Iron Bridge

North Star Groundwater Operating Strategy

Iron Bridge Near Mine Groundwater Supply Scheme

24 June 2024
661MI-0000-PL-HY-0001

DWER approved:

KCox

Kerrin Cox – North West Regional Manager – 28/06/2024
Department of Water and Environmental Regulation

	North Star Groundwater Operating Strategy 661MI-0000-PL-HY-0001		
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Author	Checker	Approver	Rev No.	Status	Issued Date
Richard Martin	Ian Zlatnik	Jon Clements	0	IFU	3/02/2015
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1. INTRODUCTION

1.1 Background

Iron Bridge Operations Pty. Ltd. (IBO) has been developing the North Star iron ore mine (North Star) since November 2013. The North Star site is located approximately 100 km south of Port Hedland and 25 km east of the existing Fortescue rail line to Port. North Star is located within Mining Tenements M45/1226 and M45/1244 and Miscellaneous Licences L45/294, L45/397 and L45/361, in the northern portion of a large magnetite orebody.

The North Star operations consist of two operationally distinct phases of mining operations; the Stage 1 North Star Hematite mine and the Stage 2 North Star Magnetite mine.

Stage 1 commenced in November 2013 and involved the construction of a processing plant and other aspects associated with mining of the ore body to process up to 10 million tonnes of ore each year. Ore was mined until April 2016, then operation was restricted, with full scale operations put under suspended operations from April 2016 to July 2019.

In August 2019, IBO started the construction of the Stage 2 Project with the construction of an aerodrome and associated access road, the expansion of the North Star accommodation village (up to 2,000 persons), the construction of water pipeline and infrastructure, and the development/widening of sections of existing site access road to process up to 20 million tonnes of ore each year. The Stage 2 mine entered production in 2023.

IBO, which is managing the project, has developed a water supply scheme to meet construction and dust suppression needs as well as initial operating water requirements. These demands are estimated at 90 litres per second (L/s), indicating an annual water demand of 2.8 gigalitres per annum (GL/a). This demand is currently met by GWL179289(6) and GWL164321(1).

Detailed hydrogeological investigations have identified fractured rock aquifers in the vicinity of the proposed mine. A series of field investigation and a consolidated hydrogeological (H3) assessment (Iron Bridge, 2023a) have been undertaken to establish the required volumes for the life of mine water supply, dewatering and other water management activities. IBO has submitted the H3 assessment report in support of an updated Section 5C licence application, which requested a consolidation of GWL179289(6) and GWL164321(1) into a single licence (nominally GWL179289(7) and an updated water entitlement of 7.59 GL/a, consisting of the following sub-limits by activity as follows:

- Groundwater abstraction for water supply of 2.59 GL/a, including the component of camp supply previously licensed under GWL164321(1)
- Pit dewatering of up to 4.5 GL/a, consistent with the limits prescribed in Ministerial Statement 993
- Groundwater seepage recovery up to 0.5 GL/a from water management activities across Iron Bridge Mine

This GOS covers the operation of production bores to meet the water requirements of 7.59 GL/a for North Star Stage 2. The location of existing bores and abstraction activity areas is shown in Map 1.

1.2 Document Scope

This document outlines the planned operation groundwater abstraction systems at the North Star Mine and the management systems that will be employed to monitor and mitigate potential impacts. This GOS has been prepared to meet the requirements of "*Operational Policy 5.08, Use of Operating Strategies in the Water Licensing Process*"' (DoW, 2010) and ensure monitoring and compliance requirements are addressed. Alterations to the standard document structure have been employed to better reflect the adaptive management strategy recommended in the H3 assessment (Iron Bridge, 2023a).

1.3 Administrative Requirements

1.3.1 Administrative Details

Administrative requirements to maintain compliance with this GOS are presented in Table 1.

Table 1: Administration Requirements

Requirement	Administrative Arrangement
Duration	Co-incident with duration of licence
Contact details of persons responsible for implementation of this document	Maintenance Services Manager, North Star Stage 2
Definition of water year	1 January – 31 December
Reporting commitments	See Section 1.3.2 and Table 2
Review	Refer to Section 0

1.3.2 Reporting Commitments

Reporting will be conducted as outlined in Table 2. The reports will be prepared in accordance with the Operational Policy 5.08 in "*Use of Operating Strategies in the Water Licensing Process*" (DoW, 2010).

If the Department of Water and Environmental Regulation extends the date for the submission of a report referred to in Condition 3, 4 or 5 of GWL 179289 by notice in writing, the licensee:

(i) is not required to submit the report to the Department by the date specified in Condition 3, 4 or 5, whichever is applicable; and

(ii) must submit the report to the Department by the date specified in the written notice.

Table 2: Statutory Reporting Requirements

Frequency	Contents
Annual	An Annual Groundwater Monitoring Summary will be prepared by a competent Hydrogeologist and include: • Data (both tabular and graphical) from the monitoring program (from January to December of each year) and a hydrogeological assessment of these data • An examination of compliance with the Groundwater Licence (GWL) terms and conditions • An examination of compliance with groundwater operating strategy commitments • An examination of the suitability of trigger levels and, where necessary, proposed amendments to the operating strategy • A review of the condition of all monitored pools in correlation with climate trends • An explanation of the cause and description of the action that IBO proposes to take to manage the water resource and, where necessary, recommend changes to the operating strategy should the monitoring reveal any unusual or undesirable results • Description of the effectiveness and accuracy of the monitoring program (where appropriate). • Details of any borefield changes that have occurred through the year The report will be submitted to the DWER by the 31 March of each year.
Triennial	A Triennial Groundwater Monitoring Review is to be submitted every three years in substitute of the annual summary. The Triennial Groundwater Monitoring Review will discuss all historical data with more emphasis on historical trends and anomalies, in addition to the reporting requirements of the annual review. The Triennial Groundwater Monitoring Review will include a groundwater model review, with recommendations for altered trigger levels, where required. The report will be submitted to DWER by 30 April of each year due. A triennial report was submitted to DWER in April 2023 for data up to the end of 2022. Future triennial reports will therefore be required by 30 April 2026 (for data up to the end of 2025), 30 April 2029 and so on.
As required	Trigger level exceedances will be reported to the DWER as outlined in Section 7.5.

1.3.3 Metering requirements and commitments – Regulation 41E(1)

Under Part 4A – Meters; Regulation 41C (Rights in Water and Irrigation Regulations 2000), *Each licence is subject to the condition that the licensee must – install a meter on each water draw-point through which water is taken under the licence*; and provide the regulator details of the meter every time a meter is installed including replacements. Fortescue has been granted approval for an alternative method to measure and report abstraction under Regulation 41E(1) as compliance under Regulation 41C is impractical due to the large number of water draw-points and frequent changes required to these draw-points during normal operation.

A water meter that meets the technical requirements of the Rights in Water and Irrigation (Approved Meters) Order 2009 will be installed on each draw-point through which water is taken under the inforced version of GWL167289. Water meters will be maintained in good condition and will operate within a permissible error margin of plus or minus 5 per cent of the quantity of water that passes through the meter when tested in field conditions. Meter readings will be taken recorded on the last calendar day of each month or as closest practicable. Monthly and annual cumulative abstraction volumes will be reported within the Groundwater Monitoring Summary and Groundwater Monitoring Review reports stipulated in the inforce version of GWL167289. On request, Fortescue will provide DWER with monthly meter readings for individual draw-points within 14 calendar days of receiving the request from DWER.

2. STAKEHOLDER CONSULTATION

Development of the North Star GWOS has incorporated stakeholder feedback from DWER and Nyamal, the traditional custodians and registered native title group for the North Star area.

Revisions 1 – 3 of the GWOS only incorporated DWER feedback, documented within the Hydrogeological Assessment (Iron Bridge, 2023a). Nyamal have been engaged, through their representative body Nyamal Aboriginal Corporation (NAC) and heritage service provider Barlbinbinya Aboriginal Corporation (BAC), to develop a Social Cultural Heritage Management Plan (SCHMP) for North Star Extension (related to a s38 amendment application for MS993). This engagement has led to a greater understanding of heritage values associated with water sources, and collaboration on what is required to manage risk to these values.

The SCHMP, endorsed by Nyamal on 30 June 2023, refers to other management plans (e.g. the GWOS) for details on how water-related heritage values will be managed (Iron Bridge, 2023b). Section 5 of the SCHMP contains details on consultation, and a framework for ongoing consultation associated with IBO's operations.

A specific consultation session, associated with the development of this GWOS, was undertaken with the Nyamal Heritage Sub-Committee (HSC) on 06 September 2023. Hydrogeologists representing IBO presented details of the hydrogeological assessment, and proposed management strategies that could be implemented to reduce the risk of unwanted impacts. The minutes of this meeting are confidential; a summary is provided in Table 3 below.

Table 3: Summary of September 2023 Consultation with Nyamal on the Near Mine Borefield

Topic	Consultation Summary
Licence Application	Information provided on proposed licence amendment and purpose thereof
Abstraction and Use	Acknowledgement of site water balance, with water being sourced from West Canning Basin area, and used recycled at Port Hedland's concentrate handling facility
Hydrogeology	Discussion regarding complexity of aquifer system and the need to monitor and adjust management to address uncertainty. Data presented to show conceptual geology and discuss variance in depth to groundwater
Risk to receptors	Information presented to characterise degree of groundwater dependence against level of understanding of each receptor. Nyamal expressed concern about the water resource as a whole which was acknowledged. Management focus will be on receptors as a degree of impact to the water resource is required to progress dewatering and water supply abstraction.

Topic	Consultation Summary
	Nyamal expressed the need to see the risk to Mundagoora Pool lowered from moderate to low.
Management Options	Presentation on different management options, their respective pros/cons and how monitoring would influence the adaptive management process. Acknowledged that stopping abstraction might not resolve risk straight away, and that a combination of management options may be required. If supplementation takes place, the priority for this use will need to be assessed against water use for mining related needs. Nyamal expressed preference for supplementation to take priority. Discussion regarding the setting of trigger levels and the need to engage Nyamal on agreement for adaptive management measures. For Mundagoora Pool, Nyamal requested telemetry monitoring of nearby bores, with a contingency action in the event of dropping groundwater levels being implemented pool telemetry. IBO outlined they would progress relevant approvals to allow supplementation construction/operation at short notice (pending agreement at the time from Nyamal). Nyamal HSC supported the proposed management recommendations

3. NORTH STAR WATER SOURCE DESCRIPTION

The abstraction of groundwater at North Star is for the following overall purposes:

- Groundwater abstraction for water supply of 2.59 GL/a;
- Pit dewatering of up to 4.5 GL/a. This aligns with the Part IV limit under Ministerial Statement 993; and
- Seepage recovery up to 0.5 GL/a from water management activities across Iron Bridge Mine, which currently include downstream of the TSF, approved under Works Approval W6322/2019/1, and future planned seepage recovery from the "Plug" downstream of the Waste Rock Dump (approved under Mining Proposal 93044). This does not include recovery of water which seeps or decants into a Return Water Pond, as this does not require abstraction regulation under the RIWI Act.

Abstracted groundwater is to be utilised for different usages[1]:

- commissioning of the pipeline and processing plant;
- ore processing;
- tailings deposition;
- dust suppression;
- ongoing construction and maintenance of infrastructure in the region, including workshops and solar/wind farms; and
- camp and office water supply.

The above requirements for groundwater abstraction will be met by abstracting water from fractured rock aquifers in the vicinity of the mine, as shown in Map 1. The fractured rock aquifer system is characterised as fresh and there is no differentiation in terms of water quality in the either the source of water or its utility.

[1] Not all usage categories mentioned were available to select for this application in DWER's Water Online portal. This list should be referenced for compliance purposes.

3.1 Project Development

The location of existing water infrastructure is shown on Map 2. A high-level description of the infrastructure system is provided below. Water infrastructure has been and will be developed to meet the needs of the business, the environment and stakeholders whilst aiming to maintain flexibility in operations.

3.2 Raw Water Supply System (Potable and Process Water)

The water supply system for Stage 2 consists of several bores, completed in fractured rock aquifers with an estimated deliverability of 90 L/s. These bores discharge into a pipeline that delivers the water to turkeys nest dams used for dust suppression and a raw water storage pond associated with the mine process plant. The water is used for dust suppression, and beneficiation of the ore and then recirculated to a process water point or discharged to a tailings storage facility.

One bore (NS-ObS09) exists as a dedicated potable supply to Japal Camp; however the raw water system can be configured to allow additional supply capacity from other bores.

Table 4 details bores equipped and connected to the water supply pipeline. It is anticipated that additional bores may be equipped (or new bores drilled) as required to maintain the required supply, with these bores being connected to the existing pipeline network. Section 7.2 outlines the process for managing changes to the borefield.

Current production bore construction logs are provided in Appendix 1.

Table 4: Equipped Bores used for North Star Stage 2 (as of October 2023)

Bore Name	Easting	Northing	Location	Casing (ID, mm)	Ground RL (m AHD)	Cased Depth (m bgl)	Slotted Interval (m bgl)	SWL (m bgl)	Screened Lithology
NS-PBW08	700162	7648328	Western Borefield	193	232.23	215	54 – 83; 131 - 215	15.28	Shale, chert and sandstone/wacke
NS-EXS03	710677	7644835	Southern Borefield	n/a	272.00	n/a (drilled to 210)	uncased	11.73	Sandstone/wacke and chert
NS-ObsS09	708989	7646707		104.5	268.67	140	26 - 128	7.83	Sandstone/wacke and chert
IB_SB_P01	709470	7644926		274	273.57	199.85	103.85 - 199.85	14.87	Sandstone
IB_SB_P02	708765	7644344		274	259.47	212	32 - 212	9.39	Sandstone/wackie, siltstone and chert
IB_SB_P03	710890	7644617		305	270.434	260.5	30 – 260.5	24	Sandstone
IB_SB_P04	709214	7644854		305	272.89	214.7	41.6 – 214.64	36.1	Chert, quartzite and sandstone
NS-PBS23	709373	7643734		193	256.26	188.5	98.5 - 182.5	5.78	Sandstone/wacke, chert and schist
NS-PBS25	710074	7643535		193	269.15	86	5 - 83	10.45	Schist, chert and sandstone/wacke
NS-PB15	709403	7647283	Northern Borefield	193	268.19	120	12 - 90	3.07	Serpentinite
NS-PB19	709162	7647131		193	267.44	157.4	2 - 157	11.08	Chert, wacke and siltstone
NS-PB31	709501	7647558		193	271.57	101	5 - 83	6.19	Basalt, shale and chert
NS-PB32	709611	7647018		193	270.22	76	10 - 70	6.84	Basalt
NS-PB33	710800	7647246		193	277.71	59	5 - 53	3.97	Basalt and shale
NS-PB02	710143	7654606	TSF Area	193	242.19	105	9 – 99	3.66	Shale and Sandstone

3.3 Environmental Release (Supplementation)

As discussed in Section 7, adaptive management may require the implementation of one or more supplementation systems. If required, these systems will be licensed under an appropriate licence pursuant to Part V and the EP Act, with monitoring of environmental objectives documented within this GWOS.

4. ENVIRONMENT

A detailed description of environment, including climate, geology and hydrogeology has been included within the H3 assessment prepared for the 5C licence application submitted to DWER in August 2023 (Iron Bridge, 2023a). A summary of that information is provided below.

4.1 Climate

The climate of the Pilbara is subtropical dry, characterised by low and variable rainfall, high daily temperatures, high diurnal temperature variability and high evaporation rates. Summer months extend from October to April, when maximum daily temperatures can exceed 35°C. The winter months extend from May to September, with temperatures ranging from approximately 7°C to 23°C.

Average annual rainfall is approximately 318.8 mm, as measured by the Bureau of Meteorology (BoM) at rainfall station Wallareenya (BoM station 004038) and is characterised by frequent, low-intensity events related to localised thunderstorms and highly episodic large cyclonic events concentrated around the summer months (October to March). The large variability in annual rainfall (from 248 to 507 mm) is influenced by the cyclonic events. Average annual (pan) evaporation in the area is greater than 3000 mm per year, which greatly exceeds annual rainfall and consequently contributes to the arid environment.

The long term cumulative deviation from mean rainfall indicates a current wetting cycle in rainfall, which started in in 1990's. A reduction in the rate of change since 2020 may be indicative a change in the cycle.

4.2 Geology

The stratigraphic sequence of the IB area, from oldest to youngest, is as follows:

- Sulphur Springs Group, comprised of:
    - the Leilira Formation (A-SSl-s),
    - the Kunagunarrina Formation (A-SSk-b), and
    - the Kangaroo Caves Formation (A-SSc-xf-s) with the Pincunah Banded-iron Member (A-SScp-ci) occuring at the top of this unit.
- The Corboy Formation of the Gorge Creek Group (A-SOc-s).

Sheetwash deposits composed of silt, sand, and pebbles, are deposited on distal fans with no defined drainage, whilst creeks and other drainage features contain unconsolidated silt, sand, coarse sand, and gravel (Van Kranendonk, 2000).

The bedded geological units are sub-vertical, with oxidation commonly 50 – 70 m from surface, although this could be deeper in some areas. Conceptually, the pit area is sandwiched between what could be described as highly recessive, poorly exposed shales of the Kangaroo Formation to the west, and inter-bedded shales, mudstones, cherts, BIF and quartzite of the Corboy Formation to the east. Structural complexity exists in the form of extensive faulting throughout both the pit area and borefields; particularly within the Southern Borefield.

4.3 Hydrogeology

Several studies have been undertaken in the North Star mine area since 2012, with over 140 bores drilled, 70 hydraulics tests completed, and 370 samples taken across the site.

Groundwater conditions are governed by hydraulic characteristic of the regional stratigraphy, faulting and fracture structure and interplay of topographic-driven weathering and recharge processes. Drainage features are likely to play an important part in recharge, thereby influencing groundwater flow patterns.

4.3.1 Hydrostratigraphy

The main hydrostratigraphic units recognised in Iron Bridge (2023a) are:

Distributed in all areas

- Alluvium

Within the orebody area

- East and West Shale
- Weathered Orebody
- Faulted Orebody
- Fresh Orebody

Regionally, including water supply borefield areas

- Weathered Basement
- Faulted Basement
- Fresh Basement

4.3.2 Aquifer Connectivity

Whilst prospective hydrostratigraphic units are likely to be vertically connected, the presence of lower permeability units (e.g. East and West Shale) and structural features is likely to compartmentalise groundwater flow.

4.3.3 Groundwater recharge and discharge

The main recharge processes to groundwater are infiltration of rainfall associated with cyclonic events and the interaction with intermittent stream flows occurring during the wet season. Areas with shallow groundwater experience a more notable response to rainfall, likely through the interaction with drainage features. On average, recharge is approximately 5% of rainfall, and there is an approximate rainfall threshold of 20 mm before recharge occurs.

Discharge/outflow is primarily via seepage into creek beds and evapotranspiration.

4.3.4 Groundwater Chemistry

Groundwater in the North Star area is fresh to marginal, with TDS ranging from 100 – 3,000 mg/L, and is of a magnesium-bicarbonate type.

4.4 Receptors

Map 3 illustrates the location of receptors identified in Iron Bridge (2023a), summarised below.

4.4.1 Social and Cultural Heritage

The cultural significance of water resources has been recognised in consultation with Nyamal representatives. Water flow, quality, presence and influence on flora and fauna were all considered part of cultural heritage value (Table 5). In the case of Site 12 Pool and Mundagoora Pool, the significance of the site has resulted in these being registered as heritage places.

There is overlap between the cultural and environmental significance of groundwater dependent receptors; specific receptors are outlined within the following sections.

Table 5: Water related heritage values of the Iron Bridge Mine area

Aboriginal Cultural Heritage Values	Water Related Factors for Consideration
Important water sources connection Nyamal people to Country and the activities of their ancestors	Water quality Water flow Water catchment stability
Mythological connection to the surrounding cultural landscape through creeks and tributaries	Water catchment stability Water flow Heritage place integrity
Hunting, fishing and resource collection	Health of flora and fauna Water quality

4.4.2 Stygofauna

There is a high likelihood of the North Star area hosted in intermediate richness of stygofauna species, predominantly in areas of shallow groundwater. Whilst most likely associated with higher transmissivity zones, habitat may also exist in less prospective fractured rock. Three species, Tubificidae 'BOL066', Parabathynellidae sp, and Atopobathynella `BSY214` were identified as being at risk.

4.4.3 Groundwater Dependent Vegetation

Three vegetation community assemblages were identified in the North Star area as being potentially groundwater dependent:

- EvCC (Eucalyptus victrix (Coolibah) +- Eucalyptus camaldulensis (River Red Gum) open mid-woodland over Cenchrus ciliaris tussock grassland)
- EvApTl (Eucalyptus victrix over Acacia pyrifolia over Triodia longiceps); and
- EvAtCc (Eucalyptus victrix mid woodland over Acacia tumida)

In some cases these communities occur in areas of shallow groundwater, although E. victrix and E. camaldulensis are both considered facultative phreatophytes, and may meet their water requirements from the unsaturated zone. Vegetation monitoring to date has not identified any impact from changes to groundwater levels since borefield abstraction commenced.

4.4.4 Pools

A number of pools exist in the North Star mine area, with varying degrees of connection to groundwater. Certainty of pool conceptualisation is also variable, primarily owing to the amount of baseline knowledge available. Plate 1 illustrates the current state of conceptual certainty against degree of groundwater connection for each pool or group of pools.

Iron Bridge (2023a) contains additional information regarding the conceptual hydrogeological setting and risk to each pool.

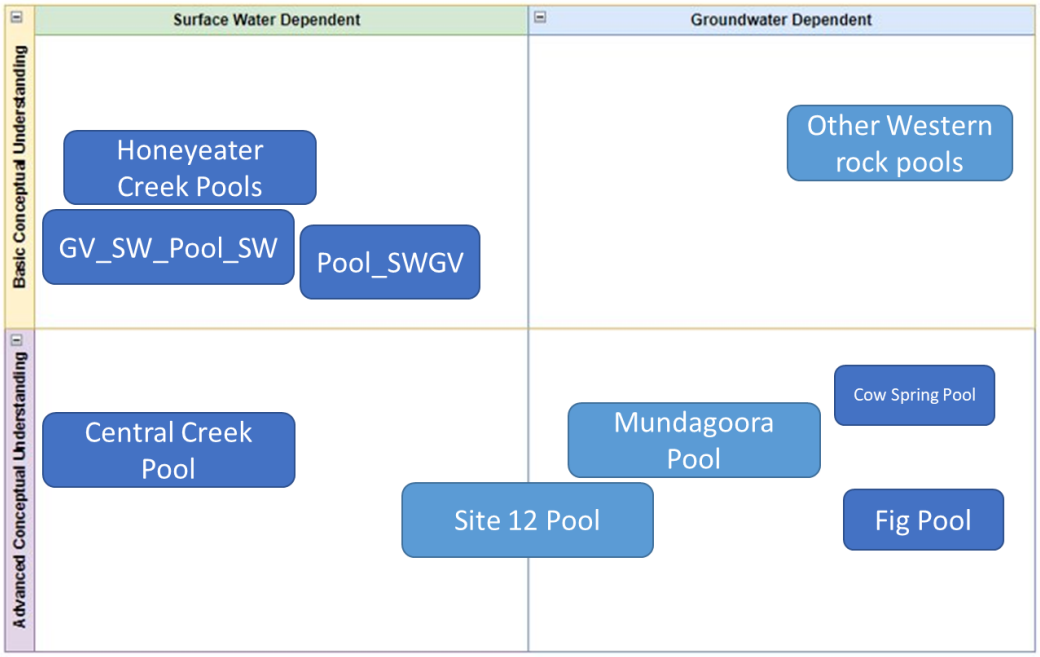

Plate 1: Comparison of pool dependency and degree of conceptual understanding

5. IDENTIFYING POTENTIAL IMPACTS

Groundwater abstraction and other groundwater interactions associated with operations have the potential to adversely impact upon groundwater levels and groundwater quality. The high level of modelling uncertainty lends to a risk-based approach to the identification of impacts. The following summary from the Hydrogeological Assessment (Iron Bridge, 2023a), referencing unmitigated or inherent risks, utilises IBO's risk assessment framework.

5.1 Impacts from Groundwater Level Change

Groundwater level changes, and potential impacts have been assessed for: bore yields; other users; the environment and cultural heritage.

5.1.1 Bore Yields

The risk of a reduction in water supply is being managed by IBO through the implementation of the West Canning Basin borefield, along with groundwater reuse across such in the form of:

- Return water from magnetite concentrate dewatering in Port Hedland;
- Return water from the Tailings Storage Facility, via both a return water pond and seepage capture bores;
- Stormwater harvesting on waste rock dumps.

Additional bores should be considered if appropriate to reduce "per bore" abstraction rates, and manage localised drawdown.

5.1.2 Other Users

No other industrial, pastoral or recreational users were identified within the potential drawdown extent. The uses of Traditional Owners are considered within the "Environment" context below.

5.1.3 Environment and Cultural Heritage

Table 6 below summarises the potential impacts and risks to cultural and environmental receptors from groundwater level changes. Further information on these receptors can be found in Section 11.1.3 of the Hydrogeological Impact Assessment.

Table 6: Summary of potential impacts and inherent risk to environmental groundwater receptors from groundwater level changes (from IB (2023))

Receptor	Sensitivity to Groundwater Level Change	Predicted Range of Drawdown (m)	Predicted Rate of Drawdown (m/yr)	Risk of Impacts (refer to IB (2023a))
Stygofauna	Potentially sensitive. Drawdown will deplete approximately 50% of the habitat (based on volume) within the study area but: • large size of the borefields means they may encompass whole ranges of some species; and • all areas with >2-5 m drawdown should be treated as total loss of habitat. Therefore, greater than 50% of habitat is highly likely to be impacted. Borefield is prospective for stygofauna but unsampled; species richness and extent of occurrence is unknown.	Loss of theoretical habitat volume (declining from 1.6 x 10^9 m^3 to 0.8 x 10^9 m^3); however all areas with >2-5 m drawdown may be unsuitable for stygofauna		Extreme
Western borefield potentially groundwater dependent vegetation	Moderate to low sensitivity. Vegetation community unlikely to be dependent on groundwater, with high resilience to change	0 – 45	0 - 2	High
Southern borefield potentially groundwater vegetation		75 – 95	3.4 - 4.3	High
Mundagoora Pool	Moderate to high sensitivity. Pool is groundwater dependent but also has surface water contribution. Baseline suggests pool is permanent	50 – 62	2.3 - 2.8	Very High
Site 12 Pool	Moderate. Pool is known to dry out and has contribution from surface water. A drop in upstream catchment bore NS-0664 groundwater level beyond 279.25 mAHD is associated with a drop in pool levels (Iron Bridge, 2021).	0 – 6	0 - 0.3	Medium
Fig Pool	High. However, whilst pool is groundwater dependent, pool elevation is above regional groundwater level and considered perched.	9 – 16	0.4 - 0.7	Low
Cow Spring Pool		26 – 34	1.2 - 1.5	Low
Astrid Bee Cave; Craig's Pool; Dingo Lair Pool; Zane's Gorge Pool		various		Low

5.2 Impacts from Groundwater Quality Changes

Field investigations and analysis have not identified any risks to groundwater quality associated with dewatering or water supply abstraction. Management may be required to address the risks of seepage from waste rock dumps and tailings facilities on groundwater (refer to Table 7 below).

Table 7: Summary of potential impacts and inherent risks to groundwater quality (from FMG(2023))

Activity / Source	Potential Risk	Risk of Impacts
Seepage from Tailings Storage Facility	Changes to groundwater quality downstream of TSF.	Low
Seepage from Waste Rock Dump	Changes to groundwater quality in Site 12 pool. WRD may contain PAF material	Medium

6. MANAGEMENT OBJECTIVES

This GOS has been prepared so management of the operation of the North Star Borefield(s) achieves the following objectives:

1. No unauthorised impact to identified environmental groundwater receptors, beyond natural variability;
2. Groundwater quality and level trends are in line with expectation;
3. Successful and safe dewatering of below water table pits; and
4. Water supply abstraction optimised to contribute to overall mine water balance

Table 8 lists the management objectives to address each of these key issues, along with the primary methodologies for each. Section 7 includes full details of these methodologies, as well as contingencies developed to address circumstances where management objectives are initially threatened.

North Star also has management objectives and obligations under other regulatory approvals, which complement the objectives below. A summary of these are included for reference in Table 9.

Table 8: RIWI Act Management Objectives for Operation of North Star Borefield

Objective	Methodology
No unauthorised impact to identified cultural and environmental groundwater receptors, beyond natural variability;	○ Apply adaptive management strategies to manage risks at a low level
Groundwater quality and level trends are in line with expectation;	○ Monitoring of groundwater levels and quality regionally ○ Analysis of results presented in annual and triennial aquifer reviews ○ Continuous improvement of hydrogeological knowledge base
Successful and safe dewatering of below water table pits	○ Complete internal dewatering planning based on mine plan ○ Ongoing tracking of dewatering performance (drawdown vs pit progression)
Optimising groundwater supply to support the water balance	○ Cycling of bore use as required to manage bore yields and drawdown. ○ Maintain ongoing tracking of borefield performance (yield vs drawdown) ○ Operational monitoring and reporting of site water balance (supply and consumption)

Table 9: Non-RIWI Act Management Objectives for Operation of North Star Borefield

Plan Name	Associated Approval / Instrument	Groundwater Related Management Objective(s)	Applicable Methodologies
Iron Bridge vegetation health monitoring and management plan. 662NS-0000-PL-EN-0004.	North Star Stage 2 (Amendment 2) Mining Proposal (Reg ID 93044).	No decline in downstream GDE, riparian vegetation, within the MDE due to project related operations. No decline in vegetation health as a result of TSF2A and RWP operation.	Monitoring of vegetation health, with trigger and threshold criteria, response actions and reporting.
Site 12 Pool Water Quality and Quantity Monitoring Plan. 662MI-5700-PL-WM-0001.	Condition 12 of MS 993.	Ensure implementation of the proposal within the catchment of Site 12 Pool that is located within the MDE does not have a detrimental impact on the water quality or hydrological regime of Site 12 Pool.	Monitoring of pool and groundwater water level/quality and pool ecological criteria. Tiered trigger criteria, response actions and reporting.
Tailings Storage Facility Monitoring Procedure , 662NS-0000-PR-EN-0020.	Condition 19 of Part V Licence L8845/2014/1, amendment 29/08/2023.	Management of TSF seepage water quality.	Monitoring and reporting commitments, including assessment of data against water quality threshold values.
Social Cultural Heritage Management Plan. NS-0000-PL-HE-0001.	Commitment made as part of Section 38 submission associated with MS993.	Maintain hydrological regimes including quality, and quantity of culturally significant water sources within and surrounding the North Star Extension MDE. Maintain ecological health of culturally significant water sources within and surrounding the North Star Extension MDE to the extent that existing and potential uses, and reliant ecosystems are protected.	Implement Groundwater Operating Strategy, Site 12 Pool Water Quality and Quantity Monitoring Plan and Iron Bridge Vegetation Health Monitoring and Management Plan.

7. MANAGEMENT METHODOLOGIES

The proposed management methodologies, particularly for managing risks to environmental receptors, largely align with the principle of adaptive management, outlined in

Plate 2.

Plate 2: Adaptive Management Framework in the Context of Iron Bridge Groundwater Management

The details of how this framework is applied is addressed in the following sections.

7.1 Adaptive Management Strategies

Whilst adaptive management by its very nature should be based on evaluation of monitoring data, IBO recognises the need to outline strategies that will be considered for implementation in the event of a receptor risk scenario being realised.

Table 10 provides a summary of the *potentially relevant* adaptive management strategies that might be considered as part of an action to meet environmental objectives. Table 11 demonstrates how these strategies may be applied to specific receptors, and the residual risk once implemented. Where the residual risk is not “Low”, further actions have been outlined which IBO will be required to complete. For further detail on the framework for this risk assessment, refer to Appendix 10 of Iron Bridge (2023a).

Table 10: Summary of adaptive management strategies that may be applicable as specific adaptive actions in response to a trigger level exceedance.

Strategy	Objective	Description
Direct Supplementation – surface	Manage soil moisture. Manage groundwater levels.	Adding water directly at surface at one or more locations, from a raw water source of similar quality. Water is distributed to the area via a pipeline (size depends on amount of water required) and flows out of an open end (called a spigot). This method delivers water quickly on surface to a specific location, which can include a creek or a pool. The movement of this water downstream depends on the creek environment. More water lost to evaporation.
Direct Supplementation – buried	Manage groundwater levels	Adding water via buried slotted pipe into the ground. A trench will be dug, and the slotted pipe will be buried into this trench. Water will be distributed via a pipeline (size depends on amount of water required) and allowed to flow into the aquifer from the slots in the buried pipe. Water will be sourced from a raw water source of similar quality. This method delivers water to the shallow subsurface across a longer, narrow area. It requires more ground disturbance but can better mimic naturally high groundwater levels without excessive ponding of water. Evaporation is also reduced.
Groundwater Injection	Manage groundwater levels.	Adding water, from a raw water source of similar quality, via one or more injection bores. Injection bores are usually 8 – 14” holes in the ground, drilled into the aquifer that needs supplementation and cased with PVC. Water will be distributed to the bore(s) via a pipeline (size depends on amount of water required) and allowed to flow into the aquifer from the slots in PVC casing. This method is most appropriate where supplementation is required for deeper aquifers that cannot be supplemented from surface or via a trench. It can also be managed to prevent water levels from rising to surface.
Alternation or reduction in abstraction (discrete bores)	Remove abstraction stress. Allow existing management to better/faster recover groundwater levels	This method is best used where unexpected drawdown (most likely associated with a structural connection) requires immediate mitigation. It can be targeted to specific bores; usually those closest to the receptor, or where a bore or bores is structurally connected to the receptor. Reduction in abstraction is best used in conjunction with methods above where the recovery of already propagated drawdown is likely to take time.
Implement additional studies	Improve understanding of receptor’s link to groundwater activities.	Additional surveys, field tests, monitoring and analysis may be required to better inform understanding of: the receptor; the risk to the receptor; and the most appropriate trigger level or adaptive management action.

Table 11: Groundwater Management Options for Consideration to Achieve Groundwater Receptor Management Objective

Receptor	Risk Scenario	Adaptive Management Strategy Options (refer to Section 7.5)	Residual Risk	Further Actions
Stygofauna	Groundwater drawdown from water supply or dewatering reduces available habitat and/or connectivity for Stygofauna species, particularly those within limited known range, but also in areas without survey where species assemblage is unknown	a. Undertake additional regional surveys to better understand species occurrence; and b. Adopt adaptive management, with strategies as follows: bi. Alteration of abstraction regime from nearest bores bii. Groundwater injection to mitigate localised drawdown and increase groundwater availability biii. Reduced or ceased abstraction from borefield	Medium	• Commit to additional surveys to better understand stygofauna throughout borefield drawdown extent • Update impact assessment and GWOS with uplifted stygofauna study outcomes
Groundwater Dependent Vegetation (both Southern and Western Borefields)	Groundwater abstraction from near mine water supply borefield reduces groundwater availability for mapped GDE or pGDE	a. Alteration of abstraction regime from nearest bores b. Direct supplementation to creekline to increase soil moisture availability c. Groundwater injection to mitigate localised drawdown and increase groundwater availability d. Reduced or ceased abstraction from borefield	Low	• Progress approvals to allow supplementation to creekline so that this can commence if required, with minimal delay.
Mundagoora Pool	Groundwater abstraction from Water Supply or Dewatering reduces water levels below baseline.	a. Alteration of abstraction regime from nearest bores b. Direct supplementation to pool c. Groundwater injection to mitigate localised drawdown d. Reduced or ceased abstraction from borefield	Medium	• Further analysis of baseline water levels from pool and bores. • Investigate potential for structural geology assessment of the pool's setting, supported by non-destructive geophysical surveys • Progress approvals to allow for supplementation infrastructure to be constructed if required, with no further delay

Receptor	Risk Scenario	Adaptive Management Strategy Options (refer to Section 7.5)	Residual Risk	Further Actions
Fig Pool and Cow Springs	Groundwater abstraction from Water Supply or Dewatering dries out pools.	a. Alteration of abstraction regime from nearest bores b. Direct supplementation to pool c. Reduced or ceased abstraction from borefield	Low	• Progress approvals to allow for supplementation infrastructure to be constructed if required, with no further delay.
Astrid Bee Cave; Craig's Pool; Dingo Lair Pool; Zane's Gorge Pool	Groundwater abstraction from Water Supply dries out pools.	a. Alteration of abstraction regime from nearest bores b. Direct supplementation to pool	Low	• If analysis of Cow Springs Pool indicates an impact, commence investigation of these pools
All ephemeral pools identified as surface water dependent in Hydrobiology (2023)	Groundwater abstraction from Water Supply or Dewatering reduces water levels below baseline.	No immediate adaptive strategy required; update plan if pool data indicates groundwater dependency	Low	• Further analysis of baseline water levels from pools. • If warranted by above, consider whether monitoring bores are necessary to establish groundwater triggers in the vicinity of the pool (a bore is already planned for Honeyeater Creek and Pool_SWGV)
Site 12 Pool	Groundwater abstraction from Dewatering leads to long term drying of pool (beyond the period of drying observed in baseline).	a. Alteration of abstraction regime from nearest dewatering bores b. Direct supplementation to pool c. Groundwater injection to mitigate localised drawdown d. Reduced or ceased abstraction from dewatering borefield	Low	• Progress approvals to allow for supplementation infrastructure to be constructed if required, with no further delay.

7.2 Operating Rules

The Hydrogeological Assessment (Iron Bridge, 2023a) identified that drawdown is constrained by low permeability geology and that bore location within a given borefield is not the primary determinant of drawdown extent and receptor risk. This has implications for operating rules as follows:

(i) There is currently no justification for setting a borefield operating protocol with flow rate limits on individual bores. Instead of prescribed abstraction limits, the adaptive management strategy will include the option to reduce individual bore flow rates if and when trigger exceedances indicate a need to do so.

(ii) The addition of new bores is unlikely to change the risk profile and management requirements, and the following approach will therefore be implemented when considering changes to the borefield:

- For any proposed bores, an internal assessment will be undertaken which considers whether operation of the bores alters the risk of impacts to receptors and requires alternative management strategies to manage this risk. If not, then no prior approval (beyond a 26D) will be sought from DWER. . Any new bores drilled will have their construction logs submitted as part of the Form 2 statutory reporting obligation, and included in future revisions of this GWOS.
- If new bores have the potential to alter receptor risk and require changes to approved management, then IBO will submit an amended GWOS for approval by DWER prior to operation of the bore.

The tracking of bores will be reported during the Annual Aquifer Review (AAR) and Triennial Aquifer Review (TAR) requirements. Any additional dewatering and abstraction bores, as well as amendments to existing bores will be documented in line with the standard *RIWI Act Section 26D Licence to Construct or Alter a Well* and *Form 2* reporting requirements.

7.3 Monitoring

Groundwater monitoring and reporting requirements detailed in the following sections relate primarily to the conditions of the Iron Bridge 5C licence governed under the RIWI Act. For completeness, monitoring and reporting requirements stemming from other instruments and addressed in other management plans (Table 9 in Section 6) are also summarised in this document. Revisions to these documents may occur independently to this GWOS; therefore the details herein are *valid only at the date of publication of the GWOS.*

Map 4 illustrates the combined monitoring commitments relevant to groundwater management at North Star Mine.

7.3.1 Groundwater Monitoring

Groundwater monitoring is completed by competent field technicians and groundwater sampling is undertaken in accordance with the Iron Bridge Groundwater Sampling Procedure (NS-03018-PR-WM-0001).

Locations of the groundwater monitoring schedule, and relevant bores regulated under the RIWI Act are provided in Table 12 and Table 13 respectively. Additional groundwater monitoring is also stipulated within the Site 12 Pool Water Quality Monitoring and Management Plan (Table 14 and Table 15). Information from the Site 12 Pool Plan is provided for reference only, the Plan will remain the source of compliance requirements.

Monitoring bore construction logs are provided in Appendix 2.

Table 12: Groundwater Operating Strategy Monitoring Schedule

Frequency	Monitoring parameter	Comments	Monitoring locations
Abstraction bores			
Monthly	Volumes	Via bore meter data	Active production bores only
	Groundwater Level	Measured using a field groundwater probe. Pumping water levels to be clearly identified as such	
Monitoring bores			
Monthly	Groundwater level	For drawdown assessments and ongoing hydrogeological assessment. Measured using a field groundwater probe or extracted from groundwater logger data.	**Table 13**
	Field electrical conductivity	Salinity is measured using a field electrical conductivity (EC) measurement probe that is lowered to a designated depth within the screen interval. The designated level is nominally set at the mid-point of the screened interval.	
Annually	Chemical analysis	• Major ions (Na, K, Ca, Mg, Cl, HCO_3, CO_3,, SO_4 and NO_3), • Metals (Al, B, Fe, Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Sn, Mn), • Electrical conductivity, pH • Total dissolved solids and Total suspended solids.	

Table 13: Groundwater Operating Strategy Monitoring Bore Locations

Monitoring Location	Type	Easting	Northing	Target Receptor
NS-ObsW04b	Trigger Monitoring Bore	696930	7649727	GDE
NS-ObsW03	Monitoring bore	700635	7648149	n/a
NS-ObsW01	Trigger Monitoring Bore	704190	7647032	GDE
NS-ObsW01a	Trigger Monitoring Bore	706103	7647616	GDE
NS-EXS26	Monitoring bore	710025	7643322	n/a
NS-ObsS29	Monitoring bore	709177	7643340	n/a
NS-ObsS18	Monitoring bore	709726	7644741	n/a
NS-ObsS28	Monitoring bore	710892	7644633	n/a
NS-Obs17	Monitoring bore	709795	7647257	n/a
NS-Obs13	Trigger Monitoring Bore	708612	7655220	GDE
NS-Obs19	Monitoring bore	709165	7647117	n/a
NS-ObsS10	Monitoring bore	708817	7646653	n/a
NS-Obs29	Monitoring bore	712100	7650421	n/a
NS-PB02	Monitoring bore	710143	7654606	n/a
NS-EXS23	Trigger Monitoring Bore	709377	7643734	GDE
IB_MP_M01	Trigger Monitoring Bore	712846	7645936	Mundagoora Pool
IB_MP_M02	Trigger Monitoring Bore	712143	7645669	Mundagoora Pool
IB_RWP_MB1	Seepage Monitoring Bore	710534	7654522	Downstream of TSF
IB_RWP_MB2	Seepage Monitoring Bore	710512	7654459	Downstream of TSF

Monitoring Location	Type	Easting	Northing	Target Receptor
IB_RWP_MB3	Seepage Monitoring Bore	710479	7654455	Downstream of TSF
IB_RWP_MB4	Seepage Monitoring Bore	710453	7654460	Downstream of TSF
IB_RWP_MB5	Seepage Monitoring Bore	710399	7654347	Downstream of TSF
IB_RWP_MB6	Seepage Monitoring Bore	710361	7654339	Downstream of TSF
IB_WRD_M03	Seepage Monitoring Bore	715171	7649098	Waste Rock Dump “Plug”
IB_WRD_M04	Seepage Monitoring Bore	715177	7649257	Waste Rock Dump “Plug”
IB_WRD_M05	Seepage Monitoring Bore	715184	7649325	Waste Rock Dump “Plug”
IB_WRD_M06	Seepage Monitoring Bore	715222	7649376	Waste Rock Dump “Plug”

Table 14: Site 12 Pool Water Quality and Quantity Monitoring Plan Groundwater Monitoring Schedule (from Iron Bridge (2021), valid as of 21/08/2023)

Frequency	Monitoring parameter	Comments	Monitoring locations
Monthly	Groundwater level	Automatic logger 3h	NS-0664
	Field water quality	Dissolved oxygen, pH, Electrical Conductivity, Turbidity, Temperature	
Annually	Chemical analysis	• Major ions (Total alkalinity, total acidity, Hardness, Na, K, Ca, Mg, Cl, F, HCO_3, CO_3,, SO_4 and NO_3), • Metals (Al, B, Ba, Be, Co, Fe, Cu, Zn, As, Cr, Pb, Cd, Hg, Ni, Se, V, Mn), • Electrical conductivity, pH • Total dissolved solids, Total suspended solids, Total Organic Carbon, Dissolved Organic Carbon.	

Table 15: Site 12 Pool Water Quality and Quantity Monitoring Plan Bore Location (from Iron Bridge (2021), valid as of 21/08/2023)

Monitoring Location	Type	Easting	Northing	Target Receptor
NS-0664	Trigger Monitoring Bore	715502	7649266	Site 12 Pool

7.3.2 Pool Monitoring

Monitoring of pool water levels is an important component of the risk mitigation proposed under the adaptive groundwater management strategy. Relevant pool monitoring is stipulated within the Site 12 Pool Water Quality Monitoring and Management Plan (Table 16 and Table 17) and also the Iron Bridge Project Surface Water Management Plan, NS-00000-PL-EN-0001 (Iron Bridge, 2023c) (Table 18 and Table 19 below). Water quality and ecological monitoring parameters specified under NS-0000-PL-EN-0001 are summarised in Table 20 and Table 21. Note that this information is provided for reference only; the source plans will remain the relevant source of compliance requirements.

No additional pool monitoring is proposed directly under the GWOS.

Table 16: Site 12 Pool Water Quality and Quantity Monitoring Plan Pool Monitoring Schedule (from Iron Bridge (2021), valid as of 21/08/2023)

Frequency	Monitoring parameter	Comments	Monitoring locations
Monthly	Pool water level	Automatic logger 3h	NS-0664
Monthly from Nov to Apr, Quarterly from May to Oct, and/or event based	Field electrical conductivity	Dissolved oxygen, pH, Electrical Conductivity, Turbidity, Temperature	
Monthly from Nov to Apr, Quarterly from May to Oct, and/or event based	Chemical analysis	• Major ions (Total alkalinity, total acidity, Hardness, Na, K, Ca, Mg, Cl, F, HCO_3, CO_3,, SO_4 and NO_3), • Metals (Al, B, Ba, Be, Co, Fe, Cu, Zn, As, Cr, Pb, Cd, Hg, Ni, Se, V, Mn), • Electrical conductivity, pH • Total dissolved solids, Total suspended solids, Total Organic Carbon, Dissolved Organic Carbon.	

Table 17: Site 12 Pool Water Quality and Quantity Monitoring Plan Pool Monitoring Location (from Iron Bridge (2021), valid as of 21/08/2023)

Monitoring Location	Type	Easting	Northing	Target Receptor
IB_SW_Pool12_01	Pool	715794	7649302	Site 12 Pool

Table 18: Surface Water Management Plan Pool Monitoring Schedule (adapted from Iron Bridge (2023c), valid as of 21/08/2023)

Frequency	Monitoring parameter	Comments	Monitoring locations
3 Hourly	Groundwater level	Automatic water level logging	IB_SW_Pool_Fig IB_SW_Pool_Cow_Spring GV_SW_Pool_Mundagoora_SS GV_SW_Pool_SW GV_SW_Pool_NJA21-006_DS
Monthly from November to April, Quarterly from May to October, and/or event based.	Physicals, Nutrients, Ions, Metals Suite (refer to Table 20)	Field water quality and chemical analysis (grab sample)	IB_SW_Pool_Fig IB_SW_Pool_Cow_Spring
Biannual and/or Event-Based	Physicals, Nutrients, Ions, Metals Suite (refer to Table 20)	Field water quality and chemical analysis (grab sample) *These sites require helicopter access, hence less frequent sampling*	GV_SW_Pool_Mundagoora_SS GV_SW_Pool_SW GV_SW_Pool_NJA21-006_DS
Biannual	Ecosystem health (refer to Table 21)	Visual inspection Fauna traps Grab water samples	IB_SW_Pool12_01 IB_SW_Pool_Fig IB_SW_Pool_Cow_Spring GV_SW_Pool_Mundagoora_SS GV_SW_Pool_SW GV_SW_Pool_NJA21-006_DS

Table 19: Pool Water Quality and Quantity Monitoring Schedule at North Star (from Iron Bridge (2023c), valid as of 21/08/2023)

Monitoring Location	Type	Easting	Northing	Target Receptor
IB_SW_Pool_Fig	Pool Monitoring	711676	7650629	Fig Pool
IB_SW_Pool_Cow_Spring	Pool Monitoring	711100	7648583	Cow Spring Pool
GV_SW_Pool_Mundagoora_SS	Pool Monitoring	712554	7645679	Mundagoora Pool
GV_SW_Pool_SW	Pool Monitoring	712588	7643393	Pool_SWGV
GV_SW_Pool_NJA21-006_DS	Pool Monitoring	720043	7644906	Honeyeater Creek Pool
IB_SW_Pool12_01	Pool	715794	7649302	Site 12 Pool

Table 20: Pool Water quality parameters (from Iron Bridge (2023c), valid as of 21/08/2023)

Parameter Class	Monitoring Parameter
Physical chemical	pH, Temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity, Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC)
Nutrients	Total Nitrogen, Total Phosphorus, Ammonia/Ammonium, Total Kjeldahl Nitrogen: TKN, Nitrate+Nitrite (NOx as N)
Ions – Major anions	Total Alkalinity, Chloride, Fluoride, Sulphate, Bicarbonate/Carbonate
Ions – Major cations	Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), Total Acidity as CaCO3, Hardness
Metals suite –Dissolved	Al, As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V
Metals suite – Total	Cu, Hg, Zn

Table 21: Pool ecological health parameters (from Iron Bridge (2023c), valid as of 21/08/2023)

Indicator	Monitoring Parameter	Collection Method
Diatom community	DSIAR scores and diversity	Diatom plates (periphytometers)
Aquatic macroinvertebrate community	EPT abundance index	Sweep nets
Fish community	Presence/absence Size structure	Fyke nets
Sediment quality	Total Alkalinity, Total Acidity, SO4, Nutrients (nitrite, nitrate, phosphate), Ions (Cl, F, Ca, Mg, Na, K), total metals (As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V), TOC	Sediment sampling
Habitat assessment	Wider habitat health	Visual inspection of habitat Quality / health record on habitat sheet Visual inspection of habitat
Macrophyte diversity	Presence/absence	Habitat sheet

7.3.3 Vegetation Monitoring

Vegetation monitoring is undertaken on riparian vegetation at risk of health decline from implementation of the North Star Mine activities. Monitoring is documented within 662NS-0000-PL-EN-0004, with key aspects summarised in Table 22 and Table 23. Note that groundwater monitoring is specified within 662NS-0000-PL-EN-0004; however this monitoring has been explicitly included within the GWOS and is outlined in Table 12 and Table 13.

Table 22: Vegetation monitoring details from 662NS-0000-PL-EN-0004 with relevance to groundwater management at North Star

Frequency	Monitoring parameter	Comments	Monitoring locations
Annual	Leaf water potential	Leaf shoots are collected pre-dawn and midday from mid-canopy to be tested for water potential using a pressure chamber	Riparian vegetation of significant surface water pools (refer Map 4)
	Condition and health	Visual assessment of condition and health NDVI analysis	
	Condition and health	Visual assessment of condition and health NDVI analysis	Riparian vegetation (inclusive of GDV) downstream of the Waste Rock Dump (WRD2), Tailings Storage Facility 2A (TSF 2A) and all processing infrastructure (refer Map 4)

7.3.4 Water Infrastructure Monitoring

Flow meters and pressure gauges are located at key locations on transfer pipelines and storage ponds to allow IBO to undertake water balance calculations and checks. The location and validity of these locations is constantly being reviewed with development and expansion of the water infrastructure system to ensure water movement can be quantified. Flow meters located throughout the water delivery and distribution network are installed in accordance with the DoW *Guidelines for Water Meter Installation* (DoW, 2009). IBO has sought an exemption to s41E of the Rights in Water and Irrigation Regulations 2000 as outlined in Section 1.3.

Leak detection

Leak detection is undertaken via regular visual inspections of pipework, ponds and fittings. Comparison of meter readings at various points between abstraction and consumption points are used to identify losses from the system. If leaks are detected, the location is isolated and repaired.

Maintenance schedule

Valves are regularly installed along bulk lines to allow for isolation of sections should damage occur, or for maintenance activities. Each abstraction bore has the ability to be isolated from the system in order for repairs and maintenance works to be carried out at discrete locations. The maintenance schedule is as follows:

- all water storage facilities and water conveyance infrastructure are inspected daily by the maintenance personnel, checking for water leaks, controls and condition of containment dams. Problems are rectified as they arise; and
- flow meters on all bores are tested for accuracy and calibrated by in-situ validation, twice a year or as per manufacturer specifications.

7.4 Evaluation

Section 1.3.2 outlines the administrative requirements associated with annual statutory reporting. In addition to this, IBO identifies the need for data management, QA/QC, and evaluation to inform ongoing adaptive management.

7.4.1 Data Management

Compliance and operational monitoring data will be uploaded onto IBO's Data Management System. Alerts will be configured to assist with:

(iii) Scheduling of in scheduled monitoring

(iv) Potential QA/QC issues

(v) Identification of trigger level exceedances

7.4.2 QA/QC

IBO adopt Fortescue's *Groundwater Monitoring Procedure* (100-PR-EN-1065) to manage the safety protocols, collection, quality control and data review for groundwater samples collected in

the field. Additional quality control / assurance checks are conducted as part of the annual reporting process.

7.4.3 Data Evaluation

The evaluation of collected data is undertaken at scheduled and ad-hoc intervals in order to:

(i) Develop hydrogeological knowledge through reviewing borefield and aquifer performance to iteratively update conceptual understanding of mine hydrodynamics and calibrate groundwater models (and associated predictions);

(ii) Assist operational planning by reviewing borefield operation, performance and water levels along with water demand profiles; and

(iii) Comply with statutory and corporate reporting requirements, including the compilation of approval submissions, such as Mining Proposals.

7.5 Trigger Levels and Adaptive Management Actions

IBO recognises the need to establish an appropriate system to alert the operation to changes in groundwater conditions that have the potential to result in a breach of the environmental management objectives.

As outlined in Section 6, management of some groundwater related receptors already exists in plans under other regulatory instruments. IBO has therefore developed a trigger level framework for the GWOS that takes into consideration where risks are not already managed elsewhere. These trigger levels are linked to adaptive management actions (also referred to as contingency actions) to mitigate the observed changes in groundwater conditions.

- Tier 1 (Early Warning Criteria): Considered an early warning and catalyst for further detailed engagement with Nyamal on adaptive management. Outcomes of engagement reportable to DWER in the form of an updated GWOS.
- Tier 2 (Trigger): Trigger for implementation of the adaptive management strategy agreed to with Nyamal. Reportable to DWER
- Tier 3 (Threshold): Probable failure of management objective and adaptive management strategy. Reportable to DWER.

For the three remaining objectives, the dewatering of pits and optimisation of the water balance are considered operational in nature and not related to environmental management. Contingency options are outlined below; however no compliance trigger levels are proposed.

7.5.1 Triggers and Actions for Receptor Impacts

In comparison to the previous GWOS, receptor specific trigger levels have been developed using, where possible, metrics directly associated with the receptor itself. There is also a greater integration with other existing management plans to avoid dual management and compliance regulation. As a result, groundwater level triggers for Site 12 Pool and potentially groundwater dependent vegetation will be focussed on a tier 1 leading indicator approach only, as both the Site 12 Pool WQQMP and the VHMMP contain trigger based on pool and vegetation health metrics respectively, that guide further investigation and corrective actions.

Appendix 3 contains the technical analysis used in deriving the groundwater and pool trigger levels outlined in Table 23. Table 23 outlines further detail on the timing of response actions committed to in Table 23.

The associated distribution of trigger monitoring bores is illustrated in the context of overall monitoring in Map 4

Table 23: Trigger level framework to achieve management objective of no unauthorised impact to environmental groundwater receptors

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
Mundagoora Pool	Groundwater level at IB_MP_M01	This is a tier 1 only leading indicator for the pool. Water level decline may be indicative of drawdown abstraction	290.00	Nyamal notified. Confirm approval from Nyamal for telemetered monitoring of Pool. Development of designs for further contingency actions (from the receptor specific list provided in Table 11) in the event of pool trigger level breach. Update GWOS if required.	n/a	n/a	n/a	n/a
	Groundwater level at IB_MP_M02		277.50		n/a	n/a	n/a	n/a
	Pool water measurement at GV_SW_Pool_Mundagoora_SS	Water level decline indicative of potential	288.66	Nyamal notified. Investigate causes and develop designs	287.88	Nyamal and DWER notified. Implement adaptive management	287.00	Nyamal and DWER notified. Implement adaptive management

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
		drawdown from water supply or dewatering abstraction		for further contingency actions (from the receptor specific list provided in Table 11) in the event of pool tier 2 or 3 trigger level breach. Update GWOS if required		strategy of: - Altered abstraction regime from nearest bores		strategy of at least one of: - Direct supplementation to pool - Groundwater injection to mitigate localised drawdown - Reduced or ceased abstraction from borefield Seek input from DWER on further actions required
Fig Pool	Pool water measurement at IB_SW_Pool_Fig	Water level decline indicative of loss	302.85	Nyamal notified. Investigate causes and	302.62	Nyamal and DWER notified. Implement adaptive	302.19 [2]	Nyamal and DWER notified. Implement adaptive

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
		of permanent water source		develop designs for further contingency actions (from the receptor specific list provided in Table 11) in the event of pool tier 2 or 3 trigger level breach. Update GWOS if required		management strategy of: - Altered abstraction regime from nearest bores		management strategy of at least one of: - Direct supplementation to pool - Reduced or ceased abstraction from borefield Seek input from DWER on further actions required
Cow Springs Pool	Pool water measurement at IB_SW_Pool_Cow_Spring	Water level decline indicative of loss of permanent water source	296.23	Nyamal notified. Investigate causes and develop designs for further contingency actions (from the receptor specific	295.97	Nyamal and DWER notified. Implement adaptive management strategy of: - Altered abstraction	295.37 [2]	Nyamal and DWER notified. Implement adaptive management strategy of at least one of:

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
				list provided in Table 11) in the event of pool tier 2 or 3 trigger level breach. Update GWOS if required		regime from nearest bores		- Direct supplementation to pool - Reduced or ceased abstraction from borefield Seek input from DWER on further actions required
Site 12 Pool	Groundwater level at NS-0664	A value of 0.5 m below lowest baseline level has been adopted as an early-warning criteria. This will act in conjunction with the other ecological performance	282.20	Nyamal notified. Investigate causes and develop designs for further contingency actions (from the receptor specific list provided in Table 11) if groundwater level change is	n/a	n/a	n/a	n/a

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
		criteria documented in Iron Bridge (2021).		found to be a) caused by groundwater abstraction and b) impacting performance criteria specified in the Site 12 Pool Recovery Plan. Update Site 12 Pool Recovery Plan and GWOS if required				
Southern Borefield pGDE	As part of the IB VHMMP, groundwater levels are a secondary parameter to support analysis of primary vegetation metrics (Leaf water potential, condition and health). The plan adopts a 2-tier trigger and threshold approach as follows (valid as at 26/10/2023) Trigger Criteria: A statistically significant difference in primary parameter trends detected between impact sites and baseline monitoring values over two consecutive monitoring events. Threshold Criteria: A statistically significant difference in the primary parameter trends between impact sites and baseline monitoring values AND The decline is detected over four consecutive monitoring events and is associated with a decline in vegetation health in comparison to the reference sites AND Subsequent investigations determine that the impacts are likely a result of the implementation of the project.							
Western Borefield pGDE								

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
	If a threshold criteria is reached, one of the relevant contingency actions is to "review management measures with an adaptive management response". This may include a revision to this GWOS to include groundwater-based continency actions such as those listed in Table 10. Consultation with Nyamal will take place to support this change to the GWOS, which will be submitted to DWER.							
Stygofauna (Atopobathynella 'BSY214' & Parabathynellidae sp) [1]	Groundwater level at NS-Obs14	Water level decline leading to a reduction in habitat	265.41 (20% habitat reduction)	Investigate causes and develop designs for further contingency actions (from the receptor specific list provided in Table 11) if groundwater level change is found to be caused by abstraction activity. Update GWOS if required	262.41 (50% habitat reduction)	DWER notified. Implement adaptive management strategy of: - Altered abstraction regime from nearest bores	259.41 (80% habitat reduction)	DWER notified. Implement adaptive management strategy of at least one of: - Groundwater injection to mitigate localised drawdown and increase groundwater availability - Reduced or ceased abstraction from borefield
Stygofauna (Tubificidae 'BOL066') [1]	Groundwater level at IB_GVS_M01		368.81 (20% habitat reduction)		365.81 (50% habitat reduction)		362.81 (80% habitat reduction)	

Receptor	Measurement	Trigger Description	Tier 1 Level (m AHD)	Tier 1 Response	Tier 2 Level (m AHD)	Tier 2 Response	Tier 3 Level (m AHD)	Tier 3 Response
								Seek input from DWER on further actions required.

1 Listed species may be reviewed as additional surveys are completed.

2 A modified trigger level from that proposed in Appendix 3 has been requested by DWER. This level reflects a threshold criteria of 0.45 m of remaining depth of water in the pool.

Table 24: Timing associated with response actions

Action	Timing
Tier 1 Notification to Nyamal	Submit email or written notification to Nyamal representative body (NAC) within 28 elapsed days of trigger exceedance being identified.
Tier 1 Investigation	Investigation to be completed within 6 months of the breach being identified.
Development of detailed adaptive management actions	Adaptive management actions, including consultation to be completed within 12 months of the breach being identified.
Update GWOS	GWOS to be updated and submitted within 13 months of the breach being identified.
Tier 2 Notification to Nyamal	Comply with notification process outlined in the Heritage Incident Procedure (100-PR-HE-0020). Submit email or written notification to Nyamal representative body (NAC) within 28 elapsed days of the breach being identified.
Tier 2 Notification to DWER	Submit email or written notification to DWER within 28 elapsed days of the breach being identified.
Tier 3 Notification to Nyamal and DWER	Comply with notification process outlined in the Heritage Incident Procedure (100-PR-HE-0020). Submit email or written notification to NAC and DWER within 7 elapsed days of the breach being identified.

7.5.2 Triggers and Actions for Unexpected Groundwater Response

The primary trigger for acknowledging an unexpected groundwater response is the detailed analysis undertaken in annual reporting. Should an expected response be noted in the analysis, recommendations will be made for further investigations and / or remediation actions. These will be communicated to DWER within the annual report.

7.5.3 Triggers and Actions for Successful and Safe Dewatering

IBO will carry out dewatering plan revisions as per confidential business processes. In the event that dewatering is not proceeding to plan, IBO will consider:

- Additional investigations associated with elevated pore pressure or groundwater inflow to the pit;

- Provision for increased or targeted abstraction where pore pressure of groundwater inflow warrants; and
- Alteration to pit progression and/or pit design

Should any of the above result in changes to the groundwater related receptor risk profile or management requirements, an assessment will be completed and communicated to DWER for advice.

7.5.4 Triggers and Actions for Water Supply Optimisation

Similar to dewatering, the trigger for any contingencies associated with a deficit of water will be through operational and strategic monitoring, reporting and assessments conducted by IBO. In the event of an immediate or forecast deficit of water for the mine water balance, IBO will consider:

- An increase in abstraction from dewatering or water supply borefields if possible whilst meeting environmental objectives and maintaining compliance with this GWOS;
- Reduced demand through increased water efficiency and water recovery on site (refer to Section 8);
- Increasing supply from existing (e.g. West Canning Basin) or new external water supply sources; and/or
- Reduced demand from limiting operations.

Should any of the above result in changes to the groundwater related receptor risk profile or management requirements, an assessment will be completed and communicated to DWER for advice.

7.6 Plan Revision

The GWOS will be reviewed and updated as required. Updates will be carried out in accordance with the guidance provided in the DWER's Operational policy 5.08 – Use of Operating Strategies in the Water Licensing Process (DoW, 2011). Reasons for updating the GWOS may include the following;

- Amendments to licence conditions or water entitlement
- Significant changes to the project or water abstraction rate; or
- Monitoring indicates that the operation is having unintended impacts on the aquifer.

Updates to Management Plans associated with other legislation/approvals will be completed in accordance with the conditions of that legislation/approvals.

8. WATER USE EFFICIENCY MEASURES

A number of measures may be utilised to reduce the demand on fresh water; some are already deployed whilst other may be investigated for future adoption (Table 25)

Table 25: Water Use Efficiency, active and under consideration

Active	Under Consideration
Use of non-toxic, biodegradable dust suppression additives on roads	Extended use of dust suppression additives to other areas (dry rejects / stockpiles)
Process water recycling within the OPF and also at Port Hedland (concentrate handling facility)	Utilising lower-quality water (including treated wastewater) for dust suppression and other mine-site purposes
Management of water return from tailings storage facility	Capture and return of stormwater runoff to the process water system
Implement camp water efficiency measures (e.g. shower heads and low-flow taps)	

9. SUMMARY OF COMMITMENTS AND RESPONSIBILITIES

Table 26 highlights the environmental commitments that have been made by IBO throughout the content of this document and include internal responsibility.

Table 26: Summary of Licensee's Commitments

Section	Subject	Groundwater Management Commitment	Frequency	Internal Responsibility
1.3	Reporting requirements	IBO will fulfil various reporting requirements to the DWER on the operation of the system on a, annual/triennial, and as required basis.	As described in Table 2	Water Planning
1.3	Compliance with 5C licence	Abstraction bores will be operated in accordance with the terms and conditions of relevant 5C licences. Abstraction levels during the relevant licence periods will be within the respective prescribed annual water entitlement.	Ongoing after commencement.	Mine Services
3	Maintenance of the System	All water storage facilities and other water infrastructure associated with the System are inspected weekly by maintenance personnel checking for water leaks, controls and condition of containment dams with problems rectified as they arise.	Weekly	Mine Services
7.3	Operations monitoring program	IBO will fulfil various monitoring requirements on a monthly or six-monthly basis in respect of abstraction bores, monitoring bores and water use volumes.	On a monthly or six-monthly basis after commencement.	Mine Services and Environment Team
7.5	Trigger level compliance	IBO will ensure compliance with this GOS and trigger network proposals to ensure environmental impacts are mitigated where practicable.	Ongoing after commencement.	Water Planning
7.5	Contingency operations	IBO will implement contingency measures if operations are identified to impact or have potential to impact key environmental receptors.	As required	Mine Services
8	Water efficiency initiatives	IBO will continue to review and improve water efficiency initiatives across all operations to reduce water demand.	Ongoing after commencement.	All

10. REFERENCES

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Map 1: Borefield Location Plan

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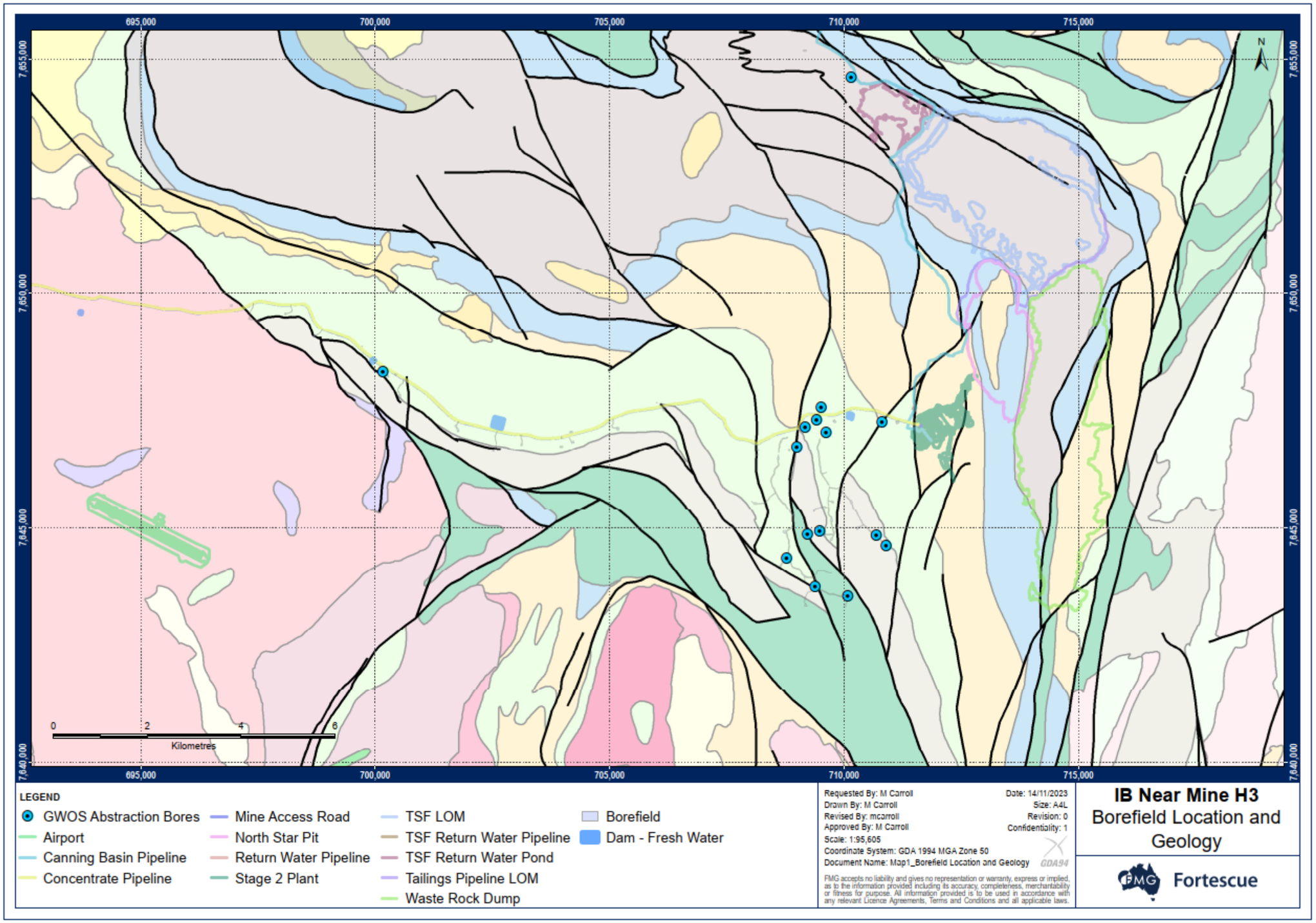
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Mine Access Road
North Star Pit
Return Water Pipeline
Stage 2 Plant
TSF LOM
TSF Return Water Pipeline
TSF Return Water Pond
Tailings Pipeline LOM
Waste Rock Dump
Borefield
Dam - Fresh Water
Requested By: M Carroll
Drawn By: M Carroll
Revised By: mcarroll
Approved By: M Carroll
Scale: 1:95,605
Coordinate System: GDA 1994 MGA Zone 50
Document Name: Map1_Borefield Location and Geology
Date: 14/11/2023
Size: A4L
Revision: 0
Confidentiality: 1
GDA94
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IB Near Mine H3
Borefield Location and Geology
FMG
Fortescue

Map 2: Raw and Potable Water Infrastructure Locations

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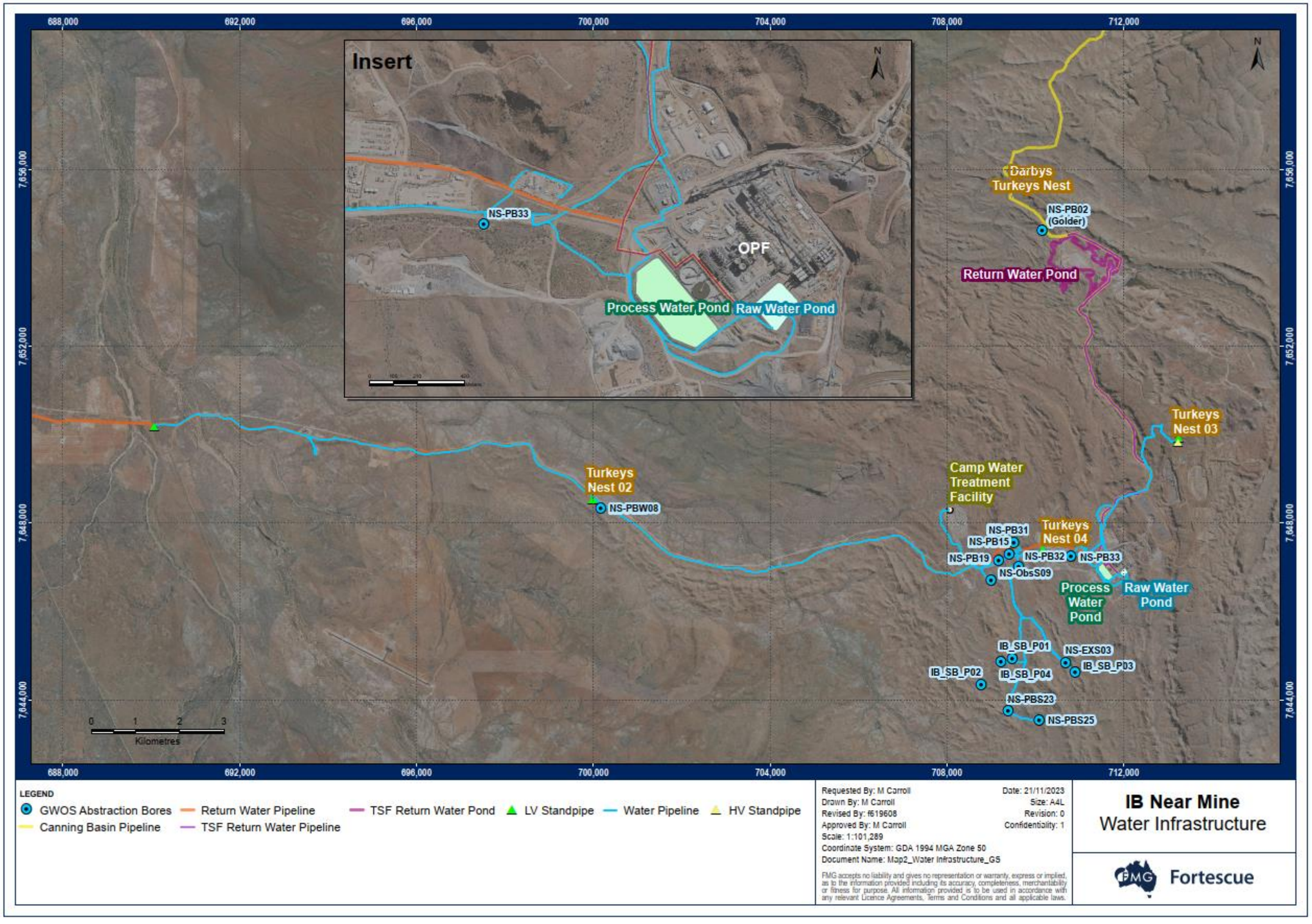
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Darbys Turkeys Nest
NS-PB02 (Golder)
Return Water Pond
Turkeys Nest 03
Turkeys Nest 02
NS-PBW08
Camp Water Treatment Facility
NS-PB31
NS-PB15
NS-PB19
Turkeys Nest 04
NS-PB32
NS-PB33
NS-ObsS09
Process Water Pond
Raw Water Pond
IB_SB_P01
NS-EXS03
IB_SB_P03
IB_SB_P02
IB_SB_P04
NS-PBS23
NS-PBS25
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Kilometres
LEGEND
GWOS Abstraction Bores
Return Water Pipeline
TSF Return Water Pond
LV Standpipe
Water Pipeline
HV Standpipe
Canning Basin Pipeline
TSF Return Water Pipeline
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Drawn By: M Carroll
Revised By: f619608
Approved By: M Carroll
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Date: 21/11/2023
Size: A4L
Revision: 0
Confidentiality: 1
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IB Near Mine
Water Infrastructure
Fortescue

Map 3: Groundwater Related Receptor Locations (from IB (2023a))

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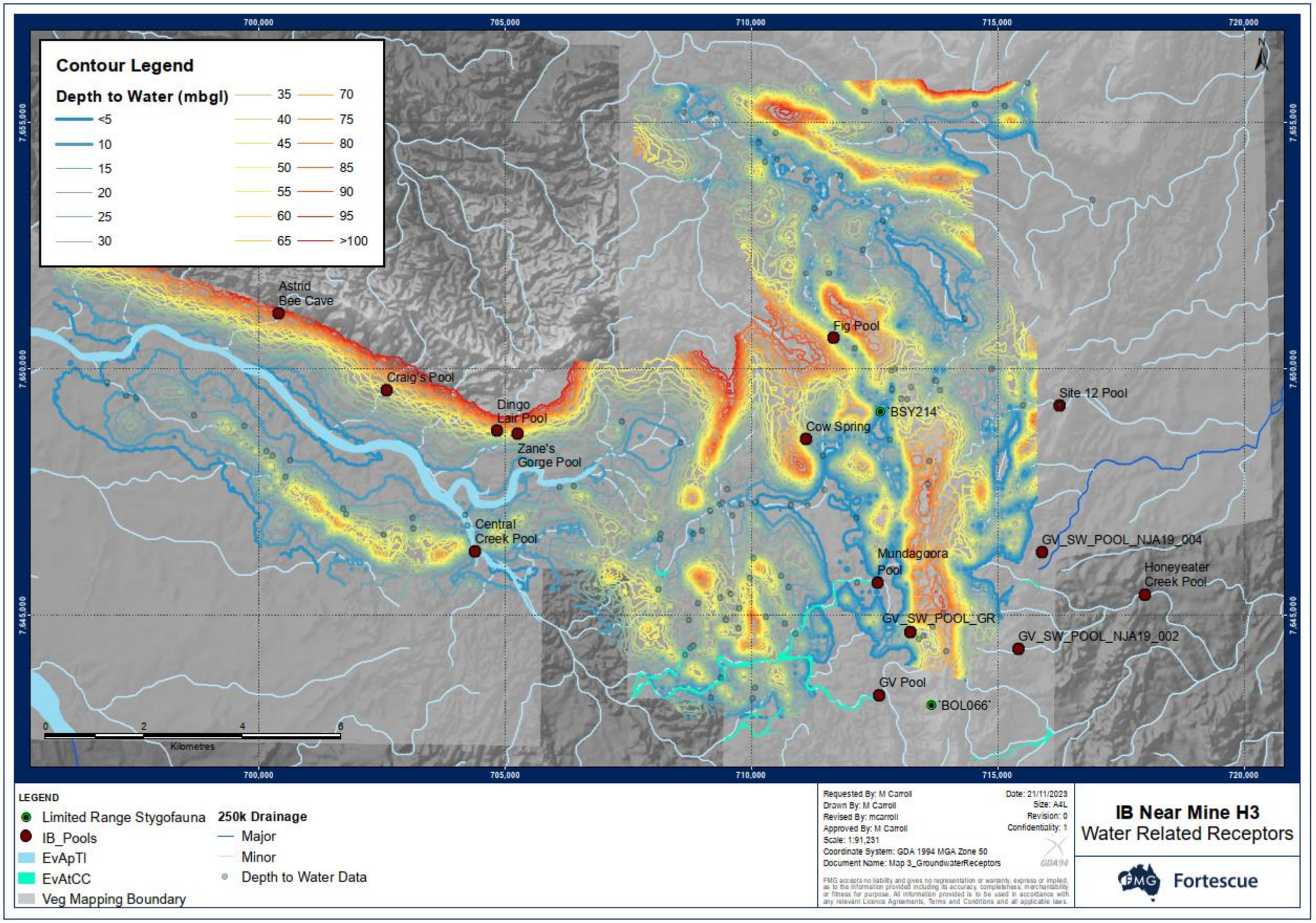
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Astrid
Bee Cave
Craig's Pool
Dingo
Lair Pool
Zane's
Gorge Pool
Central
Creek Pool
Fig Pool
BSY214
Cow Spring
Site 12 Pool
Mundagoora
Pool
GV_SW_POOL_NJA19_004
Honeyeater
Creek Pool
GV_SW_POOL_GR
GV_SW_POOL_NJA19_002
GV Pool
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Limited Range Stygofauna
IB_Pools
EvApTI
EvAtCC
Veg Mapping Boundary
250k Drainage
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Minor
Depth to Water Data
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Drawn By: M Carroll
Revised By: mcarroll
Approved By: M Carroll
Scale: 1:91,231
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IB Near Mine H3
Water Related Receptors
Fortescue

Map 4: Groundwater Related Monitoring Locations (from IB (2023a))

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NS_VH_PGDV_R1
NS-Obs13
NS-PB02 (Golder)
TSF Seepage Monitoring
NS_VH_PGDV_R2
NS-ObsW04b
IB_SW_Pool_Fig
NS-Obs29
NS-Obs14
NS-0664
IB_SW_Pool_Cow_Spring
WRD Seepage Monitoring
NS-PBW08
NS_VH_PGDV_R3
NS-ObsW03
NS_VH_PGDV_I3
NS-ObsW01a
NS-ObsW01
NS-PB31
NS-PB15
NS-ObsI7
NS-PB19
NS-PB32
NS-ObsS10
NS-ObsS09
IB_MP_M01
GV_SW_Pool_Mundagoora_SS
IB_MP_M02
IB_SB_PB04
IB_SB_PB03
NS-EXS03
IB_GVS_M01
NS_VH_PGDV_I1
IB_SB_PB02
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Trigger Monitoring Bores
GWOS Abstraction Bores
GWOS Monitoring Bores
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Pool Monitoring
Seepage Monitoring
Vegetation Monitoring
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Date: 20/11/2023
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IB Near Mine
Monitoring Locations
Fortescue

Appendix 1: Production Bore Logs

Appendix 2: Monitoring Bore Logs

Appendix 3: Trigger Level Technical Memo

Memo

Iron Bridge Trigger Level Technical Memo

OUR REF	**661MI-0000-RP-HY-0004**	**DATE**	10-Nov-23
TO	Michael Carroll	**CC**	Aline Barrabes
FROM	Guy Stock		

1. INTRODUCTION

The memorandum outlines the approach for the development of performance indicators (early warning criteria, trigger and threshold water levels) at monitoring points across Iron Bridge, proximal to, and/or directly associated with environmentally and culturally sensitive receptors. The objective of this approach is to establish a suitable series of metrics associated with changes in groundwater elevation that may be due to drawdown from Iron Bridge abstraction activities and potentially lead to subsequent environmental and cultural impacts occurring. Each performance indicator will be associated with a management response action to implement according to the level of impact.

Receptors that have been identified as at risk, or potentially at risk from Iron Bridge mining operations that require management under the Groundwater Operating Strategy, include:

- Mundagoora Pool,
- Site 12 Pool,
- Fig Pool,
- Cow Spring,
- Restricted Stygofauna species habitat,
- Western Borefield potentially groundwater dependent vegetation, and
- Southern Borefield potentially groundwater dependent vegetation.

Baseline data analysis has been completed and detailed herein to allocate appropriate performance indicators at monitoring bore sites, surface water pools and known restricted stygofauna species habitat locations. The evaluation of groundwater levels associated with groundwater dependant vegetation is included in the Iron Bridge Vegetation Health Monitoring and Management Plan (Iron Bridge, 2022) and is used to support analysis of primary vegetation metrics, which include leaf water potential, condition and health. The management strategy is detailed with the Groundwater Operating Strategy.

2. MUNDAGOORA POOL

In situ logger data has been collected from Mundagoora Pool since December 2019, which records pressure, temperature and specific conductivity at 3-hour increments (Figure 1). The data shows the influence of large flushing events during periods of high rainfall (noted during early months of 2020 and 2021) which displaces the pool volume and causes short lived flooding above the Pool's overflow point. Smaller rainfall events, most notably seen in the latter half of 2022 and early 2023, do not appear to have the required inflow volume for flushing to occur. Specific Conductivity concentrations are shown to return to equilibrium after a period of a few weeks.

Water levels remain relatively constant throughout the year in the absence of major flushing events. Information collected to date suggest this pool is a permanent feature, with recorded water levels remaining above 288.70 mAHD (water level recorded by in situ data logger on 13/10/2023). This does not suggest that historical water levels have not naturally occurred below this level.

A summary of water levels measured at Mundagoora Pool are presented in Table 1.

Table 1: Mundagoora Pool water level summary

Receptor (Sample Point)	Min. recorded level (mAHD) [Depth (m)]	Average level (mAHD) [Depth (m)]	Max. recorded level (11/12/2020) (mAHD) [Depth (m)]
Mundagoora Pool (GV_SW_Pool_Mundagoora_SS)	288.70 [3.45]	288.77 [3.52]	289.72 [4.47]

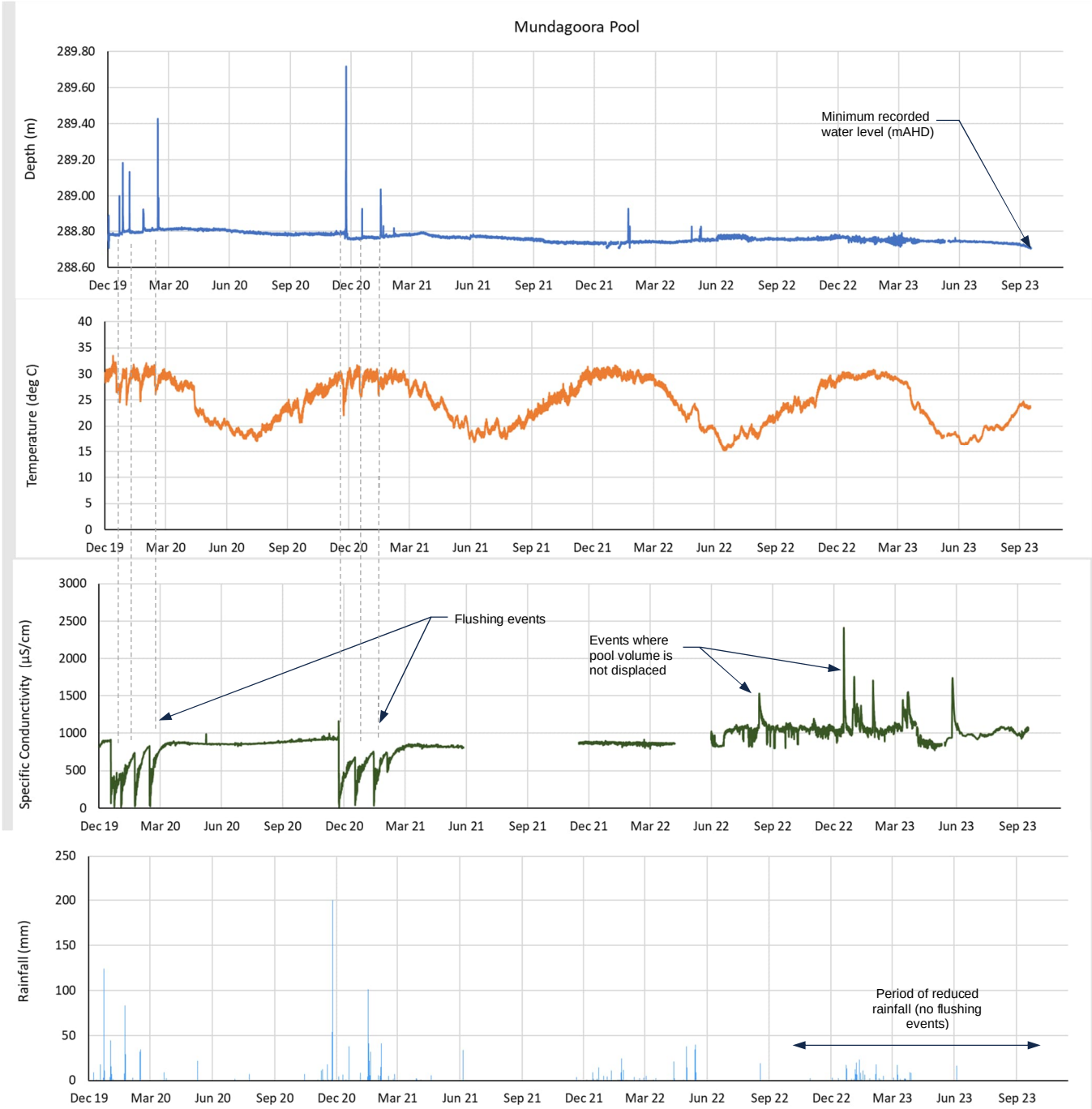

Figure 1: Mundagoora Pool water level, specific conductivity and Temperature taken from logger data in contrast with rainfall measure at Iron Bridge weather station NS_Nate_WE_WS_01, from December 2019 to June 2023.

Two monitoring bores were drilled and installed upstream and downstream of Mundagoora Pool in November 2022 (IB_MP_M01 and IB_MP_M02, respectively) (Figure 3). A manual water level reading was taken once the bores were installed on 14/11/2022. The bores were later equipped with insitu data loggers in April 2023, with water level data collected from the loggers available between 27/04/2023 and 6/06/2022. Water levels are tabulated in Table 2 and illustrated in Figure 3.

A gradual declining water level trend is observed in both upstream and downstream monitoring bores. In contrast, water levels in Mundagoora Pool showed a stable water level trend throughout the same period. There was a negligible amount of rainfall during the period logger data is available for both monitoring bores.

Due to errors in logger data and small temporal scales in which data has been collected from the monitoring bores, it is difficult to identify trends between water levels in the Pool with groundwater levels and assign performance indictors with a high level of confidence. Based on the available data (only two comparable data points), the upstream water level in IB_MP_M01 is elevated between 3.15m and 3.68m above the Pool height. However, there is not enough data to substantiate a relationship between the bores and the Pool. Therefore, monitoring bores are allocated a conservative early warning criteria to ensure impacts to the Pool are confidently mitigated. This early warning criteria, and any subsequent trigger or threshold values (if justified) will be revised upon further collection and analysis of data.

Table 2: Water level data (mAHD) taken following bore construction (14/11/2022) and at the start and end of available bore logger data (27/04/2023 and 6/06/2023, respectively), in contrast with Mundagoora Pool water level taken from logger data.

Sample Point	Manual water level (mAHD) [Depth (m)] 14/11/2022	Manual water level (mAHD) [Depth (m)] 27/04/2023	Manual water level (mAHD) [Depth (m)] 6/06/2023
IB_MP_M01	292.43	291.90	291.74
GV_SW_Pool_Mundagoora_SS	288.75* [3.50]	288.75* [3.50]	288.74* [3.49]
IB_MP_M02	280.45	279.20	279.03

*Logger data

In order to establish an appropriate alert system to identify any potential impacts from mining operations (including nearby groundwater abstraction/dewatering activities), IBO propose a three-tiered trigger level system approach to assess measured water levels in Mundagoora Pool.

The objective of this approach is to provide an early warning system to detect declining water levels as a result of IBO operations and assign appropriate corrective actions.

Tier 1 warning level for Mundagoora Pool is based on water level 0.1m below the minimum recorded water level measured in logger data since monitoring commenced in December 2019 (288.70 mAHD). Although this level does not necessarily reflect the lowest level of the Pool caused by natural climatic variation (on behalf of limited temporal monitoring data available), this will define the early warning for detailed engagement with Nyamal for adaptive and collaborative management.

It is proposed that upstream and downstream monitoring bores, IB_MP_M01 and IB_MP_M02, are exclusively assigned Tier 1 early warning levels. This approach focusses Tier 2 and Tier 3 trigger level criteria on the hydrological conditions of the Pool rather than groundwater levels due to limited temporal data available for the monitoring bores. The proposed Tier 1 level assigned to each monitoring bore is based on extrapolation of monitoring data trends over a period of one year (Figure 2). At this point, the water level elevation in the up gradient bore, IB_MP_M01, still remains above that of the extrapolated water level trend of the pool, which provides justification to meet Tier 1 warning level criteria.

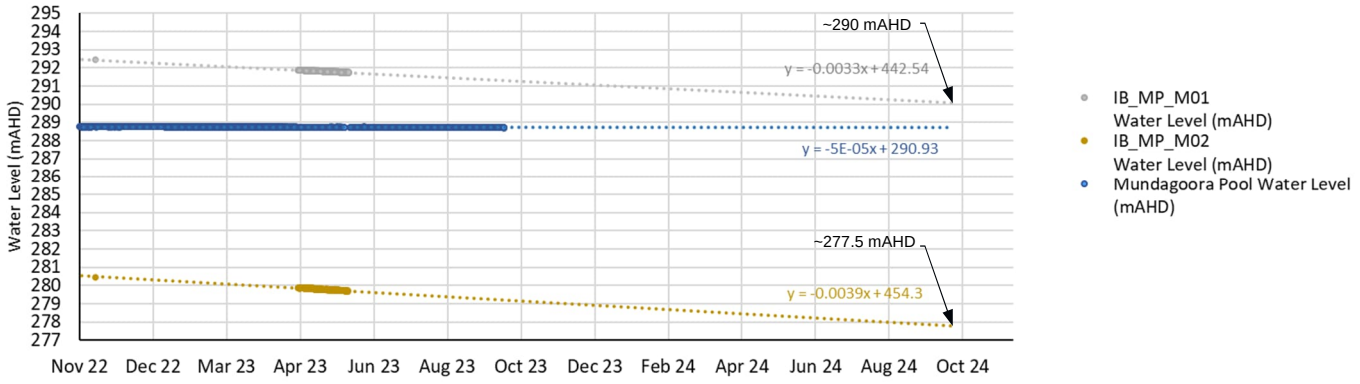

Figure 2: Measured groundwater level trends from IB_MP_M01, IB_MP_M02 and Mundagoora Pool extrapolated over a period of one year

A Tier 2 trigger level is assigned to the pool's water level based on a 25% reduction of the maximum pool depth (at the overflow point).

A Tier 3 trigger level is assigned to the pool's water level based on a 50% reduction of the maximum pool depth (at the overflow point). This level provides some level of certainly that the ecological and cultural significance of the Pool and downstream ecology, whilst potentially impacted, is likely to be recoverable.

A summary of Mundagoora Pool trigger level management criteria is presented in Table 3. Proposed trigger levels are illustrated against existing data in Figure 3.

Table 3: Mundagoora Pool trigger level management criteria

Sample Point	Base of Pool Level (mAHD) [Depth (m)]	Tier 1 Warning Level (mAHD) [Depth (m)]	Tier 2 Trigger Level (mAHD) [Depth (m)] 25% water level reduction	Tier 3 Trigger Level (mAHD) [Depth (m)] 50% water level reduction
Mundagoora Pool	285.25 [3.5]	288.60 [3.35]	287.88 [2.63]	287.00 [1.75]
IB_MP_M01	n/a	290	n/a	n/a
IB_MP_M02	n/a	277.5	n/a	n/a

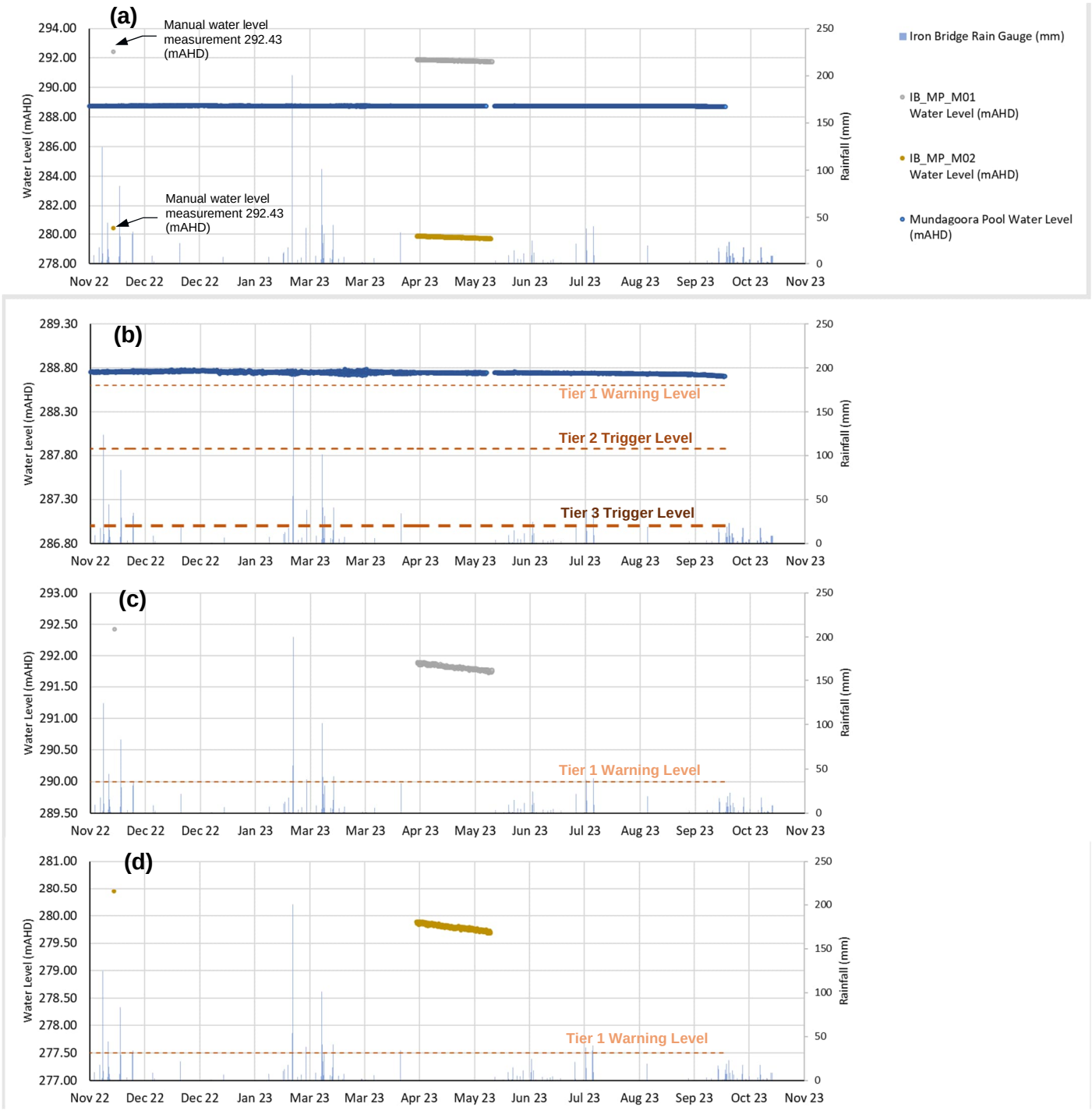

Figure 3: (a) Water levels from Mundagoora Pool logger data in comparison from upstream (IB_MP_M01) and downstream (IB_MP_M02) monitoring bores (b) Mundagoora Pool logger data with proposed performance criteria (c) Manual dip and logger water level data from upstream bore IB_MP_M01 with proposed performance criteria (d) Manual dip and logger water level data from downstream bore IB_MP_M02 with proposed performance criteria. Rainfall measurements are taken from Iron Bridge rain gauge NS_Nate_WE_WS_01.

3. SITE 12 POOL

Surface water management of Site 12 Pool is achieved through the implementation of the *Site 12 Pool Water Quality and Quantity Monitoring Plan*, (2021). This plan addresses management and monitoring actions for surface water in accordance with the objectives of condition 12-3 and 12-7 of Ministerial Statement 993. Early response and threshold criteria are allocated to water quality parameters and biological indicators in order to meet these objectives.

Monitoring bore NS-0664 is located upstream of Site 12 Pool and downstream of the proposed waste rock dump. As part of the *Site 12 Pool Water Quality and Quantity Monitoring Plan*, (2021), water levels in this bore are required to provide supplementary information upon exceedances of primary monitoring parameters in the pool (water quality and biological indicators). Previous groundwater investigations using monitoring data from this bore have correlated Site 12 Pool water levels with those in NS-0664, indicating that the Pool is partially sustained by the local fractured aquifer groundwater (Iron Bridge, 2021a). Analysis of hydrograph data identified that the Pool was sustained by groundwater at the location of the data logger until water levels in upstream bore NS-0664 dropped below 284.6 mAHD.

Hydrographs from NS-0664 and Site 12 Pool (IB_SW_Pool12_01) have been re-analysed using more recently collected logger data and presented in Figure 4. The data shows that pool water levels were sustained below the previously recognised water level in NS-0664 that indicated the start of water level decline in the pool at the monitoring location. Water levels in NS-0664 reached 284.14 mAHD in October 2021 before pool levels showed signs of decline until this location of the pool dried out in December 2021. During this time, there was no rainfall recoded at the Iron Bridge rain gauge (NS_Nate_WE_WS_01).

The high degree of seasonality, and surface water dependence of the pool, result in difficulty setting definitive groundwater level performance indicators. Performance indicators proposed to be implemented into the Groundwater Operating Strategy will focus on water levels associated with the upstream bore (NS-0664). An early warning criterion will signify the stage where groundwater availability is no longer within baseline conditions and may indicate an impact to pool water availability, triggering a response to notify Nyamal and investigate causes. However, management of the Pool will continue to be achieved through conditions outlined in the *Site 12 Pool Water Quality and Quantity Monitoring Plan* (2021), which include detailed metrics on water quality, macroinvertebrate, macrophyte, fish and diatom communities.

A Tier 1 trigger level is proposed for water levels in NS-0664 that are a nominal 0.5m below the minimum baseline water level (Table 4).

Table 4: Site 12 Pool trigger level criteria

Sample Point	Min. recorded depth (14/12/2022) (mAHD)	Tier 1 warning level (0.5m below min. depth)
NS-0664	282.70	282.20

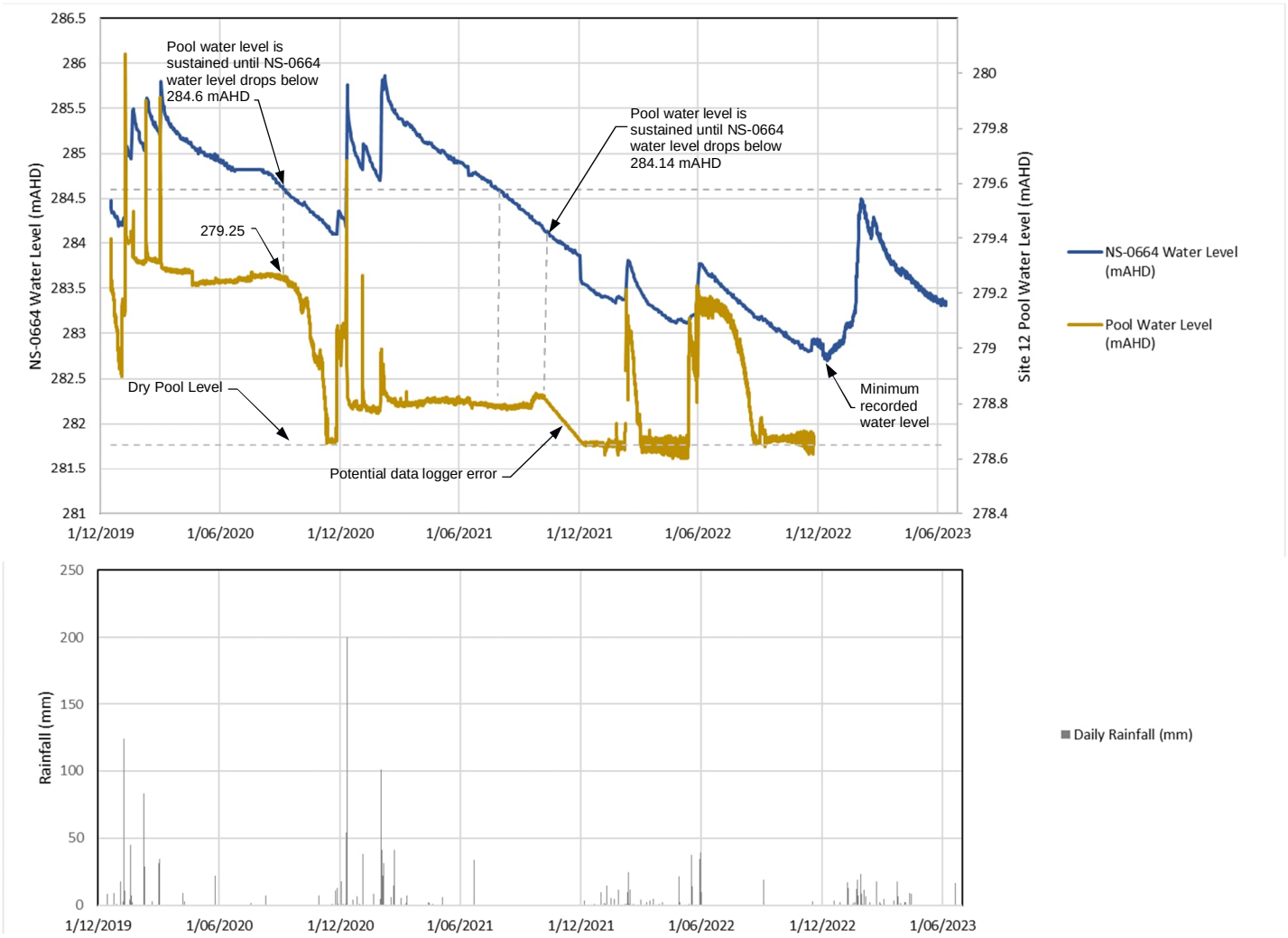

Figure 4: NS-0664 monitoring bore and Site 12 pool Hydrographs with daily rainfall collected from Iron Bridge rain gauge NS_Nate_WE_WS_01.

4. FIG POOL

In situ logger data has been collected from Fig Pool since December 2019, which records pressure, temperature and specific conductivity at 3-hour increments (Figure 5). Water levels in the pool are quite stable with the exception of very short-lived minor fluctuations resulting from significant rainfall events, likely owing to its small catchment size (0.16 km^2) and water levels being consistently at, or near its overflow point (Hydrobiology, 2023).

A summary of water levels measured at Fig Pool are presented in Table 5.

Table 5: Fig Pool water level summary

Receptor (Sample Point)	Min. recorded water level (mAHD) 10/12/2020 [Depth (m)]	Average recorded water level (mAHD) [Depth (m)]	Max. recorded water level (mAHD) 11/12/2020 [Depth (m)]
Fig Pool (IB_SW_Pool_Fig)	302.92 [1.18]	302.96 [1.22]	303.13 [1.39]

Fig Pool is suggested to be a permanent feature which is supported by groundwater, based on data collected to date. Performance criteria proposed at this Pool will follow a three-tiered approach, which will focus on maintaining the presence of water in the Pool.

The tier 1 early warning level for Fig Pool is based on 0.1m below the lowest measured water levels in logger data since monitoring commenced in December 2019 (302.92 mAHD). Similar to other pools in the North Star area, this level does not necessarily reflect the lowest historical water level caused by natural variation, rather, will act as the initial warning level to prompt investigation and collaboration with Nyamal.

Tier 2 trigger levels are assigned based on 20% reduction of water levels below the minimum baseline level of Fig Pool.

A Tier 3 trigger level is assigned based on the drying out of the Pool (water level 301.74 mAHD). This metric reflects the unwanted outcome that the ecological and cultural significance of the Pool is impacted.

Performance criteria for Fig Pool is presented in Table 6.

Table 6: Fig Pool trigger level criteria

Receptor (Sample Point)	Base of pool (mAHD)	Tier 1 warning level (mAHD) [Depth (m)]	Tier 2 trigger level (mAHD) [Depth (m)]	Tier 3 trigger level (mAHD) [Depth (m)]
Fig Pool (IB_SW_Pool_Fig)	301.74	302.85 [1.11]	302.62 [0.88]	301.74 [dry]

Figure 5: Fig Pool water level (with proposed performance criteria), specific conductivity and temperature taken from logger data in contrast with rainfall measured at Iron Bridge weather station NS_Nate_WE_WS_01, from December 2019 to June 2023.

5. COW SPRING

In situ logger data has been collected from Cow Spring since December 2019, which records pressure, temperature and specific conductivity at 3-hour increments. Water levels in the pool are very stable indicating a dependency on groundwater. Water levels are shown to increase above the pool's overflow point during significant rainfall events, before returning to equilibrium.

A summary of water levels measured at Cow Spring are presented in Table 7.

Table 7: Cow Spring water level summary

Receptor (Sample Point)	Min. recorded water level (9/01/2022) (mAHD) [Depth (m)]	Average recorded water level (mAHD) [Depth (m)]	Max. recorded water level (11/02/2022) (mAHD) [Depth (m)]
Cow Spring (IB_SW_Pool_Cow Spring)	296.33 [1.41]	296.40 [1.48]	296.59 [1.67]

Performance criteria proposed at this Pool will follow a three-tiered approach, which will focus on maintaining the presence of water in the pool.

The tier 1 early warning level for Cow Spring is based on 0.1 m below the lowest measured water levels in logger data since monitoring commenced in May 2020 (296.33 mAHD). This level does not necessarily reflect the lowest historical water level caused by natural variation, rather, will act as the initial warning level to prompt investigation and collaboration with Nyamal.

Tier 2 trigger levels are assigned based on 20% reduction of water levels below the minimum baseline level of Fig Pool.

A Tier 3 trigger level is assigned based on the drying out of the pool (water level 294.92 mAHD). This metric reflects the unwanted outcome that the ecological and cultural significance of the Pool is impacted.

Performance criteria for Cow Spring is presented in Table 8.

Table 8: Cow Spring trigger level criteria

Receptor (Sample Point)	Base of pool (mAHD)	Tier 1 warning level (mAHD) [Depth (m)]	Tier 2 trigger level (mAHD) [Depth (m)]	Tier 3 trigger level (mAHD) [Depth (m)]
Cow Spring (IB_SW_Pool_Cow Spring)	294.92	296.23 [1.31]	295.97 [1.05]	294.92 [dry]

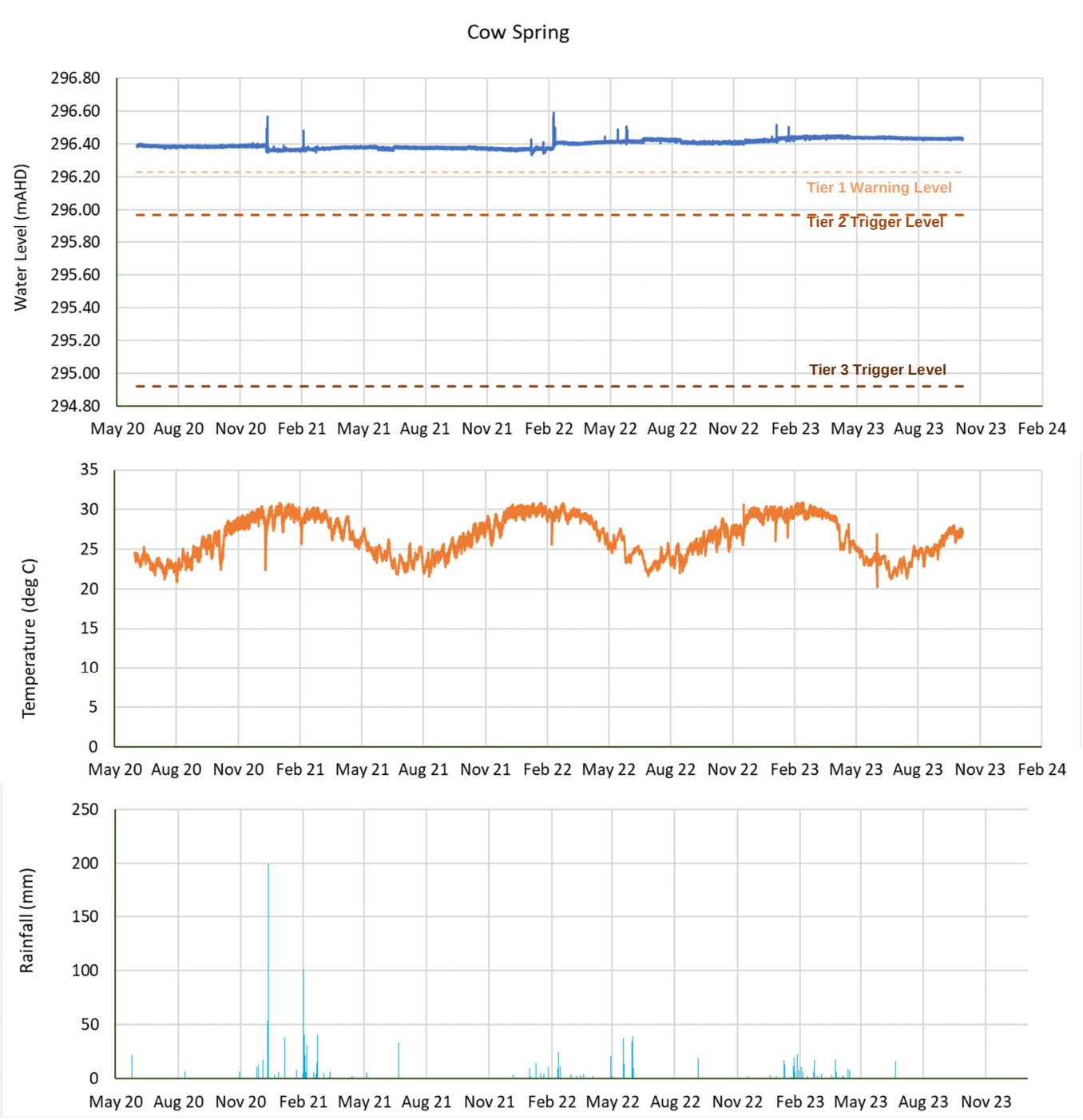

Figure 6: Cow Springs water level and temperature taken from logger data in contrast with rainfall measured at Iron Bridge weather station NS_Nate_WE_WS_01, from December 2019 to June 2023.

6. STYGOFAUNA

Performance criteria will focus on managing impacts to known restricted species identified in completed subterranean fauna surveys. Fortescue is proposing to conduct additional surveys which will aim to cover unexplored areas that are likely to be impacted based on drawdown predictions. Upon completion of the surveys, updates will be made to the proposed management strategy detailed below, if required.

Two stygofauna specimens have been identified exclusively in only one location over the surveyed area at the project. The two stygofauna specimens are detailed in Table 9. The bore in which Atopobathynella 'BSY214' was identified is proposed as the trigger monitoring bore for direct management of available known habitat for this species. Tubificidae 'BOL066' was sampled from an RC hole located to the south of the current mining area (South Star). As this is not a permanent sampling point, bore IB_GVS_M01 has been proposed as the trigger monitoring bore. This bore is located in between the active mining area and the known location of the restricted species and will act a proxy for habitat loss based on extrapolation of drawdown.

Table 9: Summary of restricted stygofauna specimens

Stygofauna specimen	Location recorded		Sampled Bore ID	Number of specimens collected	SWL mAHD [Depth mbgl]	Proposed Trigger Monitoring Bore
	Easting	Northing				
Atopobathynella 'BSY214'	715,499	7,649,267	NS-Obs14	57	267.41 [39.19]	NS-Obs14
Tubificidae 'BOL066'	713,647	7,643,194	SS0003*	8	364.99 [62.38]	IB_GVS_M01 (nearest bore to sampled species)

*RC hole

Trigger water levels are assigned to each monitoring bore location in order to provide early warning to potential habitat loss for these restricted stygofauna species. Identifying suitable stygofauna habitat in each bore acknowledges the methodology outlined in Bennelongia, (2023), where habitat potential is defined as:

- Within the phreatic zone (below water table),
- Within weathered bedrock where substrate is more permeable/porous than underlying fresh rock, and
- Depth no greater than 40mbgl.

Using drilling data for each allocated trigger level monitoring bore, an estimate of potential stygofauna habitat has been determined following the above methodology and presented in Table 10. Borelogs for NS-Obs14 and IB_GVS_M01 are provided in Appendix A.

By applying this methodology to RC hole SS0003, a theoretical habitat thickness of 0 m was noted. Similarly, a 0.81 m habitat thickness was defined for NS-Obs14. These outcomes highlight the limitations of the assumptions above, as specimens were sampled from these holes (Table 10). It is more appropriate to

recognise the habitat assumptions by Bennelongia as being reflective of higher habitat prospectivity, as stygofauna species are known to exist at depths beyond 40 m bgl.

Table 10: Estimated stygofauna habitat in the location of bores NS-Obs14, IB_GVS_M01 and RC hole SS0003 using habitat determination method outlined in Bennelongia (2023).

Bore ID	Easting	Northing	Ground RL (mAHD)	SWL (mAHD) [Depth mbgl]	SWL sample date	Depth of weathering (mAHD) [Depth mbgl]	Potential Stygofauna habitat thickness (m)
NS-Obs14	715,499	7,649,267	306.41	267.41 [39.19]	18/03/15	234.41 [72.00]	0.81
IB_GVS_M01	713,944	7,644,272	421.63	370.81 [50.82]	14/06/23	335.63 [86.00]	0
SS0003	713,647	7,643,191	423.90*	364.99 [62.38]	15/12/19	376.90 [50.47]	0*

*Ground RL taken from drill hole location. Due to 60° dip, relative ground RL above SWL is 427.37 mAHD

To overcome this limitation, Trigger levels associated with Tubificidae 'BOL066' and Atopobathynella 'BSY214' habitat are proposed based on habitat estimation methodology that assumes suitable habitat can extend beyond 40m bgl. Discrete fracturing and weathered zones extend beyond the overlying oxidation zone which introduces potential habitat at depth. Potential habitat related to Atopobathynella 'BSY214' and Tubificidae 'BOL066' is therefore nominated based on identified weathering thickness below water table in NS-Obs14 and IB_GVS_M01 (proxy monitoring bore), respectively. A three-tiered approach is proposed to effectively manage drawdown which is predicted to impact this zone. This approach will apply nominal water level trigger values which defines habitat loss in terms of reduced saturated thickness in each location.

Proposed trigger levels are provided in Table 11 and illustrated against monitoring data in Figure 7 and Figure 8.

Table 11: Trigger levels associated with NS-Obs14 and IB_GVS_M01

Bore ID	Easting	Northing	Tier 1 Trigger Level (mAHD) [Depth mbgl] 20% habitat reduction	Tier 2 Trigger Level (mAHD) [Depth mbgl] 50% habitat reduction	Tier 3 Trigger Level (mAHD) [Depth mbgl] 80% habitat reduction
NS-Obs14	715,499	7,649,267	260.81 [45.6]	250.91 [55.5]	241.01 [65.4]259.41 [47.00]
IB_GVS_M01	713,944	7,644,272	363.86 [57.86]	353.22 [68.41]	342.67 [78.96]

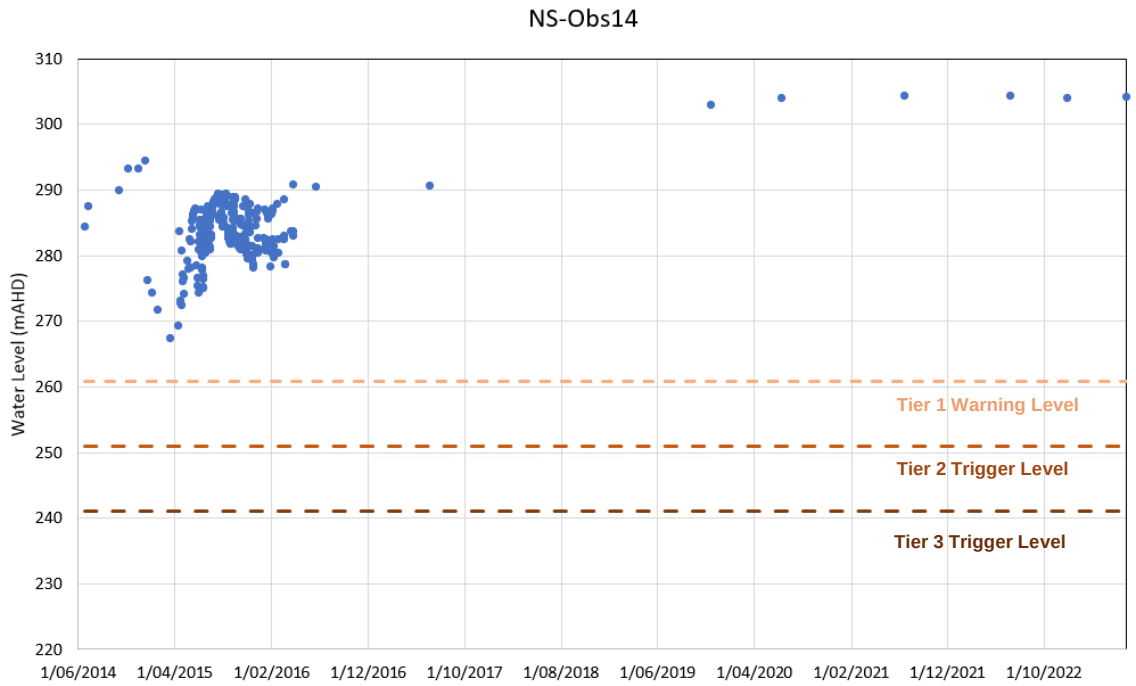

Figure 7: NS-Obs14 water level measurement with proposed performance criteria associated with stygofauna habitat reduction of restricted species Atopobathynella 'BSY214'.

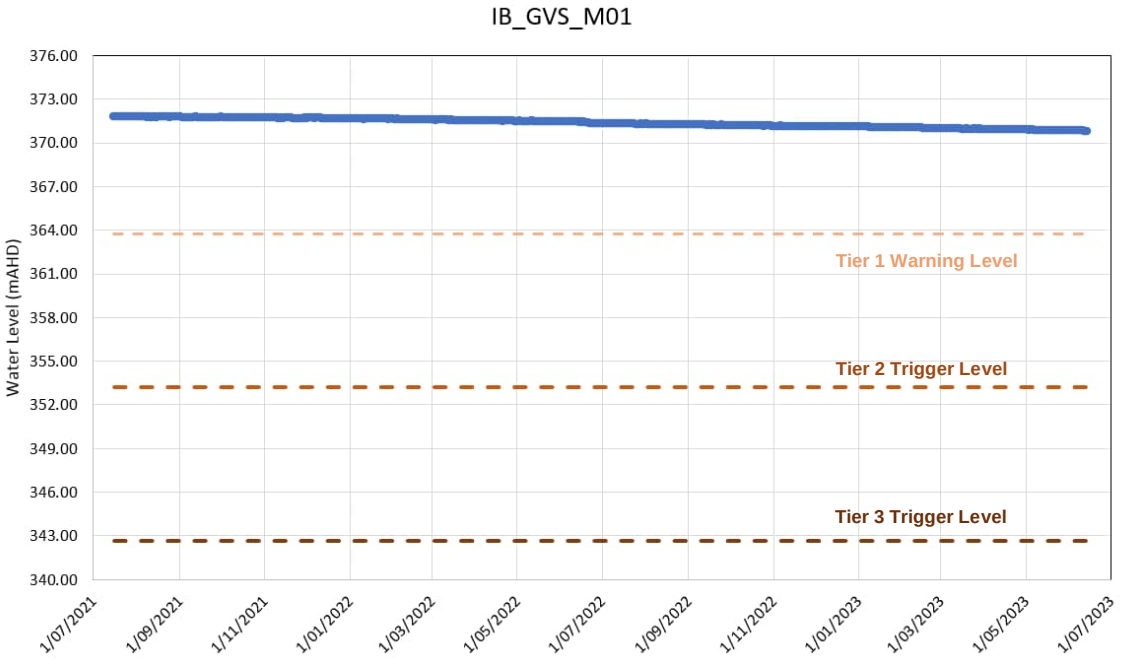

Figure 8: IB_GVS_M01 water level measurements with proposed performance criteria associated with stygofauna habitat reduction of restricted species Tubificidae 'BOL066'.

7. REFERENCES

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8. APPENDIX A – BORE LOGS