results.

9.2.2 Approach to numerical model

The Winu H3 model extends to include the Winu main study area as well as potential regional borefields for water supply.

The modelling tasks were:

- Numerical model construction in MODFLOW-USG: model setup and definition of boundaries and hydrogeological units (HSUs) based on the 3D conceptual model and model stresses.
- Steady-state calibration: developed and run to verify and test the model construction, provide initial water level through matching regional observed vs simulated groundwater levels at a single point of time.
- Transient calibration: to calibrate aquifer parameters such as hydraulic conductivity, specific storage and specific yield through the Texas and Winu pumping tests.
- Predictive modelling: simulation of the mine dewatering and borefield water supply to estimate the extent of drawdowns and borefield capacity.
- Sensitivity testing of major geological structures (potential flow barriers) at Winu: to test the influence of these structures and conceptual model uncertainty on the dewatering rates and volumes.
- Uncertainty analysis: null-space Monte Carlo uncertainty analysis to evaluate parameter uncertainty for two alternative conceptualisations.

9.2.3 Model platform

The numerical groundwater flow model is built in MODFLOW-USG. MODFLOW-USG is well-suited for achieving the model's objectives and has the following advantages:

- Efficient discretisation and improvements in numerical stability by employing unstructured, variably sized cells. These cells can assume polygonal shapes, with flexible size constraints that facilitate refinement in areas of interest, such as geological or mining features.
- Unlike earlier MODFLOW versions that confined interlayer flow to vertical connectivity, MODFLOW-USG introduces lateral connectivity between model layers. This advancement allows for more accurate representations of hydro stratigraphic units, particularly those exhibiting pinching out, outcropping, or intersecting geological faults.
- Moreover, MODFLOW-USG has the capability to efficiently simulate desaturation and resaturation of model layers, enabling the representation of progressive mine dewatering and post-closure rewetting within the model.
- In the context of the Project model, vadose zone properties are omitted, and the unsaturated zone is modelled using the upstream-weighting method.
- A mature and stable open-source (i.e., transparent and reproduceable) code base, which has been widely applied in Australia and elsewhere since its original release in 2013.

9.2.4 Model grid

The model domain is at regional scale, covering an area of 3,000 km², with discretisation refined around the project area. The extend of the model domain is shown in Figure 9-2.

The unstructured model grid (USG) has a higher density Voronoi cells around the geological contacts, geological structures, bores, and the mine pit, with larger cells outside these areas where high resolution detail is not required.



The USG mesh was generated using a combination of Python scripting and ALGOMESH v2 software (HydroAlgorithmics).

Overall, the model comprises 22,391 cells with variable cell sizes. Cell spacings range from 500 m along the model boundaries to approximately 30 m proximate to the Winu mine pit and production bores at Winu, Texas and Rimfire.

This methodology maintains consistency with the grid creation approach employed in the Winu model (Advisian, 2022a) and Texas model (Advisian, 2023f).

9.2.5 Model Layers

The model comprises six (6) layers and were built based on the HSUs presented on Table 9-3. The layer elevations, layer thicknesses were developed on the basis of available information including 2D geology surface mapping, bore logs and any other publicly available information. Figure 9-3 shows a cross section through the model in the main Winu project area.

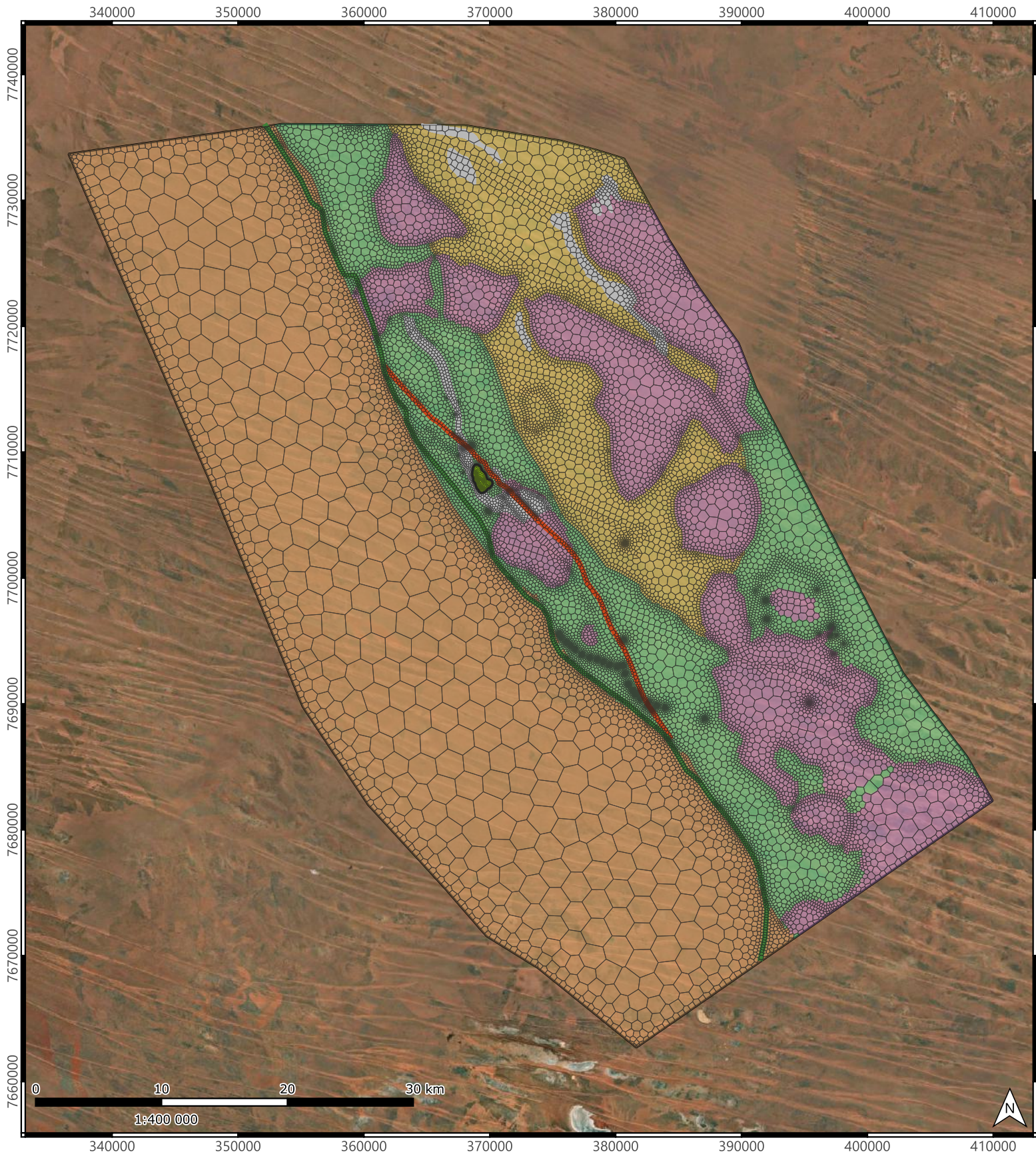
The geology contacts used to construct the model layers are based on the latest conceptual model:

- The base of layer 1 is defined from the contact between the sandstone unit. The layer combined the aeolian sand, ferricrete, silcrete and sandstone lithological units and are only partially saturated at the base of this unit.
 - Consideration should be given to split this unit for Winu closure modelling to simulate the potential for the silcretes to act as an aquitard to infiltration and seepage from the infiltration ponds and TSF.
- Layer two comprises of the mudstone unit acting as an aquitard where present, however, in areas where mudstone is absent this layer pinches out and there is a direct connection between layer 1 and layer 3 below.
- The weathered metasediment is defined as layer 3, with an increased depth in the Winu proposed pit area due to secondary faulting and weathering.
- Model layer 4 and 5 represents the fresh metasediments. The vertical subdivision of this layer is to allow for flexibility of simulating wells from different depth.
- Layer 6 considers the same lithology as layer 4 and 5 with a lesser degree of weathering and fracturing. Therefore, representing a denser lithology across the model domain.

The subdivided layer 2 is laterally connected to the regional layers where it pinches out based on the elevations at the cell faces where they intersect with the regional layers. This allows for a numerical groundwater model that is not excessively large to have undue influence on model stability, calibration and predictive uncertainty analysis.

Table 9-3: Numerical model layers

Layer	HSU	Thickness (m)
1	Unconfined sandstone	50-60
2	Permian mudstone	0-400
3	Weathered (granite, Coolbro, Broadhurst and Malu & Palaeozoic)	70-100
4	Fresh Metasediments Upper (granite, Coolbro, Broadhurst and Malu & Palaeozoic)	75
5	Fresh Metasediments Lower (granite, Coolbro, Broadhurst and Malu & Palaeozoic)	115
6	Very Fresh Metasediments (granite, Coolbro, Broadhurst and Malu & Palaeozoic)	190



Legend

- | | |
|--|---|
|  Winu H3 Model Outline | Geology |
|  WINU PIT |  Palaeozoic |
|  Model grid |  Granites |
|  Ankatell line fault |  Broadhurst and Malu |
|  Thorny Devil fault |  Coolbro |
|  Mafic Sill | |

Numerical Model domain and Voronoi mesh discretisation

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 9-2
-----------------------------	----------------------------	-------------------

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 30/05/2024, 13:42

References

Consultant



Client

RioTinto

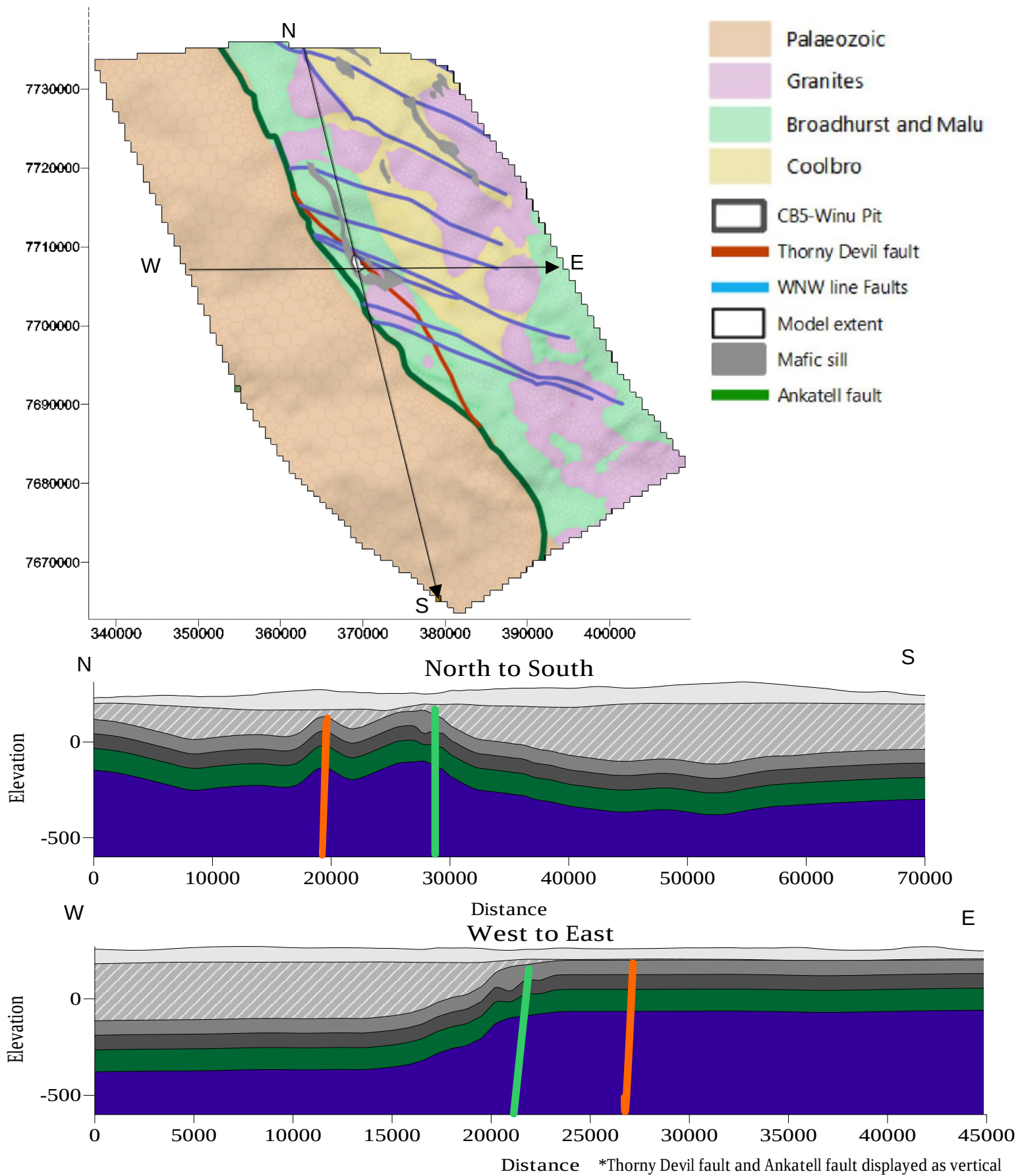


Figure 9-3 Numerical model construction

9.2.6 Hydraulic properties

Initial hydraulic properties are based on the those compiled in Section 7.6 and further adjusted to the modelling layers (Table 9-4).

Hydraulic properties for each layer use initial values from the conceptual model for one or more zones that exist within the layer. A combination of pilot points and zonal distribution is used for spatial parameterisation. Pilot points are implemented in areas where more detailed hydrogeological information is available, however, a zonal approach applies in the regional areas where no site-specific data is available.

The parameter ranges used have been peer reviewed during previous iteration of the model. The horizontal conductivity and specific yield ranges are shown in Figure 9-4.

Table 9-4: Winu Model Parameterisation

Formation	HSU	Kh low	Kh up	Kv low	Kv up	Ss low	Ss up	Sy low	Sy up
Permian Sandstone, layer 1	Unconfined sandstone	0.1	5	0.01	5	1.00E-05	3.70E-05	0.005	0.05
Permian Mudstone, layer 2	Permian mudstone	0.001	0.1	0.0001	0.1	5.00E-06	1.00E-05	0.005	0.02
Weathered Granites, layer 3	Weathered granitoid	0.001	0.3	0.0001	0.3	1.00E-06	5.00E-06	0.005	0.02
Weathered Coolbro, layer 3	Weathered metasediment	0.05	1	0.005	1	5.00E-06	3.70E-05	0.005	0.02
Weathered Broadhurst and Malu, layer3	Weathered metasediment	0.0001	5	0.00001	10	5.00E-06	3.70E-05	0.002	0.02
Weathered Palaeozoic layer 3	Weathered metasediment	0.05	1	0.005	1	5.00E-06	3.70E-05	0.005	0.02
Fresh Granites layer 4,5	Fresh granitoid	0.0001	0.005	0.00001	0.005	5.00E-07	3.00E-06	0.001	0.01
Fresh Coolbro layer 4,5	Weathered metasediment	0.001	0.2	0.0001	0.2	5.00E-07	3.00E-06	0.002	0.02
Fresh Broadhurst and Malu layer 4,5	Weathered metasediment	0.0001	0.7	0.00001	10	5.00E-07	3.00E-06	0.002	0.02
Fresh Palaeozoic layer 4,5	Weathered metasediment	0.005	0.5	0.0005	0.5	5.00E-07	3.00E-06	0.005	0.02
Very fresh Granites layer 6	Very fresh granitoid	0.0001	0.001	0.00001	0.001	5.00E-07	3.00E-06	0.001	0.007
Very fresh Coolbro layer 6	Very fresh Proterozoic metasediment	0.0005	0.005	0.00005	0.005	5.00E-07	2.00E-06	0.002	0.012
Very fresh Broadhurst and Malu layer 6	Very fresh metasediment	0.0001	0.7	0.00001	10	5.00E-07	2.00E-06	0.002	0.012
Fresh Palaeozoic layer 6	Very fresh metasediment	0.001	0.02	0.0001	0.02	5.00E-07	2.00E-06	0.002	0.012

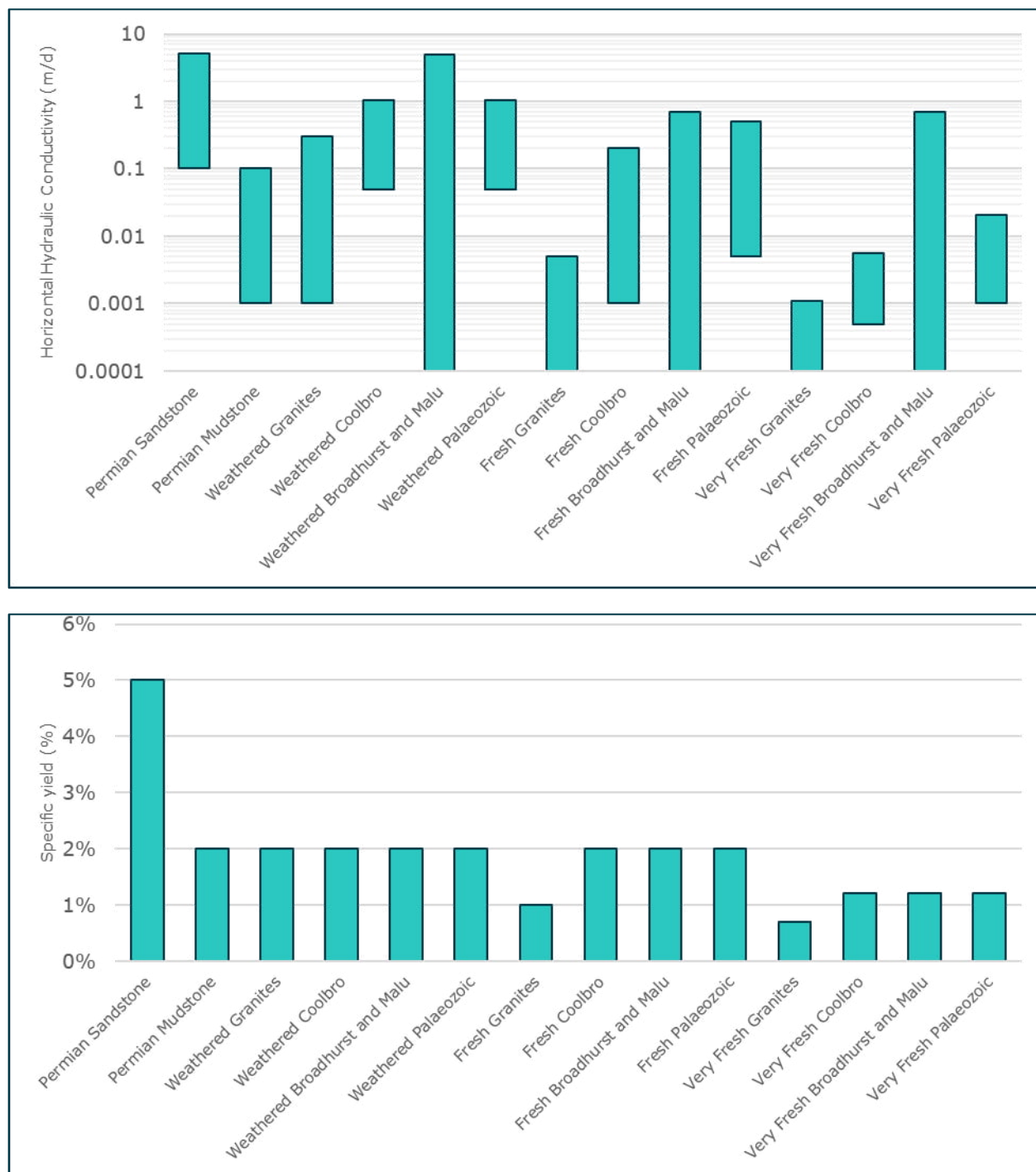


Figure 9-4: Model parameter ranges (Kh and Sy)

9.2.7 Boundary conditions

The numerical model uses of the following boundary packages:

- General Head Boundary (GHB)
- Horizontal Flow Barrier (HFB)
- WEL Package
- Drain (DRN) package

9.2.7.1 General head boundary (GHB)

General head boundaries (GHBs) are assigned to the southern and northern model boundaries to simulate regional groundwater throughflow. Groundwater levels follow the regional gradient from southeast to northwest, with the regional trend flowing towards the coast.

The inferred groundwater levels at the northern boundary are 140 m AHD, based on regional groundwater levels, with a relatively flat ground surface elevation.

The ground elevation along the southern boundary is highly variable ranging between 240 and 290 m AHD. Therefore, a variable head GHB ranging from 244 m AHD to 274 m AHD is assigned to the southern boundary (Figure 9-5).

The inferred groundwater levels at these model boundaries, facilitate the hydraulic gradient across the catchment domain.

The eastern and western model boundaries align with the major faults and were assigned as no-flow boundaries.

9.2.7.2 Flow barriers -horizontal flow barrier (HFB)

Hydrogeological conceptualisation suggests that the hydraulic role of Pre-mineralisation Sill and the Thorny Devil Fault (TDF) is important, resulting in compartmentalisation effects that influence the groundwater flow patterns (Section 7.4). As such, these features were simulated using Horizontal Flow Barrier (HFB) cells (within bedrock layers 3 to 6).

9.2.7.3 Pumping tests and dewatering bores - WEL Package

Groundwater pumping is simulated in the model using the WEL Package. Inputs to the model include bore location, screened interval, and a time series of proposed pumping rates (Section 9.4).

The following groundwater abstractions are simulated during the transient simulations:

- General site water use (Section 4 and (Worley, 2024b))
- Eight (8) pumping tests (Table 7-1 (Section 7.4))
- Pumping bores are also enabled during the predictive simulations for dewatering and water supply

9.2.7.4 Drain (DRN) package

The Winu mine vertical development is based on the 2024 bench progression (Sc23 – Bench Progression.xlsx), to reflect the schedule of the mine cutback sequences and mining depth.

The target mine dewatering aims to maintain groundwater levels to 10 m beneath the pit wall for LoP operations. The primary dewatering option is through the dewatering bores, however, in case dewatering targets cannot be achieved by bores, the model uses the DRN package to simulate dewatering from sumps.

9.2.8 Temporal discretisation

The groundwater model simulation starts with a steady state stress period to simulate the “steady-state” groundwater flow regime, reflective of chosen parameterisation and boundary conditions, before progressing to a transient model.

The transient model simulations are divided into 495 stress periods for historical matching (calibration) and prediction periods. The number and duration of transient stress periods are tailored based on the dates associated with the recorded groundwater level, pumping tests, and mine plan as follows:

- History-matching period:
 - monthly stress periods from January 2019 to March 2024 – groundwater level data are recorded from mid-2019
 - daily stress periods during pumping tests and their recovery periods
- Predictive simulation period
 - Mining
 - monthly stress periods from January 2026 to December 2050
 - annual stress periods from January 2051 for LoM (2069)

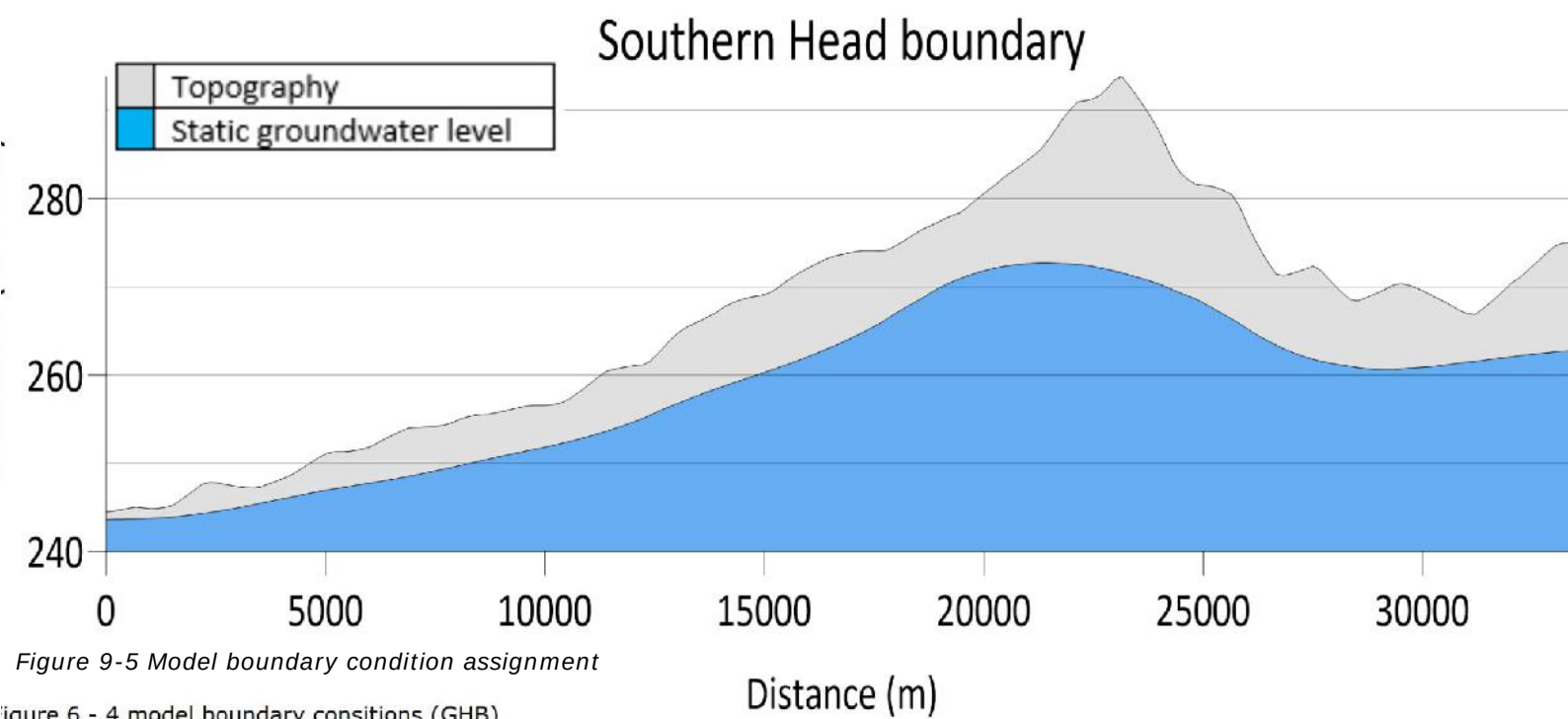
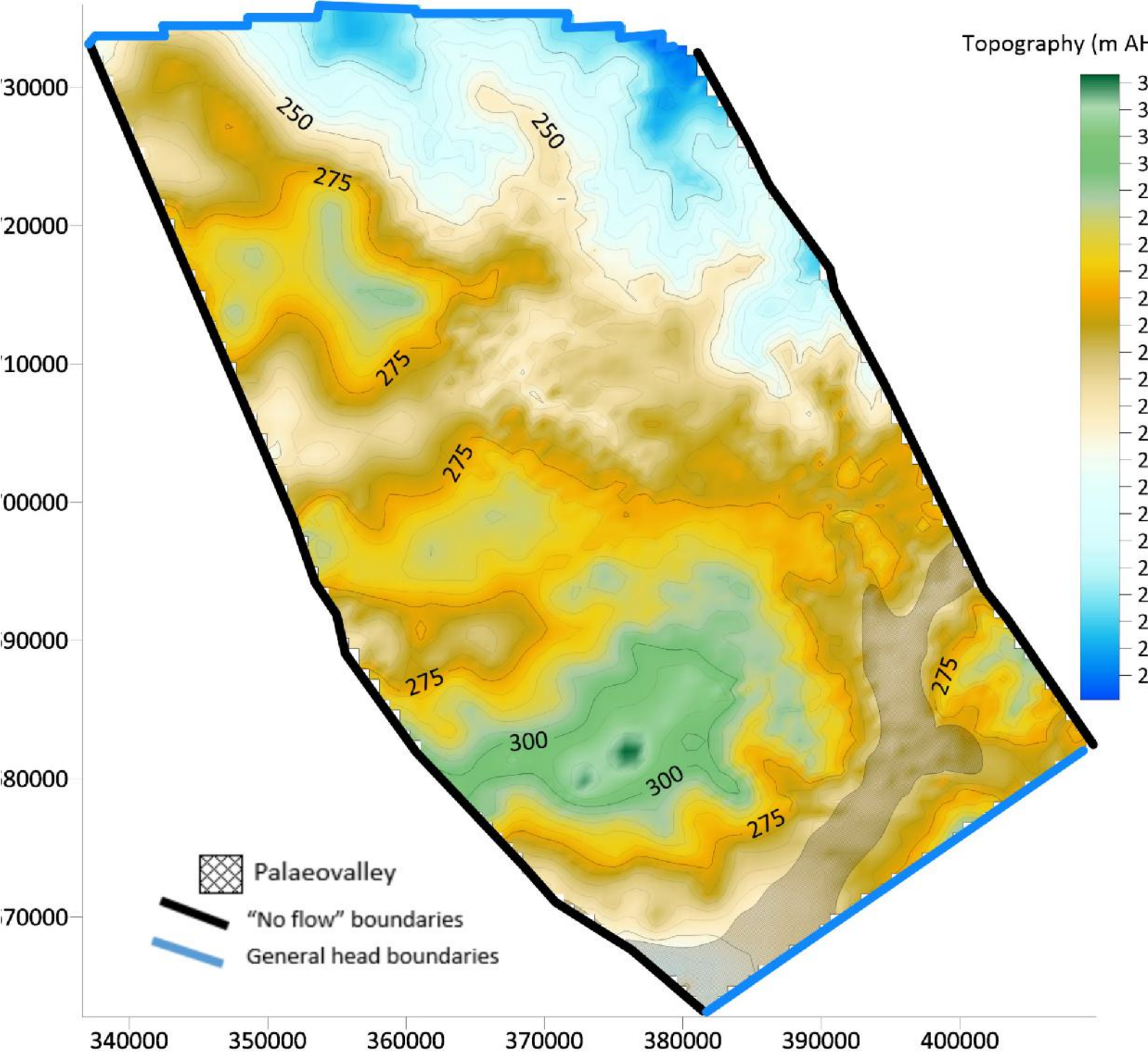


Figure 9-5 Model boundary condition assignment

Figure 6 - 4 model boundary conditions (GHB)

9.3 History matching (calibration)

9.3.1 Calibration approach

History-matching in this study refers to the process of comparing observed groundwater level data vs modelled/predicted groundwater levels. The purpose of history-matching in this context is to constrain model parameters and allowable ranges, based on what is known from field testing, conceptual understanding and observed system behaviour (ideally of direct relevance to the model predictions of interest), using a range of observation data.

This process is useful in constraining the suite of parameter sets that are used for model predictions, and to assess the predictive uncertainty, a sound basis for enhanced use and understanding of model outputs, including their limitations, in decision-making for the Project.

The performance of the model is tested against the measured groundwater levels during various pumping tests.

The combined steady-state and history-matching model are used to calibrated to develop a suitable match between the observed and simulated water levels by adjusting aquifer parameters.

The Parameter Estimation (PEST) suite of software (Doherty, 2016a, 2016b) is used to assist in this process. Pilot point interpolation across model layers is enabled through parameter list processor (PLPROC) kriging.

9.3.2 Calibration targets

Calibration targets are selected from available (and reliable) bore water level records, including long-term monitoring, drawdowns induced by pumping tests and observed vertical gradients from VWPs.

Table 9-5 summarises the number of targets used during calibration. The pumping bores and observation bores are assigned to their respective layers corresponding with the screened section of the bore.

The weights assigned to targets are:

- Steady state and transient groundwater levels (15%)
 - water level data recorded before the start of pumping test(s)
 - long-term manual and logger data recorded between January 2019 and March 2024
- Drawdown and recovery (70%)
 - water level drawdown recorded at all monitoring locations, including VWPs (vibrating wire piezometers) and pumping bores during pumping tests and recovery periods
- Abstraction (10%)
 - abstraction rate from production bores during pumping tests to ensure flow rates is not reduced during the model calibration (eliminate/minimize AUTOREDUCE)
- Vertical gradients in nested bores (VWPs) (5%)
 - groundwater pressure differences between the hydrogeological units

Table 9-5: Calibration targets

Calibration Target	Number of sites	Number of observations
Monitoring bores	148	72,711
Pumping bores	11	3,609
Vibrating wire piezometer	29	28,725
Total	188	105,045

9.3.3 Spatial variation of hydraulic properties

Initial parameters in the model are tweaked by PEST within the constraint/bounds to achieve an acceptable representation of the groundwater system response by minimising the differences between simulated and observed water levels while still approximating estimated water budget components (test pumping flow rate).

To address spatial variations in hydraulic properties, pilot points are placed around the immediate Winu and Texas areas (available test pumping data). A total of 477 pilot points is distributed throughout the model domain. Pilot points are capable of inducing perturbations in lateral and vertical hydraulic conductivity, specific storage, and specific yield.

The parameterisation scheme uses pilot points in the proximity of Winu, acknowledging the need for spatial interpolation and extraction of maximum information from observed data. All pilot points are assigned spatial covariance structures to encourage the history matching process to honour the initial (prior) parameters and their spatial differences as closely as possible. Departures from this would occur where necessary to significantly improve the simulation of historical system behaviour as measured by PEST against the weighted observation data.

The model makes use of a zonal approach for the areas outside of mine area, linking the pilot points to a HSU. During the calibration process these zones are assigned a single parameter value.

9.3.4 Calibration results

One of the metrics to evaluate the groundwater model performance is by quantifying the match between the observed and modelled groundwater levels and by assessing the consistency of their trends. The matches between individual water level and the pumping test drawdown measurements are presented as scatter plots in Figure 9-6.

The calibration statistics for water level m AHD is expressed in the first plot (Groundwater levels) by the (Root Mean Square Error) RMS and the (Scaled Root Mean Square Error) SRMS statistics of 6.9 m and 5.0%, respectively.

The calibration statistics for observed vs simulated drawdown is shown in the second plot (Pumping test drawdown). These results show a good calibration with the RMS and the scaled SRMS statistics of 2.2 m and 1.6%, respectively.

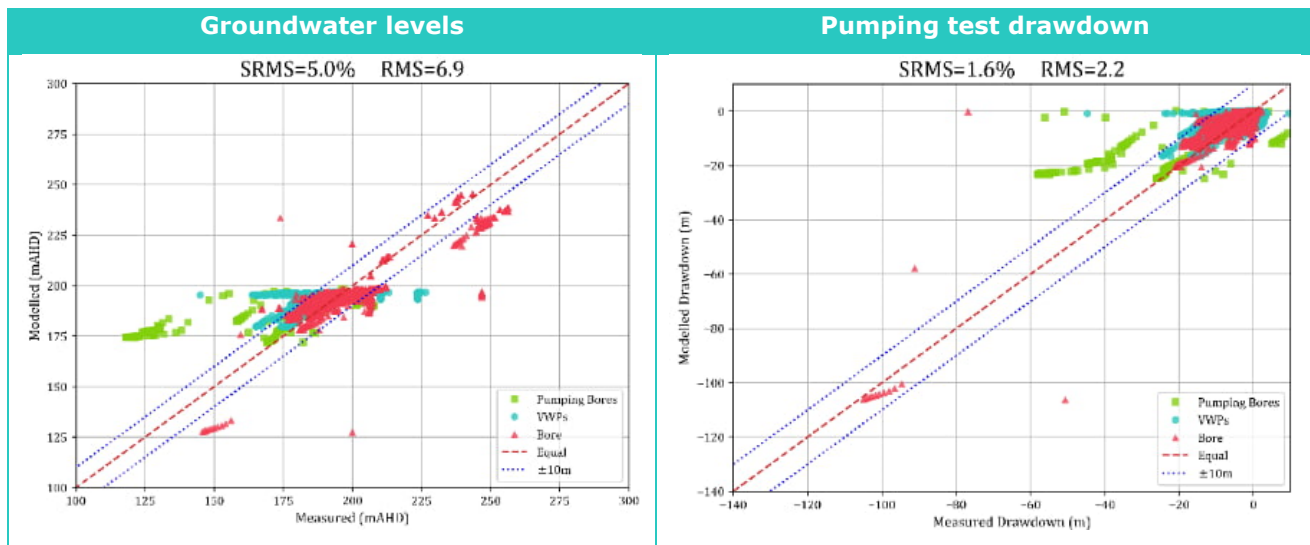


Figure 9-6: Calibration statistics (groundwater level and drawdown)

Steady state water levels are shown in Figure 9-7. The water level contours align with the regional groundwater flow, which predominantly follows a north-western direction. This alignment is in accordance with the flow along both regional and local geological structures. In areas of low-permeability granite, the groundwater contours exhibit a steeper hydraulic gradient, causing distinctive bends in the contours.

A good match with groundwater level trends is shown in Figure 9-8, and as noted in the observed groundwater levels display stable long-term trends with periods of drawdown and recovery during pumping tests.

A reasonable match between simulated and measured drawdown during pumping tests is shown in Figure 9-9. This indicates that the numerical groundwater model replicates trends and responds adequately to the stresses applied to the groundwater flow systems. Because of complexities associated with the fractured rock aquifer system, the degree of calibration at individual locations varies, however generally in agreement with the conceptual model.

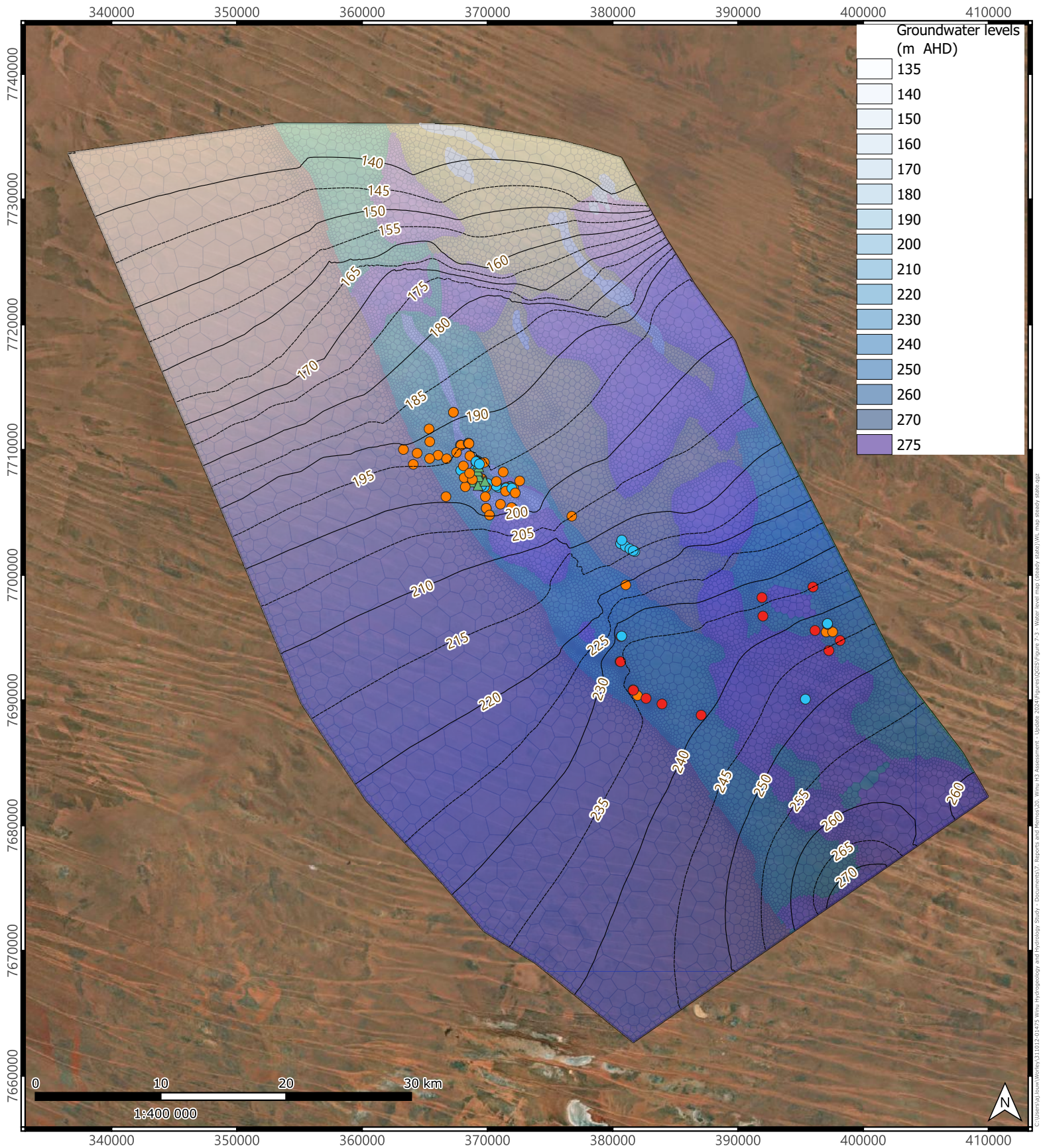
The key observations from model calibration are:

- Testing WINU0706, WINU0708, WINU0910 and WINU0917 in the main area all indicated reasonable calibration:
 - A slight underprediction is noted in monitoring bore monitoring bore WINU0472 (north) during the pumping of WINU0917, however, shows a good match during testing of WINU0910.
 - WINU0701 (north) underpredicts test pumping of WINU0706 (approx. 100 m away), however, a good match was obtained during WINU0910 and WINU0917 testing.
 - WINU0080 and WINU0166 (central) underpredict during pumping in the north (WINU0910 and WINU0917), but match well the testing of WINU0706 and WINU0708.
 - Preferential flow is along the local faults and the Thorny Devil Fault and the Pre-mineralisation Sill act as flow barriers. Drawdown is contained largely between these structures, resulting in elongated drawdown patterns, in a north to south direction.

- Overall calibration of these pumping tests is considered successful and consistent with the current conceptualisation.
- Testing WINU0076, west of the Pre-mineralisation Sill
 - A good match with the main monitoring bore WINU0213 along structure, and overprediction at WINU0219, at a similar distance from the pumping bore.
 - VWP_WINU0760 and VWP_WINU0381 indicates a good match with the vertical gradients, between the deeper metasediment and shallower mudstone units.
 - Simulated drawdown in VWP_WINU0760 along structure matches the observed levels well.
 - Calibration is consistent with the conceptualisation and supports the no-flow boundary of the pre-mineralisation fault.
 - Calibration to WINU0076 pumping test is deemed successful
- Testing at WINU0913 and WINU0925
 - Testing at WINU0925 was terminated after two days and the results are inconclusive, hence removed from calibration.
 - The WINU0913 test calibrates well with the Thorny Devil Fault acting as a no-flow barrier and preventing flow to the north-east.
- Testing at WINU1305
 - Drawdown in WINU1307 shows a good match with observed data, with a slight underprediction in the recovery rate. This might indicate a locally overpredicted storage and it will be further assessed during the uncertainty analysis.
 - The model underpredicts drawdown at WINU0702, and overpredicts drawdown at WINU1298 halfway between this bore and the pumping bore. Preferential flow along fractures might be present causing the mismatch.

The model is considered suitably calibrated, replicates trends and responds reliably to the stresses applied to the groundwater flow systems.

All hydrographs for simulated groundwater levels and pumping test drawdowns are presented in Appendix H and Appendix I.



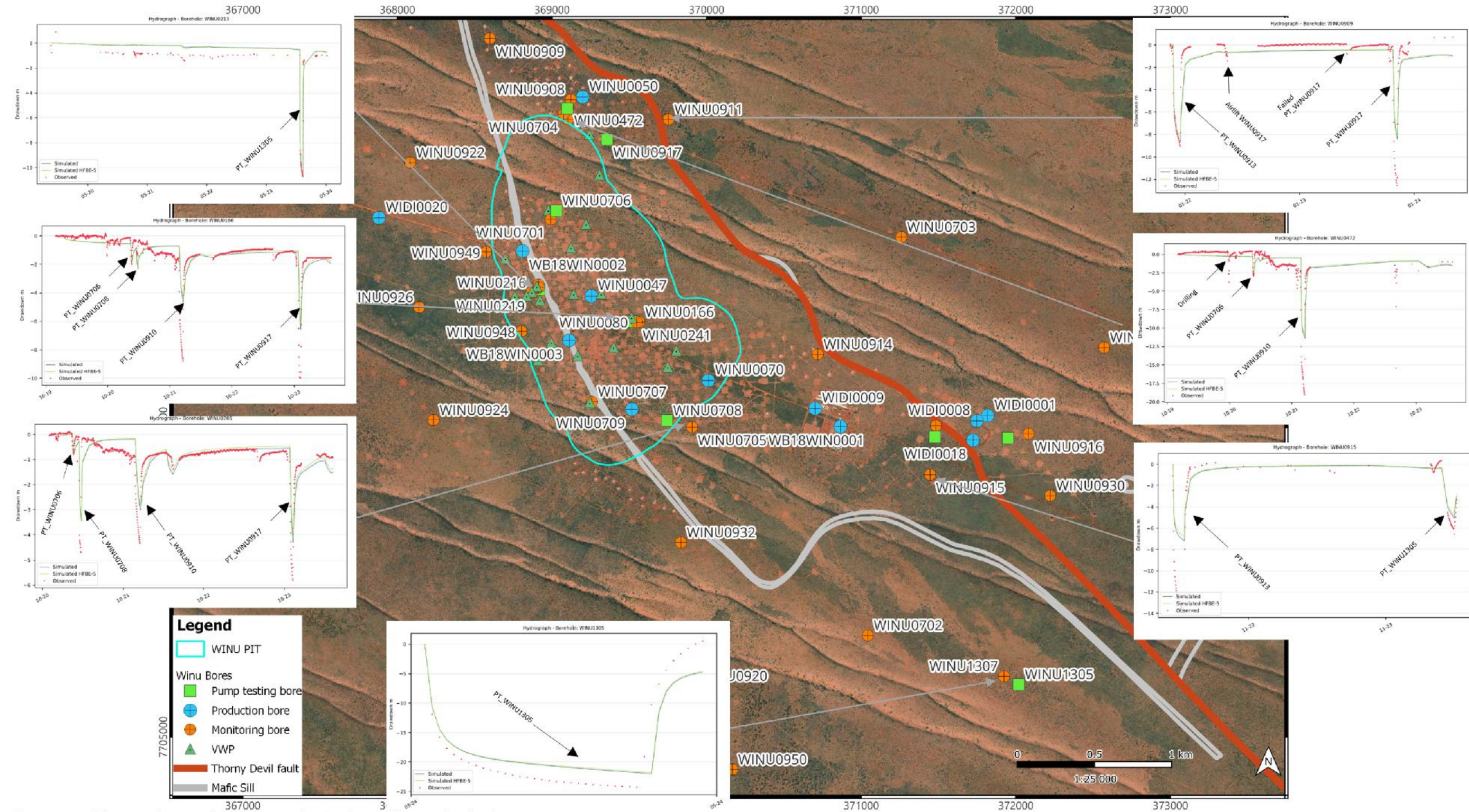
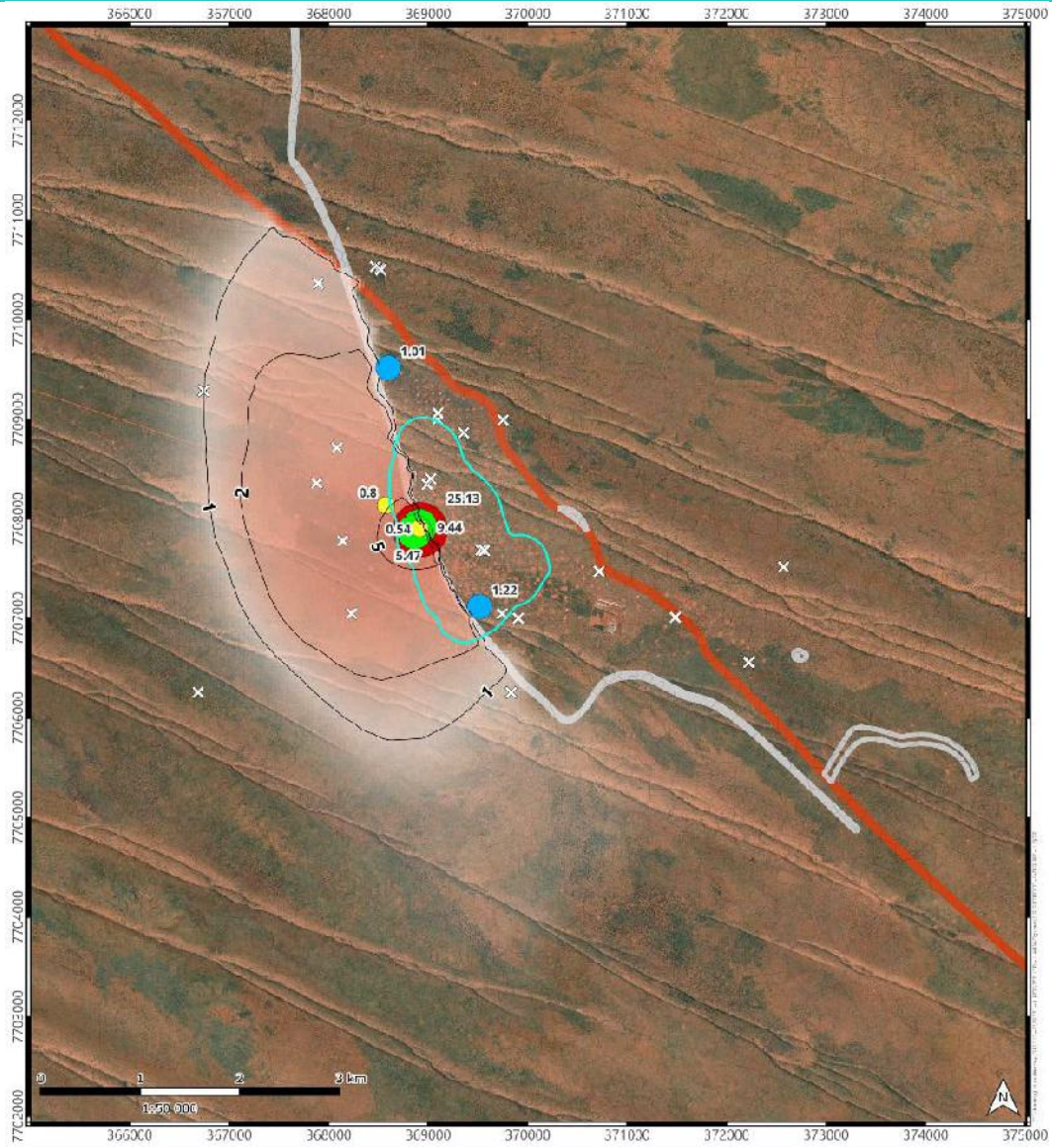


Figure 9-8 Observed vs modelled groundwater levels in monitoring bores

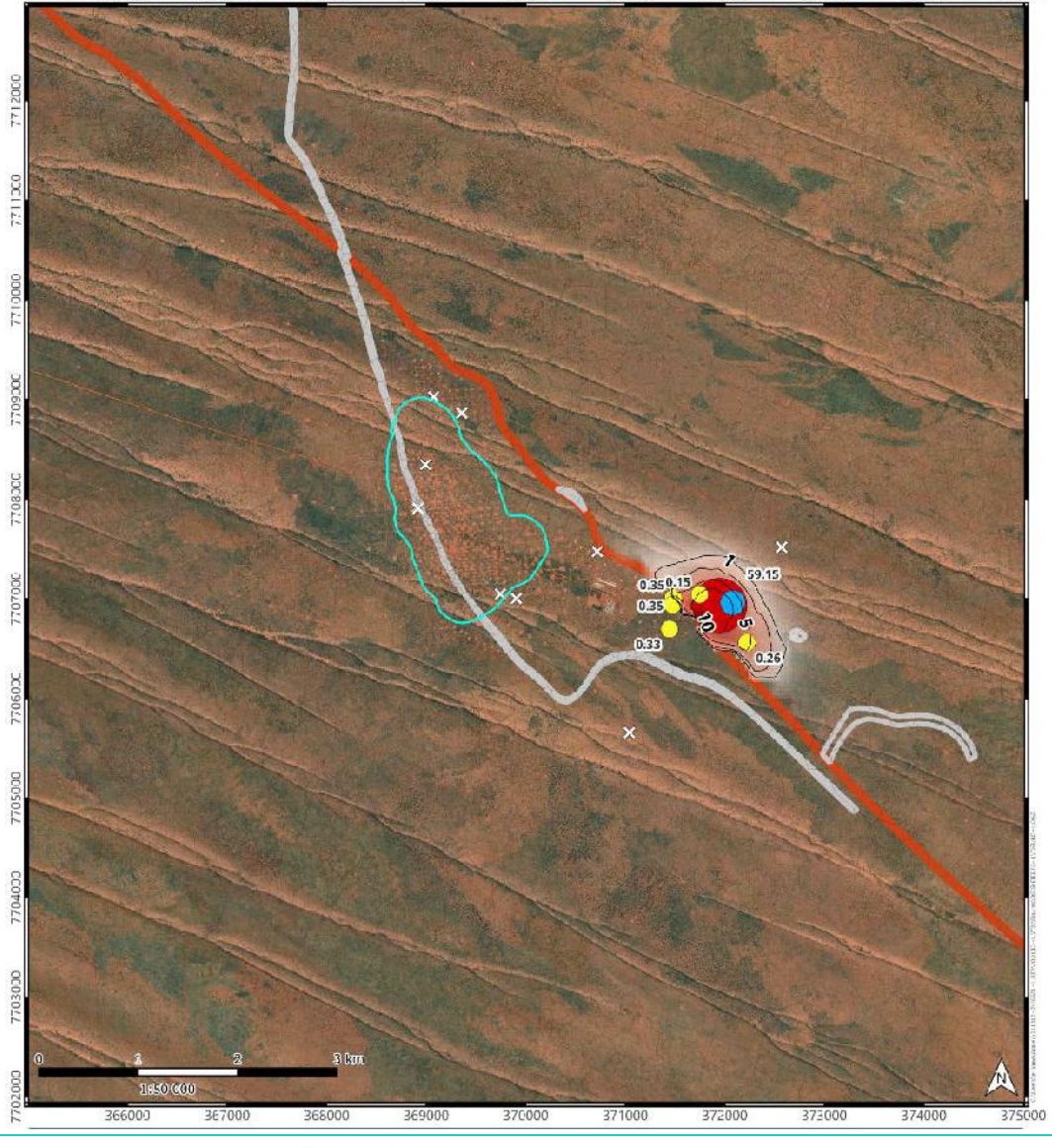
WINU0076



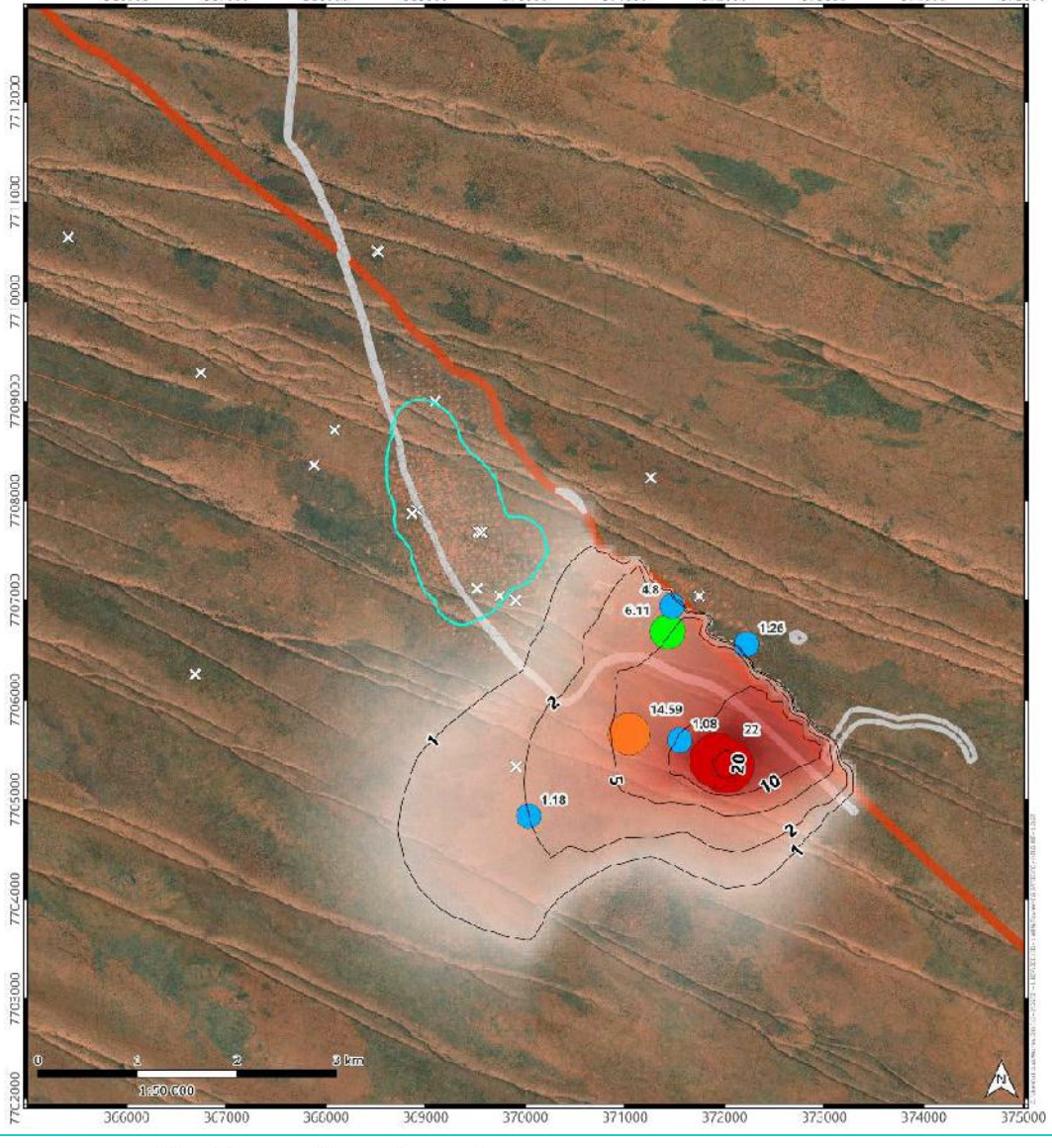
WINU0917



WINU0925



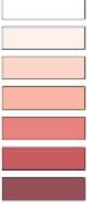
WINU 1305



Legend

- Model grid
- Thorny Devil fault
- Mafic Sill
- WINU PIT

Drawdown (m)



Observed Drawdown (m)

- No Response (NR)
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

Maximum drawdown in Metasediments during pump test

Winu Hydrology/Hydrogeology Study

Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	9-9

Notes:
Project CRS: GDA94 / MGA zone 51
Last Saved: 03/06/2024, 11:48

References

Consultant



Client



© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

9.3.5 Calibration of hydraulic properties

Hydraulic properties are summarised in a series of plots and maps. Figure 9-10 shows the ranges of horizontal (K_h) and vertical (K_v) hydraulic conductivity for each HSU. Figure 9-11 shows the specific storage (S_s) derived from model calibration. The S_s ranges applied were within the ranges reported by Timms et al (2020) from 1.3×10^{-7} to 3.7×10^{-5} m^{-1} . The range plot is drawn with the 5th and 95th percentiles making up the column, while the minimum and maximum values are represented by outlier bars. Median values are shown with the line inside the column.

The horizontal and vertical conductivities are generally constrained within a narrow band (Figure 9-10), except for the Broadhurst and Malu Formations, with the weathered unit ranging between 0.0001 m/d in the regional areas to a maximum of 5 m/d in the Winu pit area. The parameter ranges are consistent with the conceptual ranges interpreted through testing.

The vertical anisotropy (K_h/K_v) is varying between one and ten for the sandstone, mudstone, and weathered metasediments; and between one and five for the fresh and very fresh metasediments.

Maps of conductivity and transmissivity for the weathered and fresh metasediments (i.e. model layers 3 to 5) are presented in Maps 5 to Map 10 in Appendix A. The spatial distribution in Layer 3 (weather metasediments) indicates higher permeability in the Winu pit area, and along the pre-min mafic sill, consistent with secondary faulting and fracturing observed in the mineralisation zone. Layer 4 indicates higher permeability in the pit areas and at the regional location (Texas), consistent with pump testing results, indicating the presence of a deeper fractured system at the Texas area.

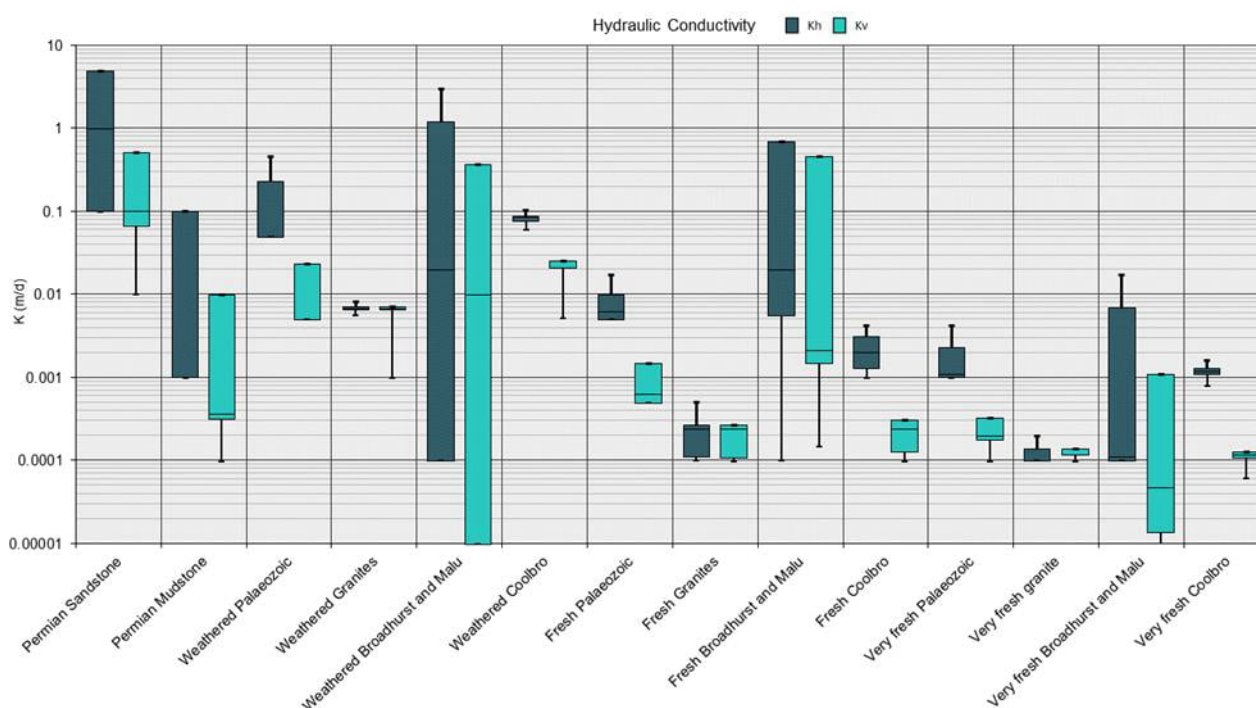


Figure 9-10: K_h and K_v values derived from calibration

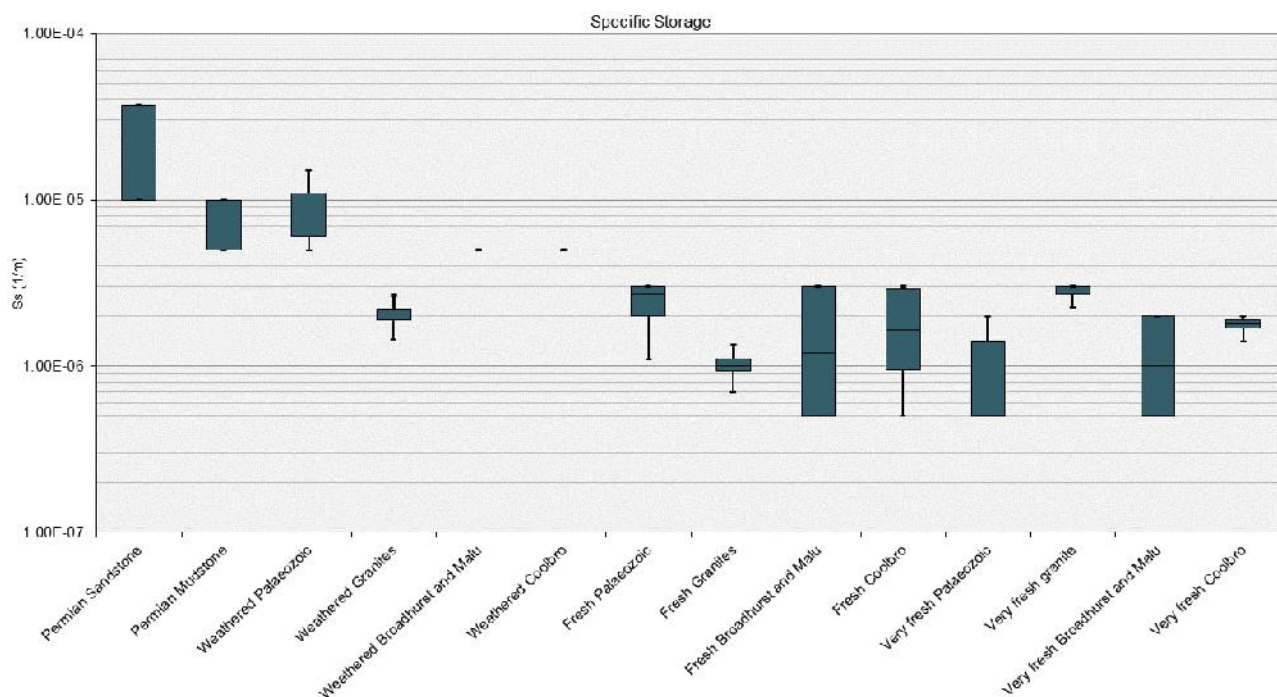


Figure 9-11: Ss values derived from calibration.

The modelled Sy values are presented in Figure 9-12. Due to the reduced variability in Sy, the figure presents only the average values for each HSU.

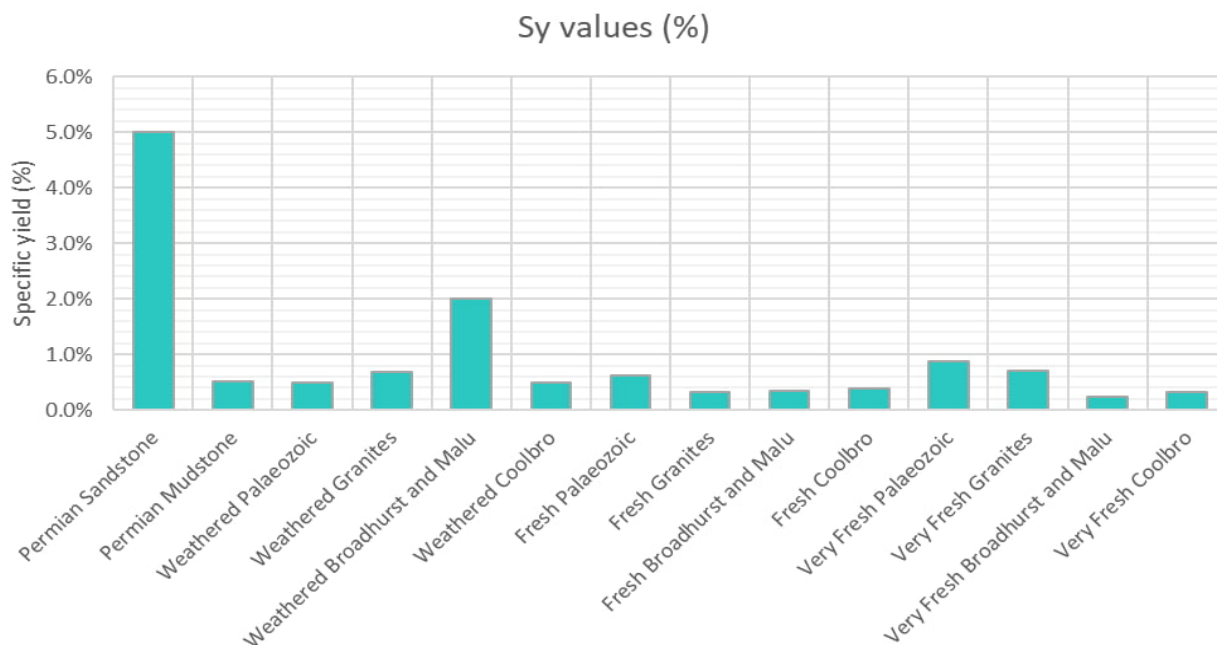


Figure 9-12: Sy Values derived from calibration

9.4 Predictive modelling

9.4.1 Predictive model setup

The predictive model is set up to simulate dewatering and water supply from Winu open pit mine. It covers 324 monthly stress periods, including 3 years for model calibration, and then forward predictions of Year 1 to Year 24. An additional 19 annual stress period cover the simulation period between Year 24 to Year 43.

The key objectives of the predictive modelling were:

- Achieve groundwater levels of at least 10 m beneath the pit floor during LoM operation
- Develop a bore construction schedule for the LoM

The latest mine plan update "Pit progression_ Sc23" is used for the predictive model. A pit dewatering target is defined on the basis of the final mine schedule provided. The minimum floor elevation data and related dates were extracted from the mine schedule and a notional 10 m offset applied to provide a buffer in case of dewatering system failure, i.e., the dewatering target is 10 m below the lowest pit floor elevation.

The target is applied during Year 1 to Year 43, while the open pit mining is completed by Year 29 (i.e., end of Cutback 6), rehandle from stockpiles is planned to continue to operate the plant until 2069.

Dewatering will use a combination of ex-pit bores, in-pit bores (mostly situated at 170 m RL on a specifically designed hydro bench in the west of the pit), and sumps. It was noted that the 170 m RL hydro benches in CB5 and CB6 do not line up and the CB4 and CB5 bench will be used for bench in-pit bores. Sumps will only be considered necessary when modelling indicates that dewatering targets cannot be achieved by bores.

The effect of a more permeable HFB has been tested to assess the likely impacts on dewatering and water supply. Therefore, predictive modelling assesses two model runs.

1. Low permeable flow barriers (No-flow barriers ($K_h=1 \times 10^{-8}$ m/d)
2. Higher permeable flow barriers (Partial flow barriers ($K_h=1 \times 10^{-5}$ m/d)

9.4.2 Dewatering strategy

Following discussions with RTC, dewatering bores designs are assumed to have a 250 mm diameter bore casing, a maximum depth of 300 m and a potential head drawdown 250 to 260 m to also account for well losses. Existing bores are assigned abstraction rates derived from pumping tests while yields for additional (planned) bores are estimated by the model, allowing flow to decrease based on falling water level.

The initial pit dewatering volumes are estimated using the DRN package (drain cells) assigned to the pit floor for each cutback with a target head of 10 m below surface elevation. The estimates from this modelling were then iteratively modified into a set of dewatering bores, with optimisation focused on the number and locations of pit dewatering bores.

Various combinations of dewatering bore locations and pumping rates were applied in the model and the model was run on a trial-and-error basis until the key objective was met, i.e., groundwater levels 10 m below pit wall were maintained below the dewatering target level.

Proposed dewatering bores are positioned in “ex-pit” and “in-pit” locations (in the model) to achieve effective pit dewatering (Table 9-6). The ex-pit dewatering bores are located outside of the final pit shell design and in-pit bores are mostly located on the east of CB5, and will likely be destroyed late in the LoM. Additional bench bores are located on a wide bench on the west wall of the pit at an elevation of approximately 170 m RL (Figure 9-13).

Some bores are assumed to have a limited life due to pre-strip and mine development activities. For example, WINU0076, WINU0706, and WINU0080 are assumed to be decommissioned during the mine progression from Cutback 1 to Cutback 3.

With the current model, dewatering could be achieved with twenty-four (24) bores. Bore coordinates and IDs are nominal.

Table 9-6: Proposed dewatering bore locations (Water supply bores are not included in this table)

BH No.	ID	Easting (mE GDA94)	Northing (mN GDA94)	Comment	Period
1	WINU0076	368918	7707893	Existing, destroyed with CB1	Yr 1 (Jan – Dec)
2	WINU0080	369528	7707687	Existing, destroyed with CB4	Yr 1 to Yr 8
3	WINU0706	369027	7708404	Existing, destroyed with CB3	Yr 1 to Yr 16
4	WINU0708	369743	7707047	Existing, destroyed with CB6	Yr 1 to Yr 17
5	WINU0910	369097	7709064	Existing	Yr 4 to Yr 43
6	WINU0917	369357	7708865	Existing	Yr 1 to Yr 43
7	in-pit_1	369470	7707938	In-pit, destroyed with CB4	Yr 1 to Yr 8
8	in-pit_2	369523	7707834	In-pit, destroyed with CB4	Yr 1 to Yr 8
9	in-pit_3	368784	7707882	In-pit, destroyed with CB3	Yr 1 to Yr 24
10	ex-pit_1	368699	7708903	Ex-pit	Yr 2 to Yr 43
11	ex-pit_2	370120	7707667	Ex-pit	Yr 2 to Yr 43
12	ex-pit_8	369786	7707144	Ex-pit	Yr 4 to Yr 43
13	ex-pit_10	369634	7708441	Ex-pit	Yr 4 to Yr 43
14	ex-pit_11	369524	7706814	Ex-pit	Yr 9 to Yr 43
15	ex-pit_12	369293	7706722	Ex-pit	Yr 7 to Yr 43
16	ex-pit_13	369113	7706811	Ex-pit	Yr 5 to Yr 43
17	bench_1	369084	7707552	In-pit, on a bench at ~170 mAHD	Yr 8 to Yr 43
18	bench_2	368899	7708135	In-pit, on a bench at ~170 mAHD	Yr 9 to Yr 43
19	bench_3	368951	7707825	In-pit, on a bench at ~170 mAHD	Yr 8 to Yr 43
20	bench_4	369027	7707657	In-pit, on a bench at ~170 mAHD	Yr 9 to Yr 43
21	bench_5	368897	7708357	In-pit, on a bench at ~170 mAHD	Yr 9 to Yr 43
22	bench_6	369110	7707392	In-pit, on a bench at ~170 mAHD	Yr 9 to Yr 43
23	bench_7	369273	7707138	In-pit, on a bench at ~170 mAHD	Yr 8 to Yr 43
24	bench_8	369200	7707204	In-Pit, on a bench at ~170 mAHD	Yr 8 to Yr 43

Pit dewatering stages and model predicted flow rates are presented in Table 9-7. Predicted groundwater levels relative to the dewatering target for the two scenarios are shown in Figure 9-14. The number of dewatering bores is based on model predictions and the minimum estimated number of bores required to achieve the required dewatering target.

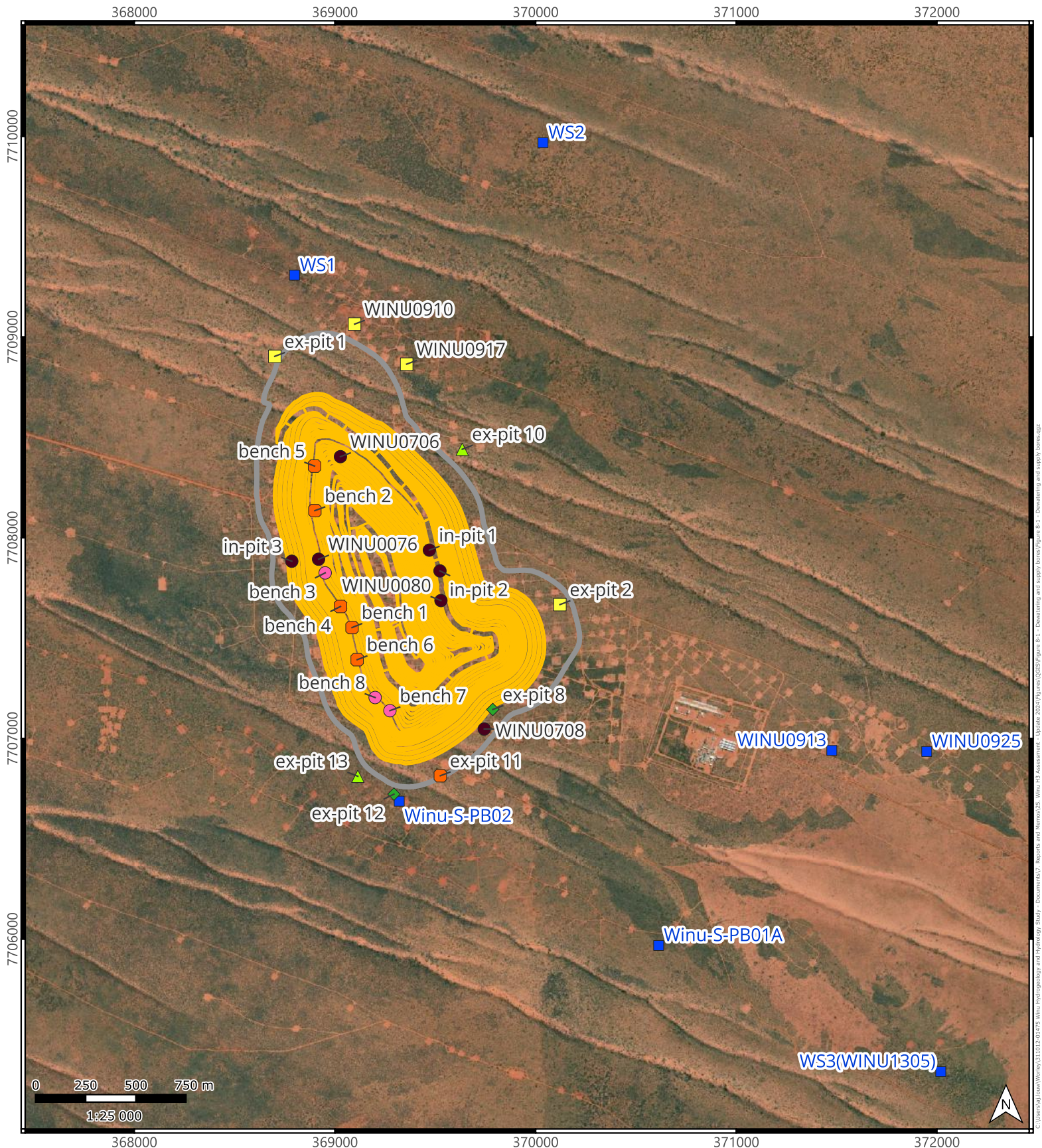
Key findings are:

- The ex-pit bores become effectively redundant at around Year 17 due to reduced groundwater levels. The current pit progression proposes the dewatering bench at an elevation of 170 m RL to be installed by Year 8.
- Groundwater modelling predicts that dewatering will be partially maintained using sumps from Year 17 onwards at a dewatering target elevation of -85 m RL, indicating that dewatering bores become less effective considering the limitations associated with dewatering of deeper-set low-permeability.
- Potential pit inflows from the overlying mudstone and sandstone are negligible. The results of initial calculations indicate that pit inflow rates from these units are likely to be low to very low, due to expected low permeability of the mudstone units, limited saturated thickness of the sandstone units and the absence of groundwater level responses in the sandstone units to high-intensity rainfall associated with Cyclone Blake in January 2020 (Golder, 2020a).
- No contingency or pump utilisation has been applied (other than the 10 m offset from the lowest pit floor RL to dewatering target), at this stage to cover bore failure/decommissioning or other operational factors that could potentially contribute to downtime of the dewatering system.
- Pumping from dewatering bores, once they are installed, needs to be continued over the life-of-mine period for all bores.
- Water captured in the pit during intense rainfall events could influence groundwater quality and quantity. Therefore, a contingency plan should be developed to remove in-pit water via sump pumping in an acceptably short period of time.

Table 9-7: Dewatering periods

Dewatering Phase	Dates	No of active dewatering bores*	Average pumping rate per bore (L/s)	Average pumping rate per bore (m ³ /d)
1	Yr 1 (Jan – Dec)	7	17.8	1543
2	Yr 2 to Yr 3	8	20	1728
3	Yr 4 (Jan – Dec)	11	15.7	1360
4	Yr 5 (Jan – Dec)	12	11	946
5	Yr 6 (Jan – Dec)	14	10	880
6	Yr 7 to Yr 8	17	8.3	717
7	Yr 9 to Yr 13	17	9.4	808
8	Yr 13 to Yr 17	18 - sumps	5.6	482
9	Yr 17 to Yr 43	18 - sumps	2	160

* Some bores are partially active within the dewatering phases before decommissioning during mine progression (e.g. WINU0706 or WINU0080)



Legend

- | | |
|------------------|----------------------|
| Dewatering bores | ■ Water supply bores |
| ● Stage 1 | — WINU Pit Cutback 1 |
| ■ Stage 2 | — WINU Pit Cutback 2 |
| ◆ Stage 3 | — WINU Pit Cutback 3 |
| ▲ Stage 4 | — WINU Pit Cutback 4 |
| ● Stage 5 | — WINU Pit Cutback 5 |
| ● Stage 6 | — WINU Pit Cutback 6 |
| | □ WINU Pit Cutback 6 |

Dewatering and supply bores around the Winu pit

Winu Hydrology/Hydrogeology Study

Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	9-13

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 03/06/2024, 21:19

References

Consultant



Client



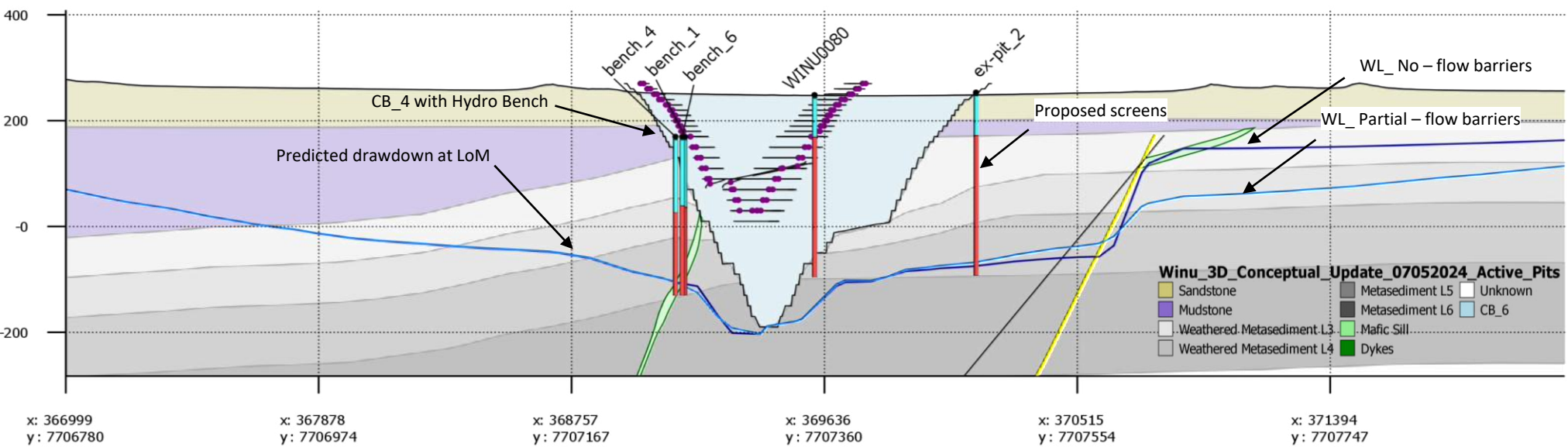
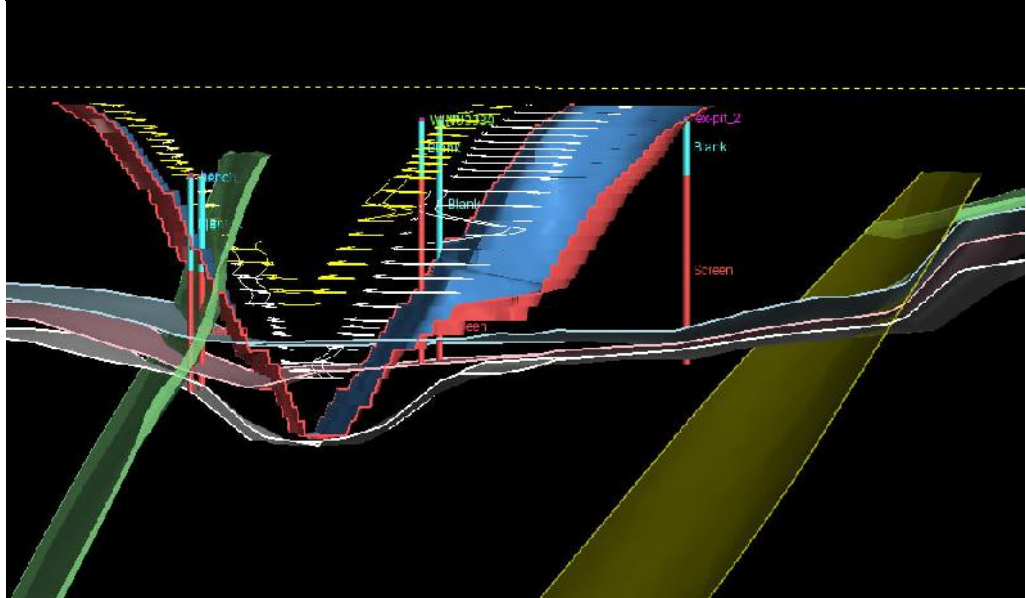
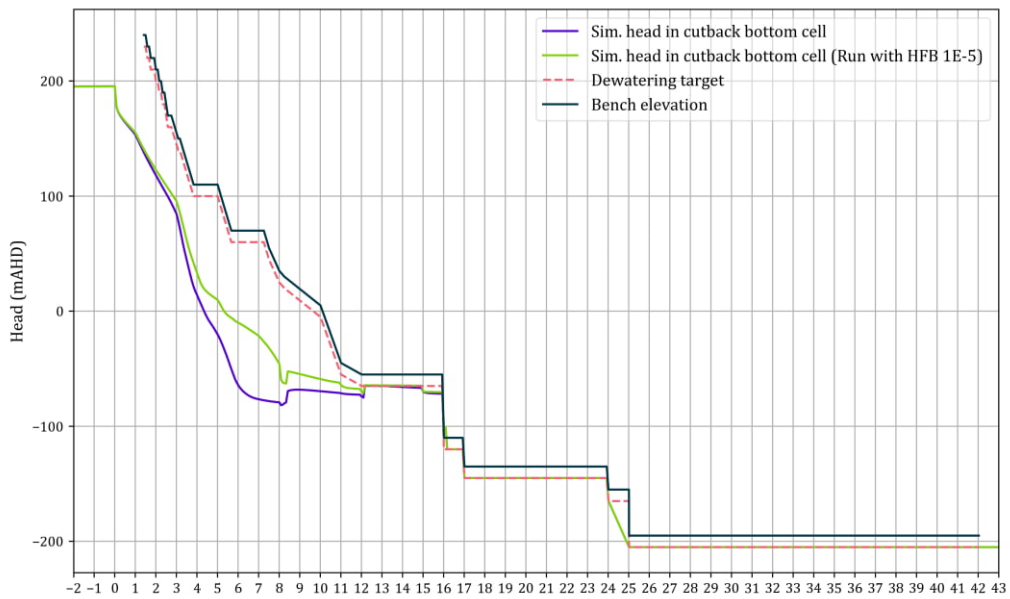


Figure 9-14 Dewatering target and predicted groundwater drawdown (Cross-section facing north)

9.4.3 Water supply strategy

Water supply for the Project will be from mandatory pit dewatering (near pit bores and sump pumping), reclaim from the tailings storage facility, and regional water supply borefields. At this time regional borefields may include Rimfire (Advisian, 2023e) and/or Texas (Advisian, 2023f).

A water supply strategy has been developed to complement the mandatory pit dewatering (discussed in Section 9.4.2), and to provide water supply for early stages of the mine's development prior to the initiation of reclaimed water flows from the tailings storage facility.

The groundwater model was run with the dewatering targets as well as water supply in mind on a trial-and-error basis to simulate dewatering bores and an additional seven water supply bores (four existing bores and three proposed bores), installed to the north and south of the proposed pit.

Aquifer testing of near-pit bores is suggestive of at least partial compartmentalisation, with either partial flow or no-flow boundaries at linear structures such as the pre-min mafic sill and the TDF.

The four additional water supply bore locations do not represent an optimised solution of water supply bore depths, locations, and pumping rates but are considered an indication of likely available "groundwater supply capacity" based on drilling to date. Ultimate dewatering/water supply bore locations should be determined on the basis of further investigation and hydrogeological data.

The simulated locations for the supplementary water supply bores are presented in Figure 9-13 and on Table 9-8. The proposed bore installation sequence, addressing both mandatory pit dewatering and supplementary water supply for operational use, is in Table 9-9.

Table 9-8: Proposed water supply bore locations

BH No	ID	Easting (mE GDA94)	Northing (mN GDA94)	Comment	Period
1	WINU0913	371476	7706940	Simulated water supply	Yr 4 to Yr 43
2	WINU-S-PB01A*	370613	7705969	Simulated water supply	Yr 4 to Yr 43
3	WINU0925	371949	7706935	Simulated water supply	Yr 4 to Yr 43
4	WINU-S-PB02*	369320	7706687	Simulated water supply	Yr 7 to Yr 43
5	WS1*	368798	7709308	Simulated water supply	Yr 9 to Yr 43
6	WS2*	370036	7709968	Simulated water supply	Yr 9 to Yr 43
7	WINU1305	372019	7705340	Simulated water supply	Yr 13 to Yr 43

* Not yet drilled

The results for pit dewatering and combined supplementary water supply is presented in Figure 9-15.

Predictive simulations of dewatering with an updated mining plan and two structural permeability scenarios indicate:

- No - flow barriers
 - Between 150 and 225 L/s dewatering rates up to year 13
 - Between 125 and 150 L/s dewatering rates in year 15 to year 19
 - Less than 125 L/s from long term dewatering after year 19
- The partial - flow barriers
 - Between 150 and 250 L/s dewatering rates up to year 15
 - Between 125 and 175 L/s dewatering rates in year 15 to year 23
 - Less than 125 L/s from long term dewatering after year 23, an average groundwater supply of 105 L/s is indicated. The peak water supply is during early time from Year 7 to Year 15 due to a high mining volume and aggressive bench progression rate.

Both scenarios indicate low long term available water from the dewatering system due to the low storage observed during pumping test.

Table 9-9: Dewatering and water supply bore schedule and supply volumes

Period	Active dewatering bores	Active water supply bores	Decom. bores	Added bores per period	Comments
Yr 1 (Jan – Dec)	7	0	0	3	4 existing dewatering bores (WINU0076, -0080, -0706, -0708) 3 new dewatering bores (in-pit 1, 2 and 3)
Yr 2 to Yr 3	8	0	1	3	3 new dewatering bores (ex-pit 1 – 2) 1 existing dewatering bore decommissioned (WINU0076)
Yr 4 (Jan – Dec)	11	3	0	1	1 new ex-pit dewatering bores (ex-pit 10) 10 existing dewatering bores (in-pit 1 – 3, ex-pit 1 – 2, WINU0080, -0706, -0708, -0910, -0917) 3 existing water supply bores (WINU0913, -0920, -0925)
Yr 5 (Jan – Dec)	12	3	0	1	1 new ex-pit dewatering bores (ex-pit 13) 11 existing dewatering bores (in-pit 1 – 3, ex-pit 1, 2 and 10, WINU0080, -0706, -0708, -0910, -0917) 3 existing water supply bores (WINU0913, -0920, -0925)
Yr 6 (Jan – Dec)	14	3	0	2	3 new ex-pit dewatering bores (ex-pit 8, 12, 13) 11 existing dewatering bores (in-pit 1 – 3, ex-pit 1, 2, and 10, WINU0080, -0706, -0708, -0910, -0917) 3 existing water supply bores (WINU0913, -0920, -0925)
Yr 7 to Yr 8	16	4	1	3	3 new bench dewatering bores (bench 3, 7 and 8) 13 existing dewatering bores (in-pit 1 – 3, ex-pit 1, 2, 8, 10, 12 and 13, WINU0080, -0708, -0910, -0917) 4 existing water supply bores (WINU0913, -0920, -0925, -0931) 1 existing dewatering bore decommissioned (WINU0706)
Yr 9 to Yr 13	17	6	4	5	4 new bench dewatering bores (bench 2, 4, 5 and 6) 1 ex-pit dewatering bore ex-pit 11 12 existing dewatering bores (ex-pit 1, 2, 8, 10, 12 and 13, WINU0708, -0910, -0917, bench 3, 7 and 8) 2 new water supply bores (WS1 and 2)

					4 existing water supply bores (WINU0913, -0920, -0925, -0931) 4 existing dewatering bore decommissioned (WINU0080, In-pit 1 - 3)
Yr 13 to Yr 17	18	7	0	1	1 new bench dewatering bores (bench 1) 17 existing dewatering bores (ex-pit 1, 2, 8, 10, 11, 12 and 13, WINU0708, -0910, -0917, bench 2 – 8) 7 existing water supply bores (WINU0913, -0920, -0925, -0931, 1305, WS 1 - 2) In-pit sump pumping starting from 2043
Yr 17 to Yr 43	18	7	1	0	18 existing dewatering bores (ex-pit 1, 2, 8, 10, 11, 12 and 13, WINU0708, -0910, -0917, bench 1 – 8) 7 existing water supply bores (WINU0913, -0920, -0925, -0931, WS1 and WS2) 1 existing dewatering bore decommissioned (WINU0708) In-pit sump pumping starting from 2043

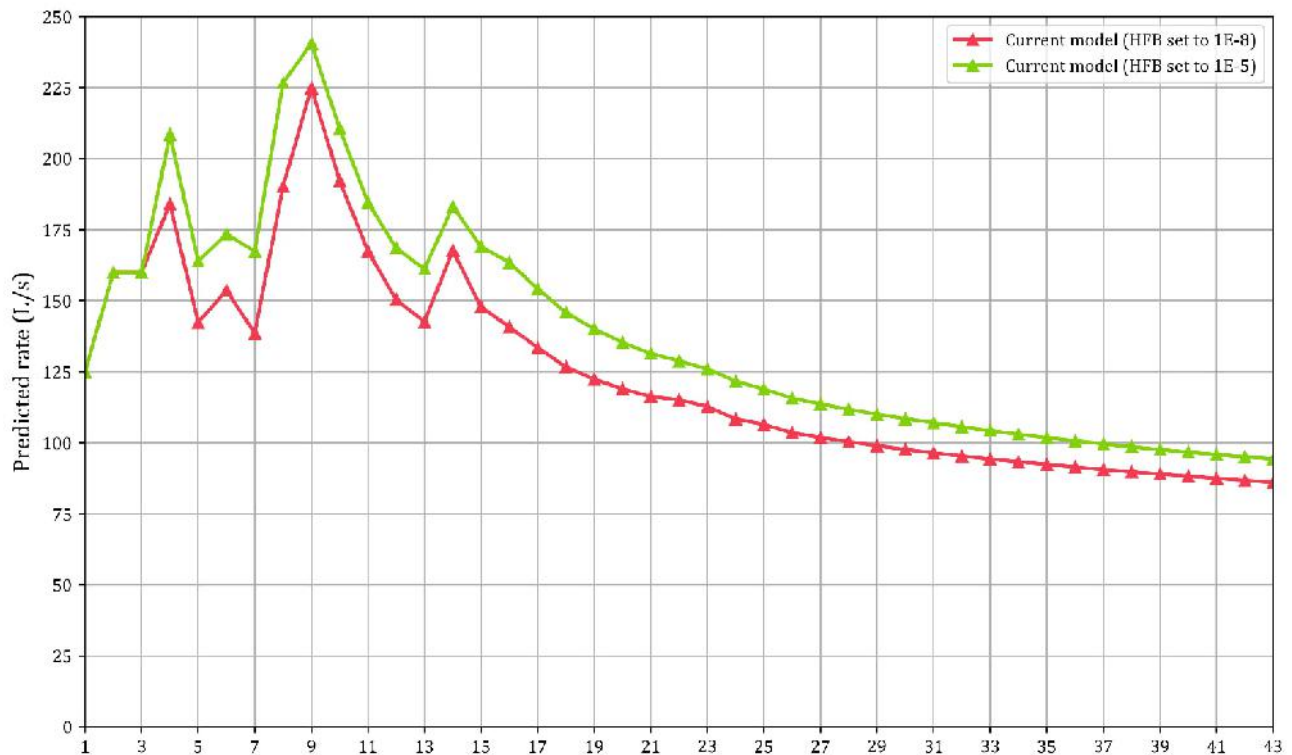


Figure 9-15: Predicted groundwater supply volume

9.4.4 Predicted drawdown at LoM

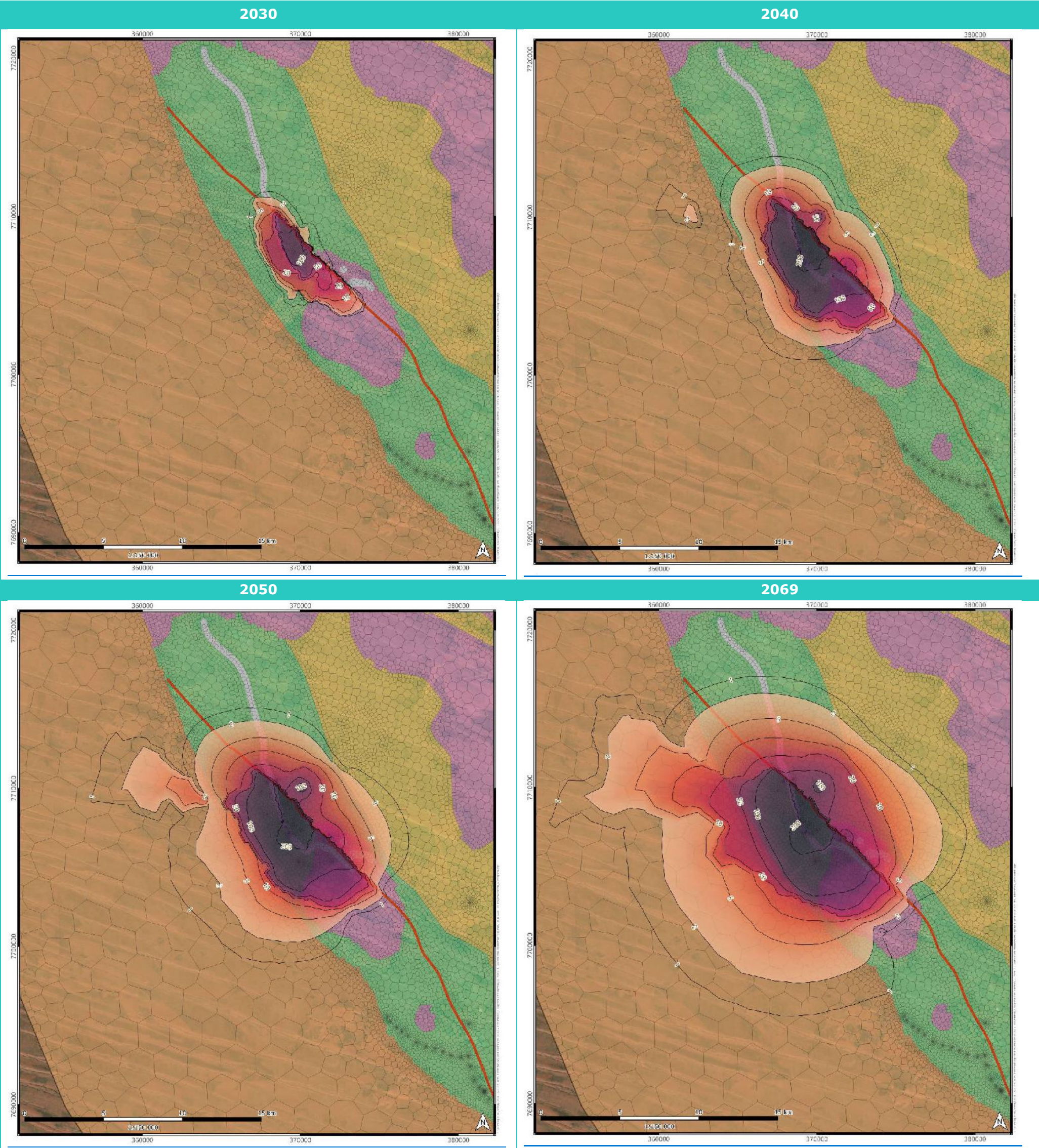
For the LoM predicted drawdown the following assumptions are made:

- The mine plan "sch55 progression.xlsx" is used
- A pit dewatering target at a notional 10 m offset is applied
- The target (10 m below pit wall) is applied for 43 years (Year 1 to Year 43)

Mine dewatering and groundwater extraction for water supply will reduce groundwater levels in the surrounding groundwater system. The extent of the affected zone is dependent on the properties of the hydrogeologic units, which are heterogeneous and/or anisotropic and incorporate the presence of inferred groundwater flow barriers (e.g., low-permeability granite plutons, mafic dykes and sills).

The numerical model estimates the extent of drawdown in all layers (representing unconfined and confined aquifers) by comparing the groundwater levels with and without dewatering for a given time interval. Predicted maximum groundwater drawdown contours within the water table during and at the end of mining are presented in Figure 9-16.

For each model cells the maximum drawdown is obtained, up to that period. This means it is not an exact snapshot in time, just a representation of maximum drawdown experienced in the model cell up to that time. There are no known groundwater receptors present within the predicted cone of depression. The impact of drawdown on potential stygofauna communities is not assessed in this study.



Legend

Mafic Sill
Model grid

Ankatell line fault
Thorny Devil fault

Geology

Palaeozoic

Granites

Broadhurst and Malu

Coolbro

Water table drawdown contours

Water table drawdown (m)

0

0 - 1

1 - 2

2 - 5

5 - 10

10 - 20

20 - 50

50 - 100

100 - 200

Water Table Drawdown

Winu Hydrology/Hydrogeology Study

Project No.
311012-01475

Client
Rio Tinto Copper

Figure No.
9-16

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 07/11/2024, 11:21

References

Consultant

worley
consulting

Client

RioTinto

© Worley Pty Ltd. While every care is taken to ensure the accuracy of this data, Worley makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

9.4.5 Model water balance

Individual water balance components during the steady state, calibration and prediction model runs are presented in Table 9-10. These results are calculated by taking long-term averages of all time steps during the calibration and prediction periods. The transient water balance is presented in Figure 9-17.

The water balance during steady state is determined by the balance in regional groundwater flows simulated using GHB boundary condition as expected with similar trend observed during the calibration period. The calibration water balance also indicates that the mass balance during pumping tests is adjusted by the lost storage. Similar balance results were observed during the prediction period which shows a water balance determined predominantly by groundwater storage loss.

The mass balance error defined as the difference between model inflows and outflows is one of the parameters that is used to quantify the accuracy of the numerical model solutions during internal iterations. The Australian groundwater modelling guidelines (Barnett , et al., 2012) outlines a maximum 2% criteria for mass balance discrepancy at any time step in a transient simulation. This model is well within the guideline criterion, with a maximum of $\pm 0.05\%$.

Table 9-10: Steady state, Transient and predictive water balance (ML/day)

Water balance component	Steady state (ML/d)			Transient (ML/d)			Prediction (ML/d)		
	in	out	in - out	in	out	in - out	in	out	in - out
Regional GW flow (GHB)	1.89	-1.89	0.00	1.89	-1.89	0.00	1.89	-1.89	0.00
Drains	0	0	0	0	0	0	0	-0.7	-0.7
Well	0	0	0	0.00	-0.21	-0.21	0	-9.40	-9.40
Storage	0	0	0	0.28	-0.06	0.21	10.11	-0.01	10.10
Total	1.89	-1.89	0	2.17	-2.17	0	12	-12	0

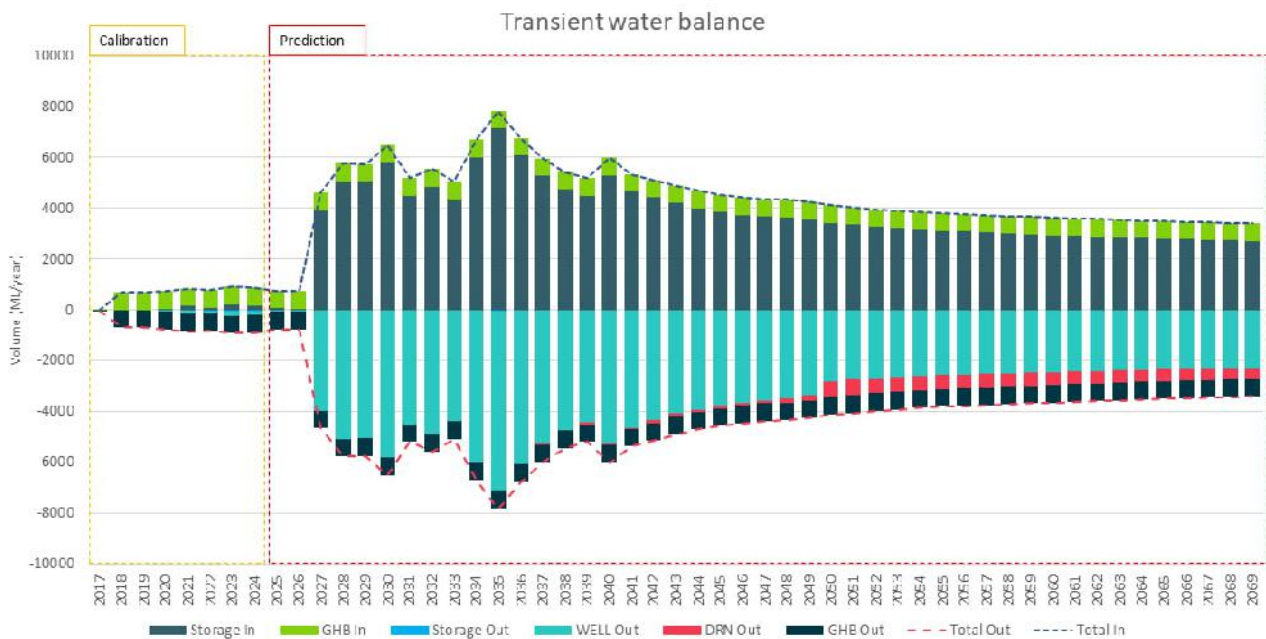


Figure 9-17: Transient water balance for calibration and predictive modelling

9.4.6 Model confidence level classification

Under the latest national best practice guidelines (Barnett , et al., 2012) the groundwater model presented herein is deemed to be Class 2 with components that are Class 1 and Class 3. Several factors are considered in determining the model confidence-level:

- Available data,
- Calibration procedures
- Consistency between calibration and predictive analysis
- Level of stresses

A Class 2 model is suitable for "providing estimates of dewatering requirements for mines and excavations and the associated impacts". A comparison against the performance indicators for individual model classes is presented in Appendix I.

9.5 Uncertainty Analysis

9.5.1 Uncertainty analysis approach

A Parameter Estimation Iterative Ensemble Smoother (PEST-PPIES) approach is employed in this study for uncertainty analysis. It is based on evaluation of 150 calibrated realisations, in which calibration uncertainty is directly propagated from calibrated models into predictive models.

The following parameter groups are included to generate parameter fields or realisations within the ranges identified in hydrogeological conceptualisation (Section 7.6 and Section 9.2.6):

- horizontal hydraulic conductivity
- vertical hydraulic conductivity

- c. specific storage
- d. specific yield

Conceptual uncertainties are discussed in some detail in the hydrogeological conceptualisation.

Uncertainty analysis simulations are aimed at quantifying the uncertainty in the predicted groundwater levels, drawdown induced by dewatering and water supply abstraction, and dewatering rates associated with open-pit mining at Winu to facilitate decision-making based on the assessment of potential impacts and risks.

The results of the uncertainty are presented using the risk-based terminology outlined in Middlemis & Peeters (2018).

Table 9-11: Probabilistic terminology used (from Middlemis & Peeters, 2018)

Percentile	Probability	Description
<10%	>90%	It is very likely that the outcome is larger than this value
10–33%	67–90%	It is likely that the outcome is larger than this value
33–67%	33–67%	It is as likely as not that the outcome is larger than this value
67–90%	10–33%	It is unlikely that the outcome is larger than this value
>90%	<10%	It is very unlikely that the outcome is larger than this value

Key Sy frequency histograms, which are designed to follow lognormal distribution within the ranges in Table 9-4 are presented in Figure 9-18. The remaining parameter distribution frequency (PDF) plots are presented in Appendix J.

All realisations successfully converged and comply with calibration criteria across 188 calibration target locations (Section 9.3.2). The majority of realisations achieved the SRMS value of 5% or less (Figure 9-18).

Two results of two ensembles are provided with the fixed permeability used for each of the flow barrier (partial flow $K=1 \times 10^{-5}$ m/d; no-flow $K=1 \times 10^{-8}$ m/d).

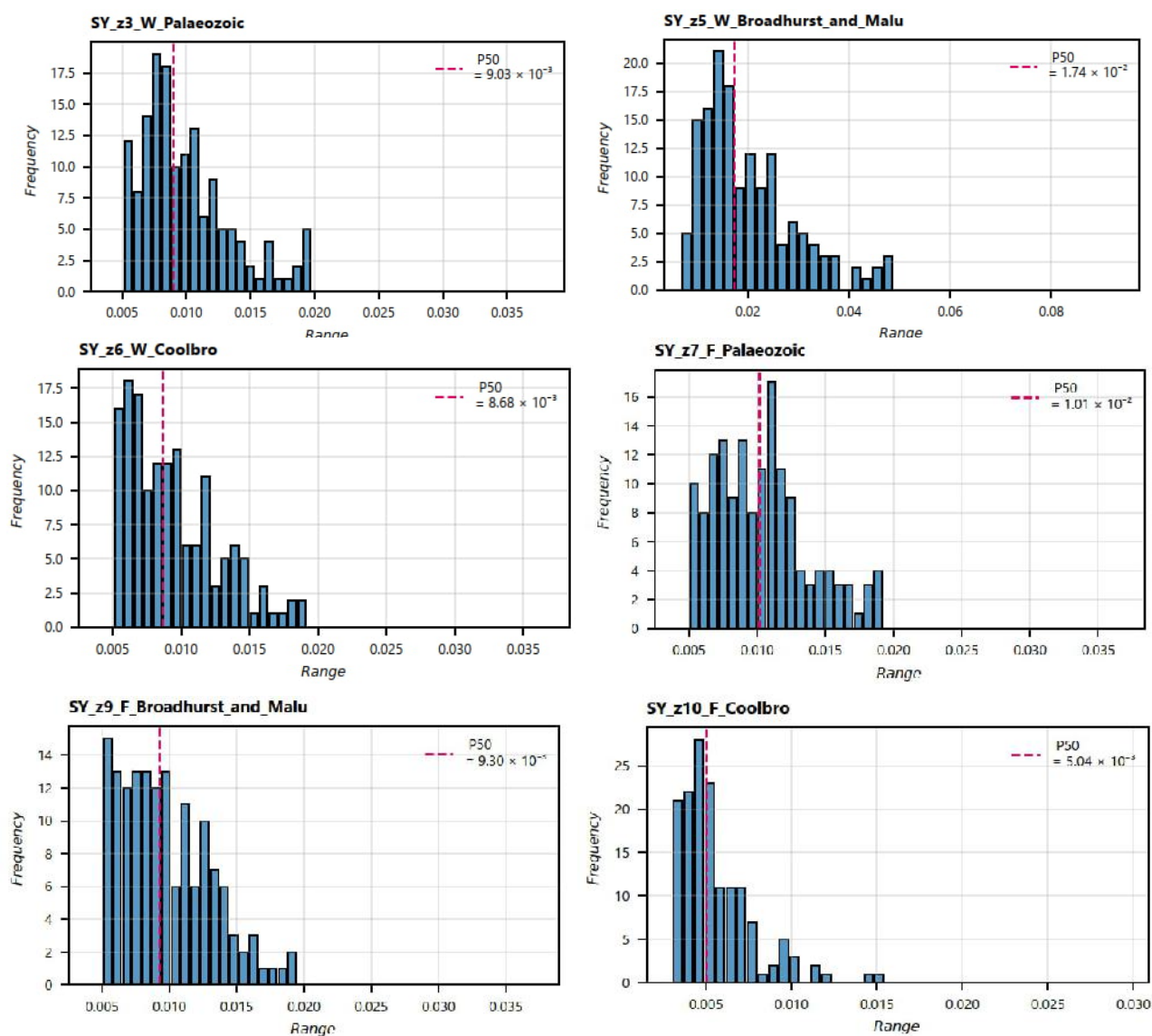


Figure 9-18: Parameter frequency histograms for PPIES workflow realisations

150 runs were analysed out of 150 realisations,
0 realisations were removed with SRMS larger than 10%

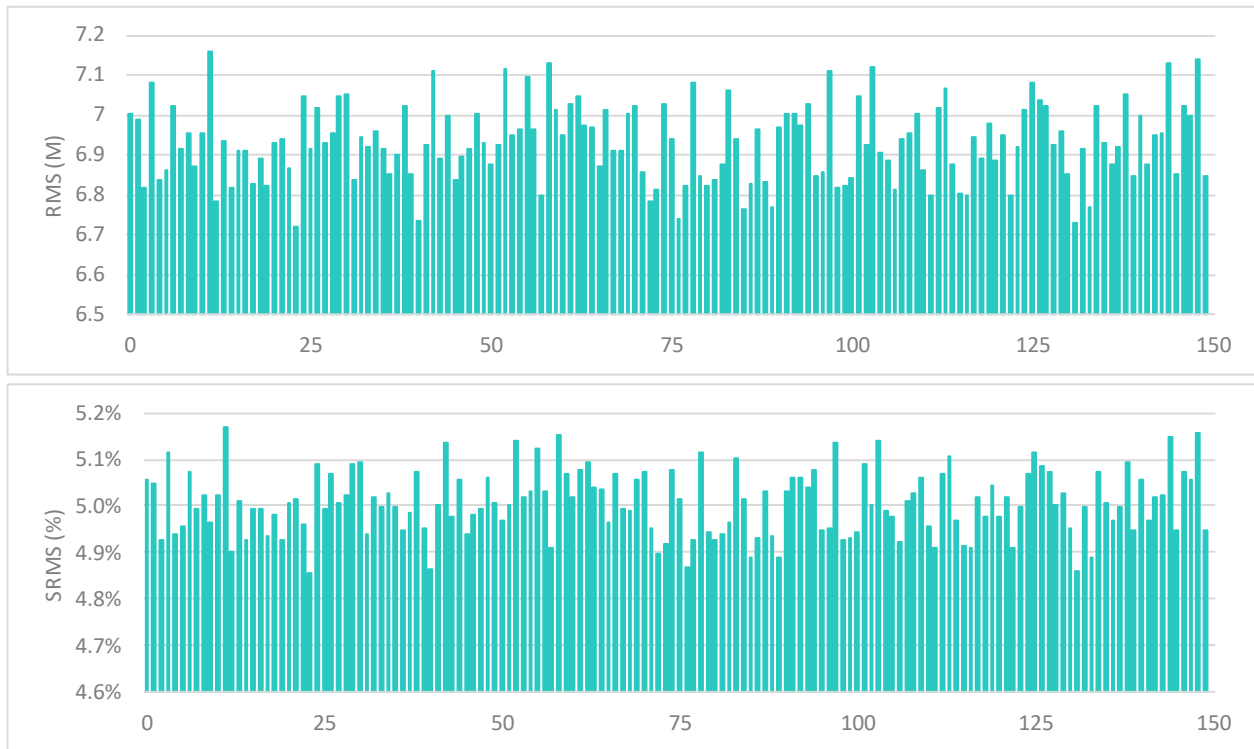


Figure 9-19: RMS and SRMS of individual realisations (no-flow barriers)

9.5.2 Dewatering rate uncertainty

Over the Life of Mine (LoM), the dewatering rates for the likely and unlikely probabilities (P33 and P67) show deviations from the P50 (median probability) by about 5 to 10% (Figure 9-20, with mean annual dewatering rate exceedance).

The maximum and minimum probabilities (Pmax and Pmin) indicate deviations of 30 to 40% from the P50 dewatering rate (Figure 9-21). The Pmax and Pmin values represent combination of parameters outliers, including those from the Sy distribution, and are considered to be rare and unlikely.

The results from the predictive uncertainty analysis indicate that **it is unlikely** that the inflow rate to the open pit will range by more than 10% of predicted inflows.



Figure 9-20: Predictive uncertainty classes for annual mine dewatering rates



Figure 9-21: Dewatering rate deviation from the median probability (P50)

9.5.3 Drawdown uncertainty analysis

The uncertainty analysis results of both structural scenarios (no-flow and partial flow barriers) indicate that **it is very unlikely** that more than 2 m drawdown for LoM reaches (Figure 9-22 and Figure 9-23):

- Beyond 15 km of open pit mining of CB_6
- No sensitive receptors will be impacted, including the regional soaks (during mining)

The 2 m drawdown threshold is used as an indicator of the potential influence of mine dewatering, assuming this variance is within the natural seasonal fluctuation (and measurement error).



Legend

-  Model grid
-  Ankatell line fault
-  WNW Faults
-  Winu H3 Model Outline

Exceedance probability (2m)

-  Very unlikely (>P90)
-  Unlikely (P90 - P67)
-  As likely as not (P67 - P33)
-  Likely (P33 - P10)
-  Very likely (<P10)
-  2m drawdown exceedance (P50)

Probability of 2m drawdown exceedance during LoM

Winu Hydrology/Hydrogeology Study

Project No. 311012-01475	Client Rio Tinto Copper	Figure No. 9-22
-----------------------------	----------------------------	--------------------

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 12/11/2024, 08:08

References

Consultant



Client

RioTinto



Legend

- Water supply bores
 - Dewatering bores
 - WINU Pit Cutback 6
 - Model grid
 - Ankatell line fault
 - WNW Faults
 - Winu H3 Model Outline
-
- Exceedance probability (2m)
- Very unlikely (>P90)
 - Unlikely (P90 - P67)
 - As likely as not (P67 - P33)
 - Likely (P33 - P10)
 - Very likely (<P10)
 - 2m drawdown exceedance (P50)

Probability of 2m ddn exceedance during LoM (Partial flow barriers)

Winu Hydrology/Hydrogeology Study

Project No.	Client	Figure No.
311012-01475	Rio Tinto Copper	9-23

Notes:

Project CRS: GDA94 / MGA zone 51
Last Saved: 12/11/2024, 07:41

References

Consultant



Client

RioTinto

9.5.4 Groundwater allocation

Based on predicted peak groundwater abstraction calculated from the base case dewatering and water supply scenarios, a GWL for 248 L/s (7.82 GL/a) will be required for peak periods. This volume may only be required in some years and could possibly change as operational data confirm “real” demands.

Uncertainty analysis indicated that over LoM, the dewatering rates for the likely and unlikely probabilities (P33 and P67) show deviations from the P50 (median probability) by about 5 to 35%.

Therefore, an application for a GWL of 7.82 GL/a is recommended.

9.5.5 Knowledge prioritisation recommendations

The history matching and predictive uncertainty provide learnings on key knowledge prioritisation recommendations (Table 9-12).

Table 9-12: Knowledge prioritisation recommendations

Learning	Prioritisation recommendation
Field characterisation focused on the mine area - data may not represent bulk regional properties	Extend monitoring bore program outside of the immediate mining area, at least within the estimated cone of depression predicted by modelling. Additional monitoring bores within the predicted cone of depression would be useful to provide valuable additional model validation/calibration data for future mining.
Limited data available at the regional proposed borefield	Extend field characterisation program at proposed regional borefields to further assess the water supply potential
Observation data shows some compartmentalisation controls (between no flow structures)	Include monitoring bores either side of structures during testing
Diffuse recharge rates have been considered negligible – the main recharge component is currently throughflow	Collect additional water quality and isotope data to better understand the rate at which groundwater is replenished. This might have major influence on closure modelling, on the speed and extent of water level recovery
Flow contribution and restrictions from regional structures	Potentially extend the field program to explore the nature of major structures and how they will impact the groundwater flow regime.
Aquifer storage parameter characterisation is currently not reliably constrained – due to the lack of larger aquifer stresses	Re-evaluate storage properties once larger scale pumping commences and update the numerical model and impact assessment

9.6 Modelling assumptions and limitations

Groundwater models present a simplified representation of what is potentially a complex hydrogeological system. This is due to the sparse and irregular distribution of information on geological structure, distribution and variation of hydraulic properties, and variations due to seasonal and climatic changes.

Current information gaps are listed below:

- **Delineation of geological boundaries:** Some of the geological boundaries were extrapolated based on best available interpretation which may change if new data becomes available.
- **Hydraulic (aquifer) parameterisation:** although hydraulic testing is available for the main study area and Texas, little site-specific hydrogeological information is available in the regional areas to the north and west of the proposed mine site.
 - Predictive uncertainty analysis is used to address this.
 - Hydrogeological information on and impacts of flow barriers are not well understood at depth, and their effects will only become more observable during the mining phase.
- **Water level accuracy:** assessment of groundwater level change and its effect on some environmental receptors is dependent on accurate representation of ground elevation by means of a digital elevation model (DEM).
 - No groundwater levels are available in the northern part of the model.
- **Groundwater recharge rate:** No vertical recharge to the groundwater system is applied at this stage. It is interpreted to occur episodically following cyclone events, where rainfall has infiltrated sufficiently to overcome the high rates of evapotranspiration, followed by diffusive percolation to the water table that is set at large depths.
 - Potential recharge zones exist to the south of the Winu area at areas of outcrop and through the Percival Palaeovalley east of the Rimfire area (30 km SE of Winu).
 - Recharge rates of between 0.4 to 2.4% of mean annual rainfall (1.5 to 8.7 mm) are currently available from isotope studies (IGS, 2021).

10. Assessment of potential impacts

Potential impacts on the environment, and other groundwater users, which may be caused by the proposed groundwater abstraction associated with the Winu project have been informed by the numerical groundwater modelling and are presented in Table 10-1.

Table 10-1: Managing potential impacts to water resources and environmental receptors

Receptor	Potential impacts	Consequence	Likelihood	Risk	Control / Comment
Soaks Maintain water quantity and quality	Drawdown area – reduction in groundwater levels Water quality impacts	Significant	Unlikely	Low	Soaks are unlikely to be fed by groundwater and rather through infiltrated rainfall and surface water runoff collected in topographic depressions. Groundwater modelling indicated no impact of groundwater levels in the area of the Soaks.
Existing users Maintain water quality and water levels	Drawdown area – reduction in groundwater levels Water quality impacts	Significant	Unlikely	Low	Continues monitoring and updating of the groundwater model. Aboriginal communities in the region are located more than 100 km from Winu, and therefore, no impacts are expected.
Groundwater resource Maintain groundwater resource for water supply to mining operations	Confined aquifer pressure is reduced associated with mine water supply	Significant	Unlikely	Low	The metasediments aquifer will be primarily impacted by dewatering, as it is the main source of groundwater which will need to be dewatered during mining. Therefore the supply of regional groundwater is considered.
Groundwater-dependent vegetation	Drawdown of water influence GDE	Significant	Unlikely	Low	All potentially groundwater dependent vegetation appears to be beyond the extent of drawdown (end of mining) at Winu. Further to this, given that the depth to groundwater in the study area it is unlikely for GDE to be influenced.
Mandora Marsh, 80-Mile Beach. Artesian pressure in the Wallal aquifer Broome and Wallal aquifers	Reduction in confined aquifer pressure, or reduced groundwater levels in the Broome aquifer will negatively impact these receptors	Significant	Unlikely	Low	These receptors are located more than 100 km from Winu, and therefore, no impacts are expected. Continues monitoring to the north of Winu in both the shallow and deep aquifers are recommended.
Stygofauna	The risk to stygofauna has not been assessed as part of this study. Biota Environmental Sciences, (2022) is currently assessing the stygofauna presence and risk in the regional aquifers				

To comply with groundwater licensing conditions, before mining progresses, a groundwater operating strategy will be developed.

Selected preliminary features of the operating strategy to guide the management of potential risks associated with future mining below the water table at Winu are:

- Groundwater management is suitably integrated with mine planning and mine development to ensure water supply is secure.
- Potential impacts to other groundwater users and environmental receptors are identified and should be continuously monitored, periodically assessed, and reviewed, and mitigation or prevention strategies developed early if potential impacts are foreseen.
- Receptors in the Wallal and/or Broome aquifers are predicted to not be impacted by Winu dewatering and water supply operations.
- Alternative water supply options are identified to meet site operational water demands, by potentially using regional aquifers.
- Groundwater management strategy and corrective action triggers (monitoring and sampling) at Winu will be developed as part of the Winu groundwater operating strategy under the 5C licence, in conjunction with all stakeholders through life of mine to monitor any impacts to groundwater levels from water supply for mining operations.
- A targeted baseline groundwater monitoring and sampling program is described in Section 11.

11. Groundwater monitoring

11.1 Baseline groundwater monitoring, sampling, and analysis

The current groundwater monitoring and sampling utilising existing bores at Winu are outlined in report: 311012-01475 - REP-HG-024: Winu Baseline Groundwater Monitoring Plan - Baseline Assessment - Update 2024 (Worley, 2024a).

Groundwater monitoring commenced in 2019, and is ongoing, with quarterly water level measurements.

Production bores are metered, and cumulative pumped volumes are recorded and reported under existing DWER groundwater abstraction licences.

The main parameters used to measure the condition of the groundwater resources are groundwater levels and water quality parameters including TDS, major ions, trace metals, and nutrients.

Over time, a history of the condition of the aquifers will be established from this information, enabling longer-term and short-term changes to be identified and correlated with either natural (e.g., climatic) or mining-induced changes.

Some bores will be destroyed during construction and development of the mine, but groundwater monitoring will continue at alternative locations, and future bores are proposed for long-term operational monitoring and measurement.

11.1.1 Mine operation monitoring

During future proposed mining operations, the monitoring objectives will be to measure groundwater level responses from mine dewatering, through a series of near-mine and regional bores, and potential groundwater quality impacts from mine operations (e.g., tailings storage facility leakage or point source contaminants).

Dewatering bore abstraction rates, pit wall seepage rates (from unconfined formations and metasediments), supplementary borefield pumping, and surrounding groundwater levels should be reviewed regularly and compared to predicted trends.

11.1.2 Groundwater monitoring program

The baseline groundwater monitoring program has been designed with an increased sampling frequency with the aim to collect 10 samples from each location, capture seasonal fluctuation, and allow for the assignation of statistically relevant trigger levels. Table 11-1 summarises the number of bores and monitoring schedule to be sampled during the baseline groundwater collection period 2024.

Monitoring locations have been divided into monitoring areas to allow for baseline requirements, however the infrastructure has not been finalised and they are subject to change. All WRL and TSF monitoring bores will be buried in future and therefore replacement bores will be needed.

Table 11-1: Baseline groundwater monitoring summary

Monitoring Location	No. of Bores to be sampled for baseline	Existing or Potential Receptor	Parameter	Frequency
Waste rock landform	5	Unconfined aquifer	Field Water Quality (Temp, pH, TDS, EC, TA, ORP)	Quarterly
			Lab Water Quality (Comprehensive analysis)	Quarterly
			Water Levels	Quarterly – Manual Quarterly – Data logger downloads
Tailing Storage Facility	5	Unconfined aquifer	Field Water Quality (Temp, pH, TDS, EC, TA, ORP)	Quarterly
			Lab Water Quality (Comprehensive analysis)	Quarterly
			Water Levels	Quarterly – Manual Quarterly – Data logger downloads
Processing Plant Topsoil Stockpiles and Ore Stockpiles	9	Unconfined/ Confined aquifer	Field Water Quality (Temp, pH, TDS, EC, TA, ORP)	Quarterly
			Lab Water Quality (Comprehensive analysis)	Quarterly
			Water Levels	Quarterly – Manual Quarterly – Data logger downloads
Operational bores	7	Confined	Field Water Quality (Temp, pH, TDS, EC, TA, ORP)	Quarterly
			Lab Water Quality (Comprehensive analysis)	Quarterly
Dewatering	32	Confined	Field Water Quality (Temp, pH, TDS, EC, TA, ORP)	Quarterly
			Lab Water Quality (Comprehensive analysis)	Quarterly
			Water Levels	Quarterly – Manual Quarterly – Data logger downloads
Regional and Airstrip	21	Stygofauna habitat/Regional users	Field (Temp, pH, TDS, EC, TA, ORP)	Quarterly
			Lab Water Quality (Comprehensive analysis)	Quarterly
			Water Levels	Quarterly – Manual Quarterly – Data logger downloads
VWP Bores	21	Nil	Water Pressures	Quarterly

11.2 Groundwater monitoring and modelling reviews

A critical aspect of the review and reporting of monitoring data will be the verification of numerical model predictions (within acceptable limits or errors). The data collected during future hydrogeological investigations (e.g., aquifer yields, transmissivity, and other hydraulic properties, mudstone continuity) will be used to further refine the hydrogeological conceptual model, and subsequently update and recalibrate the numerical groundwater model and mine water balance. This will improve confidence in model predictions through periodic review and verification of results.

Groundwater monitoring during mining operations is essential to confirm aspects of the currently accepted conceptual model and assess the effects of mine dewatering on the surrounding aquifer. This includes obtaining further evidence that the elements of the monitoring will achieve the specified performance requirements and includes verification against predicted (modelled) trends.

Where this is observed to not be the case, recalibration of the model or further investigation will be required to verify that the risks to the aquifer have not changed significantly from model predictions.

If necessary, further adjustment would be made to the model at that time, and new forward predictions of groundwater impacts would be developed. Circumstances where recalibration of the model will be needed include:

- Significant deviations in observed aquifer hydraulic response from the predicted response
- Mine dewatering system operated under substantially different conditions to those modelled, such as at higher or lower pumping rates
- Significant deviation in observed pit seepage rates from the predicted response

12. Site-wide water balance model

Water balance modelling was completed for the Winu copper-gold project and is further described in Worley, (2025).

Modelling suggests that:

- The project is likely to be in surplus during the initial phases of the project, up to approximately Year 17.
- From Year 18 to 32, the project is in deficit, and water will be required from the regional borefield. The median supply from the regional borefield during this period is 570 ML/year (18 L/s), with a range of 0 to 2,335 ML/year (74 L/s) depending on rainfall.

The variable nature of the water balance over the project life is shown in Figure 12-1:



Figure 12-1: Median annual site water balance for the HFB 1E-5 (ML/year)

Mine dewatering exceeds demand through much of the project life, resulting in a water surplus. Surplus water from the Mine Dewatering system will be directed to infiltration ponds. The peak surplus occurs during Year 3 of the project, during which mine dewatering requirements are greatest, and prior to processing commencing. Predicted mine surplus is greatly influenced by rainfall, with rainfall and runoff contributing to the water balance.

The uncertainty in mine dewatering predictions and the effectiveness of evaporation inhibitor has a significant effect on the water balance, in both the impacts on the amount of water required from the regional borefield and excess water requiring management.

The design of the water management system needs to consider a range of possible conditions and identify contingencies that can be implemented for both supply and excess management.

13. Conclusion and recommendations

13.1 Conclusion

This report presents a hydrogeological assessment for the Winu Project and aims to inform the application for a 5C GWL.

The outcomes of the most recent work, coupled with historical studies at Winu have resulted in a considerable improvement in the hydrogeological understanding, and predictive reliability.

This assessment evaluates the impact of the open-pit mining on the groundwater regime, identified environmental receptors and third-party users. The mine plan includes developments of an open pit mine currently scheduled to operate between 2027 to 2069 (sch55 prgression.xlsx).

Detailed hydrogeological conceptualisation, based on currently available spatial and temporal datasets and information, both RTC-owned and publicly available, preceded the development of the numerical model. The dataset is focused on the mining area and potential regional borefield. Outside of these developments data coverage is generally sparse.

The hydrogeological conceptualisation in the mine area is characteristic of localised fracturing in the metasediment aquifer. The immediate mine area (a small part of the model domain) has been hydraulically tested by a combination of extended pumping tests. The response of the aquifer system to recent constant rate testing is used for model calibration and for delineation of likely flow barriers within the fractured rock aquifer.

Numerical groundwater modelling, over a model domain of about 3,000 km², informs and updates predictions of potential operational outcomes and impacts to sensitive groundwater dependent receptors.

The refined groundwater model predicts most recent LoM dewatering rates at Winu, and includes a probabilistic assessment of model uncertainty, based on Middlemis and Peeters guidance (2023). The key outcomes are:

- It is likely (P50) that:
 - a. predicted dewatering requirements range from 80 to 250 L/s and averages at 105 L/s over LoM.
 - b. dewatering requirements range between 150 and 250 L/s up to year 13
 - c. dewatering requirements range between 125 and 175 L/s in year 13 to year 19
 - d. dewatering requirements are less than 125 L/s from long term dewatering after year 19
 - e. the project water balance is positive (i.e. net excess) for most years and excess water management will be required
 - f. up to 0.57 GL/a makeup water will be required in some years (after Year 17).
- It is unlikely (P33 and P67) that:
 - g. inflow to the open pit ranges by greater or less than 10% from predicted inflows based on parameter uncertainty
 - h. the project water balance is slightly positive (i.e. net excess) for most years and excess

water management will be required

- i. makeup water will be required after Year 13.
- It is very unlikely (P10 and P90) that:
 - a. predicted dewatering requirements ranges by greater than 40% from predicted inflows
 - b. up to 2 GL/a makeup water may be required in some years
 - c. that the groundwater regime will be impacted by more than 2 m drawdown:
 - iii. beyond 15 km of open pit mining of CB_6
 - iv. no sensitive receptors will be impacted, including the regional Soaks (during mining)

Predictive simulations indicate that dewatering will need to be augmented by sumps from 2043 when deeper, low-permeability sections are encountered.

Parallel investigation work has identified the Rimfire Borefield area as potentially suitable for supplying up to 2.8 GL/a of makeup water.

The refined model predicts little to no drawdown impacts away from the mine area or anywhere near identified receptors due to dewatering and the pumping at Rimfire at 2.8 GL/a over the full LoM (conservative assumption).

To allow for effective water management planning around mine dewatering and water supply pumping (as well as excess water management), the project requires a GWL allocation of 7.82 GL/a from the Winu Copper-Gold project. This covers the predicted total groundwater abstraction for the highest water use years. It is recognised that total groundwater allocation requirement will be much less than this in some years. A proposed operational monitoring programme is presented, which would require update and incorporation in an Operating Strategy to support the GWL.

An application for the selected regional water supply borefield will be lodged separately.

13.2 Recommendations

The following are recommended to support further optimisation of the groundwater model and water balance to support design activities:

- Regular updates are recommended once long-term dewatering rates are established (active mining) to better understand and calibrate Sy to determine long term dewatering and water supply potential.
- Iteratively modify the dewatering schedule and rates to coincide with seasonal patterns to reduce the average annual magnitude of deficits and excess discharge volumes.
- Water balance analyses to date have not considered water quality concentrations within the various water streams, which is recommended for future studies particularly where this could impact the suitability of the various water streams for use in meeting site water demands (process and/or non-process).
- Undertake climate change sensitivity based on the regional climate change projections for different Representative Concentration Pathways (RCPs) if these have an effect on recharge sources.

14. References

- Advisian. (2022a). *Winu Dewatering Strategy and Groundwater Supply Update 2022*. Ref: 311012-01475-5.1.3-TM-001-Rev1.
- Advisian. (2022b). *Factual Drilling Report*. Ref: 311012-01475-5.2.1-Rep-001-RevA.
- Advisian. (2023a). *Rimfire Bore Redesign for 26D*. Ref: 311012-01475-TM-HG-008-RevB.
- Advisian. (2023b). *Rimfire target identification based on RC drilling results*. Ref: 311012-01475-TM-HG-007-Rev1.
- Advisian. (2023c). *Winu Annual Aquifer Review*. Ref: 311012-01475-Rep-HG-009-Rev0.
- Advisian. (2023d). *Texas target identification based on RC drilling results*. Ref: 311012-01475-TM-HG-012-Rev1.
- Advisian. (2023e). *Rimfire H2 Assessment*. Ref: 311012-01475-Rep-HG-014-Rev0.
- Advisian. (2023f). *Texas H3 Assessment*. Ref: 311012-01475-Rep-HG-016-Rev0.
- Advisian. (2023g). *Rimfire and Texas Phase 2*. Ref: 311012-01475-TM-HG-015-RevA.
- Advisian. (2024). *Solute Transport Modelling (Groundwater), Quarry and Pond Options*. Ref: 311012-01475-TM-HG-017-Rev0 .
- Barnett , B., Townley , L. R., Post, V., Evans, R. E., Hunt, R. J., Peeters, L., . . . Boronkay, A. (2012). Australian groundwater modelling guidelines.
- Bell, J., Kilgour, P., English, P., Woodgate, M., & Lewis, S. (2012). *WASANT Palaeovalley Map - Distribution of Palaeovalleys in Arid and Semi-arid WA-SA-NT*. Canberra: Geoscience Australia.
- Biota Environmental Sciences. (2022). *Winu Project Subterranean Fauna Desktop Study and Basic Survey*.
- Czarnota, K., Gerner, E., Maidment, D. W., Meixner, A., & Bagas, L. (2009). *Paterson area 1:250 000-scale solid geology interpretation and depth to basement model – explanatory notes: Geoscience Australia Record, 2009/16*.
- Doherty. (2002). *PEST Model-Independent Parameter Estimation, Watermark Numerical Computing*.
- Golder. (2020). *2020 Winu Hydrogeological Field Investigation*. Golder Associates. Prepared for RTC.
- Golder. (2021). *Winu Regional water supply options and selection of drillhole investigation sites*. Ref: 20136763-064-M-Rev0.
- Golder. (2022a). *H3 Hydrogeological Assessment of the Winu Project*. Ref: 20136763-062-R-Rev3-Hydrogeological Assessment.

- Golder. (2022b). *Test Pumping Results and Analysis for WINU0910 (EPZ-PB01)*. Ref: 20136763-069-M-Rev0.
- Golder. (2022c). *Test Pumping and Analysis for WINU0913 (NG-PB01)*. Ref: 20136763-072-M-RevA.
- IGS. (2021). *Winu Groundwater Chemistry and Environmental Isotope Studies*. Innovative Groundwater Solutions. Report prepared for RTC.
- Kruseman, G. P., & de Ridder, N. A. (2000). *Analysis and Evaluation of Pumping Test Data*. 2nd Edition, International Institute for Land Reclamation and Improvement.
- Timms, W. A., Chowdhury, M. F., & Rau, G. C. (2020, May 4-8). *A review of specific storage values from pore pressure response to passive in situ stresses: Implications for sustainable groundwater management*. Retrieved from EGU General Assembly: <https://doi.org/10.5194/egusphere-egu2020-11002>,
- Worley. (2024a). *Winu Baseline Groundwater Monitoring Plan*. Ref: 311012-01475-Rep-HG-024-RevB.
- Worley. (2024b). *Winu Annual Aquifer review, 1st January 2023 to 31 ST December 2023*. Ref: 311012-01475-REP-HG-021-Rev0.
- Worley. (2024c). *Winu Operational Surface Water Management Plan Update 2023*. Ref: 311012-01475-REP-HY-018-Rev0 .
- Worley. (2024d). *Winu Baseline Groundwater*.
- Worley. (2025). *Winu Water Balance Update 2025*. Ref: 311012-01475-REP-WB-039-RevC.