Assessment

East Pilbara Desktop Groundwater Assessment

Civil Engineer – Water Resource

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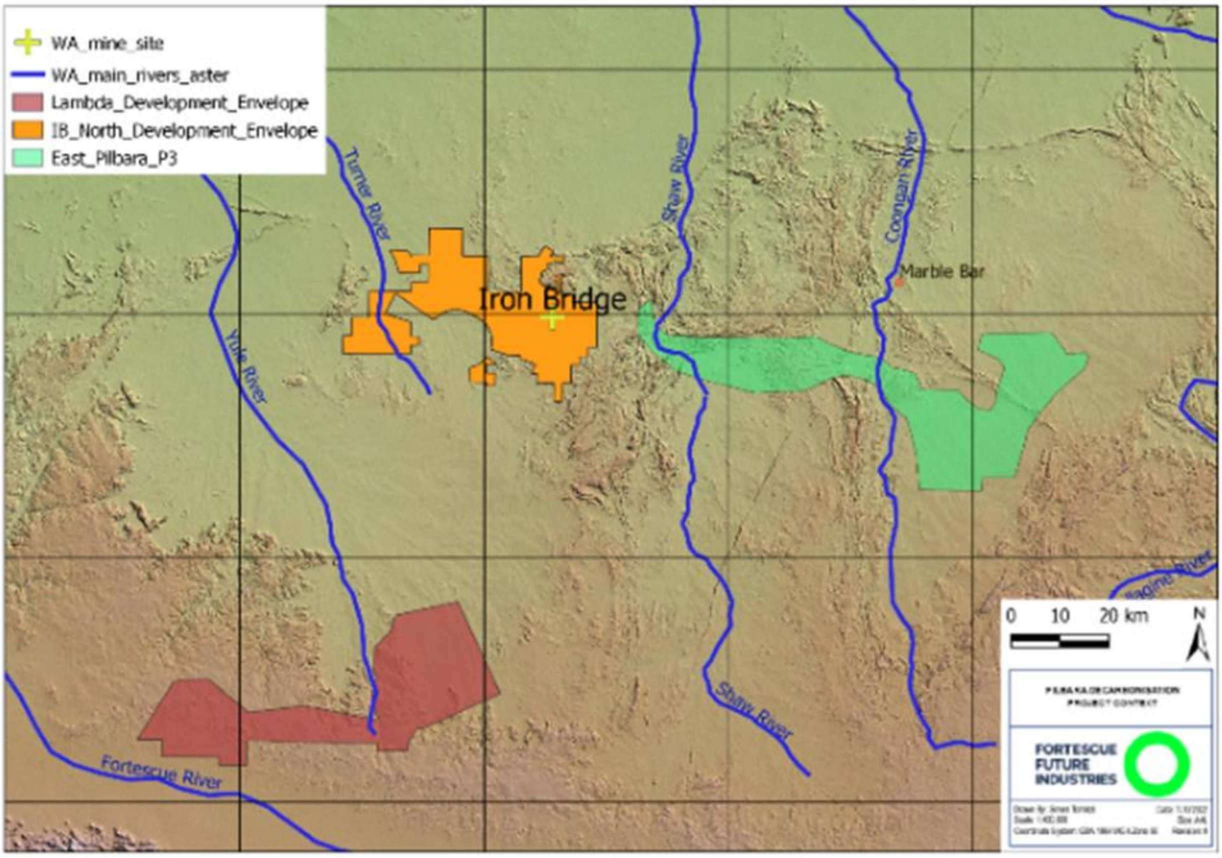
1. INTRODUCTION

Fortescue Future Industries (FFI) is currently developing the East Pilbara Green Energy Hub (EPGH). Three locations are currently being assessed for the potential development of green energy through wind turbines: Iron Bridge, Lambda and East Pilbara (see figure below). The EPGH is considered a top priority project for FFI and therefore it is pivotal a secure water source is found at each proposed location for construction and operations.

Figure 1: Green Energy Hub Area Locations in The Pilbara Region.



Note: In the figure above, Iron Bridge (orange polygon, centre), East Pilbara (green polygon, east) and Lambda area (red) to the southwest).

This report provides a desktop assessment of groundwater resources for the East Pilbara option, including an overview of available information, aquifers and potential water related risks. It also provides a tentative cost estimate for a drilling program and a set of recommendations for site investigations and water approvals.

1.1 Water Demand

Estimated volumes of water to meet this demand are in the order of 0.6 GL/a during the first 2 years (for construction) with an ongoing project demand of 0.4 GL/a (for ongoing operational purposes only and not for processing needs).

A construction water estimation exercise conducted for the East Pilbara area (refer to table below) indicates 0.6 GL/a for overall average water usage during construction of the phase I of the EPGH including 310 wind turbines. A detailed comparative assessment of the site climate conditions, water availability, footprint area and power consumption will further inform the process design technology as the project progresses and ultimately the raw water quantity requirement.

In terms of water quality during the construction phase of the project tolerance exist to allow slightly brackish to brackish water quality to be used. This will chance once a secure water source is optioned for the processing plant (Electrolysis) as filtered clean water is then required.

Table 1: Construction Water Estimate for East Pilbara Area

Component of Works		Duration (Months)	Start	Finish	Total Water Use (m^3)	Peak Water Use Rate (m^3/Month)	Peake Water Use Rate (L/s)
Construction - Early Works Office and Roads		10	1/07/2024	30/04/2025	723,364	74,253	29
Construction - Wind Turbines		16	1/02/2025	31/05/2026	315,520	20,251	8
Construction - Wind Access Roads		16	1/02/2025	1/05/2027	185,557	11,909	5
Construction - Transmission and Power		22	1/09/2024	30/06/2026	89,949	4,187	2
Offices and Accommodation		33	1/04/2025	31/12/2027	117,873	3,643	1
Personnel Water		60	1/07/2024	31/12/2027	279,700	11,238	4
Total water usage	(m^3/month)	41	1/07/2024	31/12/2027	41,755	117,730	45
Overall average water usage	(GL/a)				0.50	117,730	45
Contingency - 20%	(GL/a)				0.10	23,546	9
Overall average water usage (inc. contingency)	(GL/a)				0.60	141,276	55

1.2 Regulatory Context

The Envelope consists of an east-west oriented polygon (Figure 1) running for approximately 85 kms, with its westernmost edge immediately east from the Iron Bridge mine site. It runs south of Marble Bar and has a total area of approximately 900 km^2. An array of wind turbines comprising a maximum of 310 Vestas V162-6 MW separated by 2 km and 0.6 km in a north-south and east-west orientation respectively will be installed in two stages.

Different permits are required in order to progress with drilling within the East Pilbara project envelope. The main regulatory permits needed first to access a land to work on and second to conduct water drilling are a permit of works (POW) and a 5C license, issued by the Department of Mines, Industry Regulation and Safety (DMIRS) and the Department of Water and Environmental Regulation (DWER). The former can take up to three months before granted, the latest takes longer around six months. They can be lodged in parallel.

The area crosses two north-south oriented sub-catchments from the De Grey River system: Shaw River sub-catchment to the west and Coogan River sub-catchment to the east. It can be accessed by from the Salgash Road and Marble Bar Road (State Road No 138) located to the southeast of Marble Bar, East Pilbara.

1.3 Land Use

The East Pilbara area is partially covered by the Corunna Downs Pastoral Lease Station, on a relatively flat ground with elevation increasing gently from around 65 m above sea level up to 100 m towards the south. The vegetation is dominated by open shrublands and patterns of low dunes.

The Warrawoona Gold Project (Calidus 2019), currently under construction, is located within a small catchment area (Brockman Hay Cutting Creek Catchment) situated contiguous to the Project enveloped and to the west.

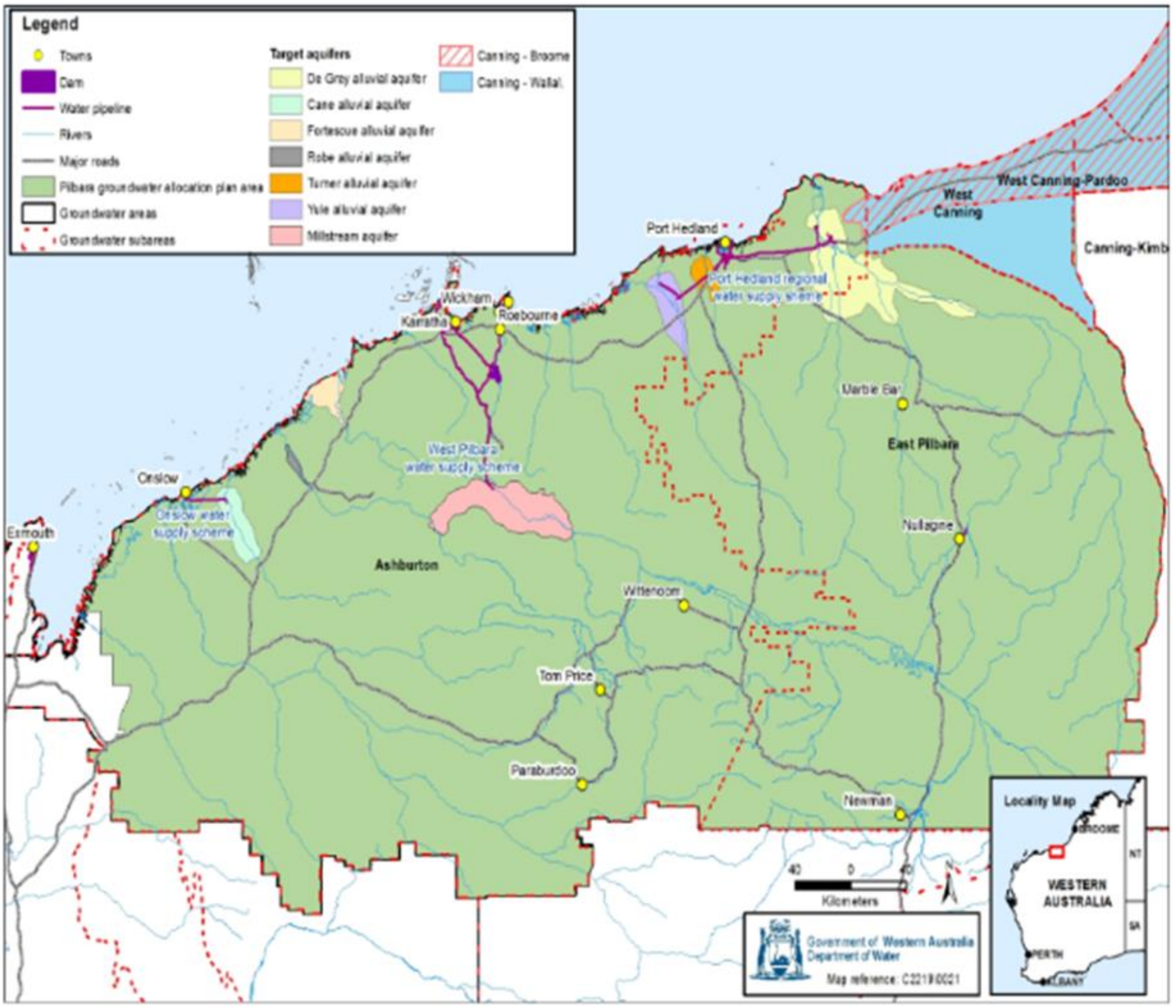
There are no other significant users or stakeholders around the East Pilbara envelope.

As with the other priority area, Iron Bridge (AUS0311-0000-HG-MEM-0001), a first estimate for a drilling budget is necessary and this is targeted at meeting the required amount of water during construction, in the order of 0.6 GL/a.

1.4 Water Allocation and Licensing

The East Pilbara enveloped is located within the larger Pilbara Groundwater Management Area (DWER 2022) which consists of a mix of alluvial, sedimentary and fractured rock aquifers. Among the most important aquifers are six coastal alluvial aquifers, the Millstream aquifer and the Broome Sandstone and Wallal Sandstone sedimentary aquifers, in the West Canning Basin (refer to figure below). Allocation limits have not been set for fracture rock aquifers as water availability is assessed on a case-by-case through licensing.

Figure 2: Groundwater Subareas in Western Australia



Note: East Pilbara Envelope situated south of Marble Bar (not shown) and within the East Pilbara area. The figure above was modified from DWER 2021.

At a local scale, water allocations surrounding the East Pilbara Envelope have been granted to mining companies and State own agencies (Water Corporation, Main Roads) to date (refer to table below). Except from Atlas Iron Pty Ltd's water license No 179423 which abstracts from the Hamersley Fracture Rock aquifer, all other licenses abstract water from the Pilbara Fracture Rock aquifer.

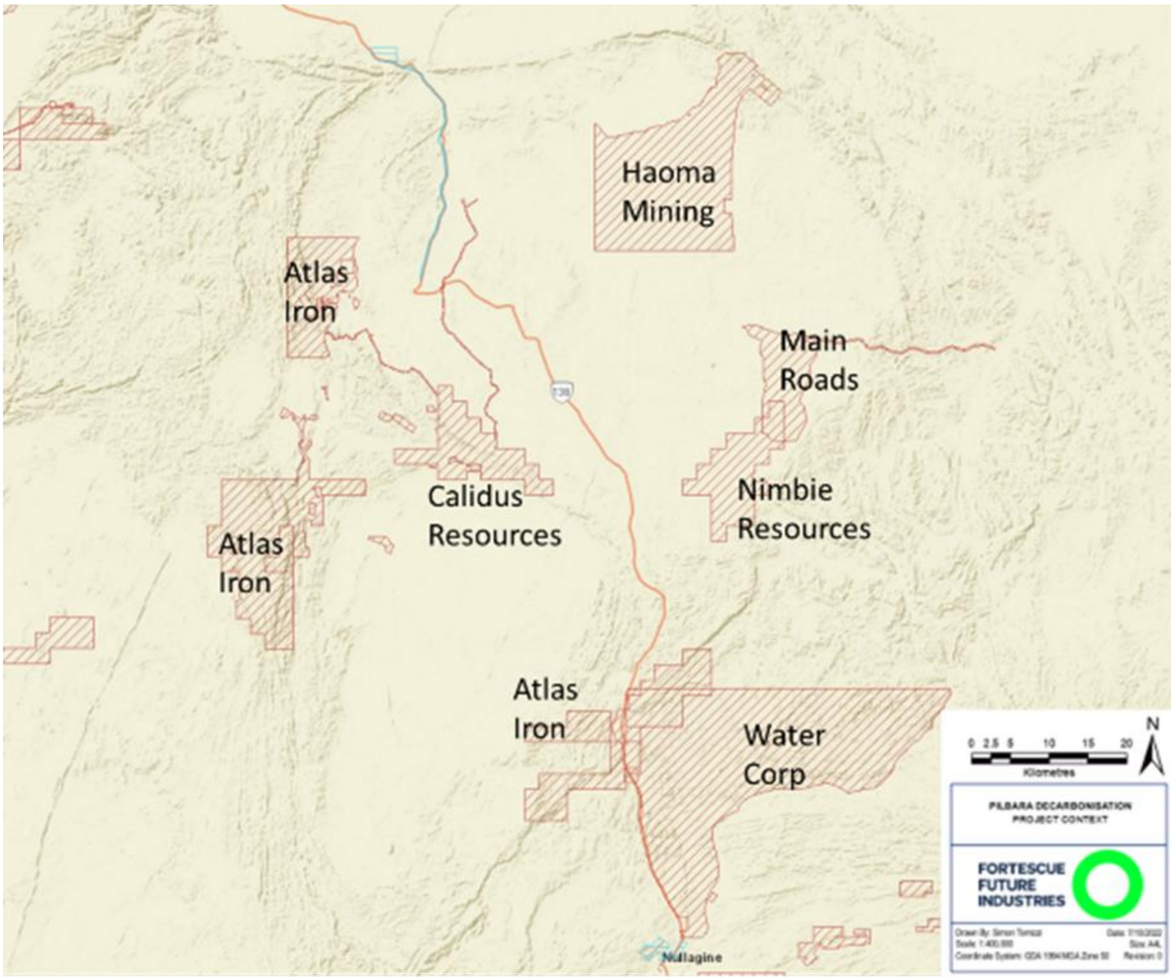
Table 2: Water License Holders around the East Pilbara Envelope

Water License holder	Allocation (KL/a)	License Number	Expire date	Aquifer
Keras (Pilbara) Gold Pty Ltd	2,100,000	204411	2032/9	Fractured Rock
Atlas Iron Pty Ltd	1,100,000	176960	2030/4	Fractured Rock

Water License holder	Allocation (KL/a)	License Number	Expire date	Aquifer
Water Corporation	220,000			
Nimbie Resources Pty Ltd	250,000	204507	2030/7	Fractured Rock
Main Roads	1,000	203581	2029/11	Fractured Rock
Haoma Mining NI	150,000	167236	2022/8	Fractured Rock
Atlas Iron Pty Ltd	135,000	179423	2024/7	Hamersley-Fractured Rock
Water Corporation	80,000	65335	2027/11	Fractured Rock

The distribution of the selected allocation is shown in the figure below:

Figure 3: Current Water License Holders around East Pilbara Area



A recent survey conducted early in 2022 to sample pastoral station bores within the East Pilbara enveloped showed they are in use and equipped with a small-scale windmill tower for cattle feeding purposes.

2. ENVIRONMENTAL CONTEXT

2.1 Climate

The Pilbara region climate is arid to semi-tropical. It is characterised by dry winters and cold wetter summers. Summer rainfall is sporadic and variable, resulting from tropical cyclone activity. Average rainfall (Figure 4) ranges between 200-400 mm per year with most rainfall constrained to December to March. Due to the influence of cyclone activity rainfall distribution is higher towards the coast compared to inland (Figure 5). Rainfall data from Marble Bar has recorded annual mean value of 394 mm (BOM, 2022). Potential evaporation rates average 3200 mm/year.

Mean annual potential evaporation (Morton's formula) ranges from 1,700 mm in the south-east to more than 2,000 mm in the northern parts. This is probably a minimum as it underestimates inland potential and hot inland winds (CSIRO 2015).

Figure 4: Marble Bar Combined Monthly Rainfall (Total of 1377 Months)

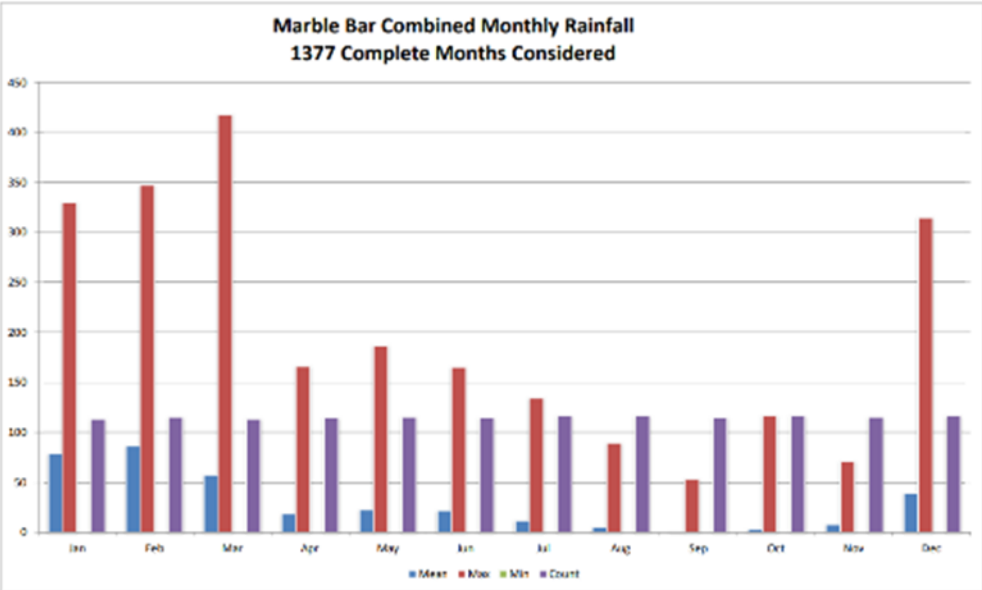
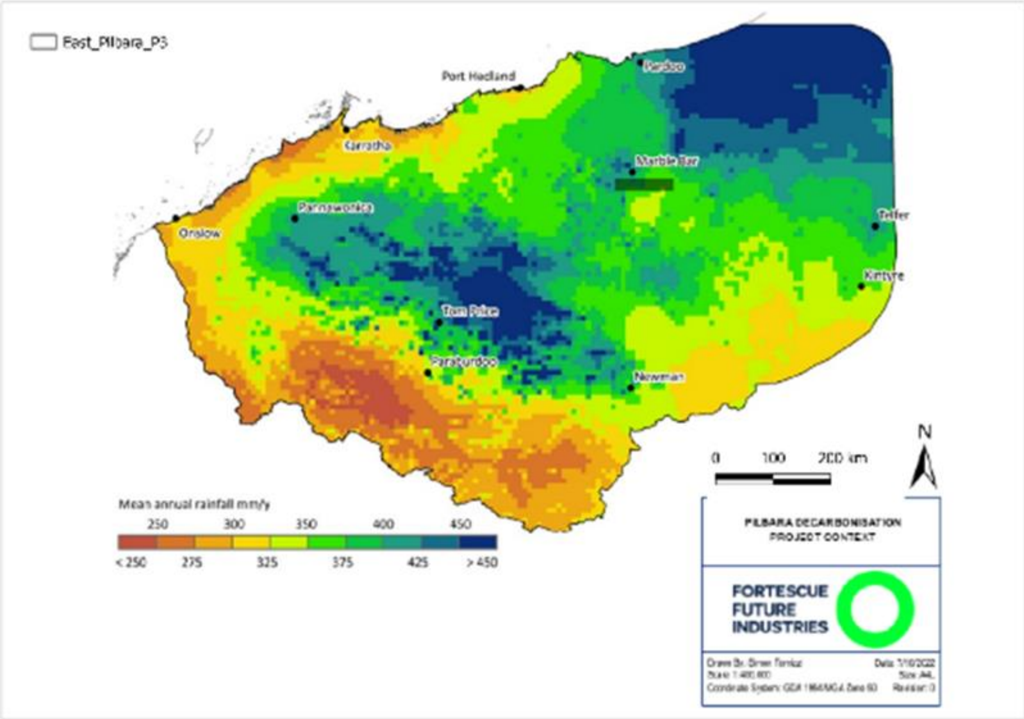


Figure 5: Rainfall Pattern for the Pilbara Area Showing Higher Precipitation Towards the Northeast



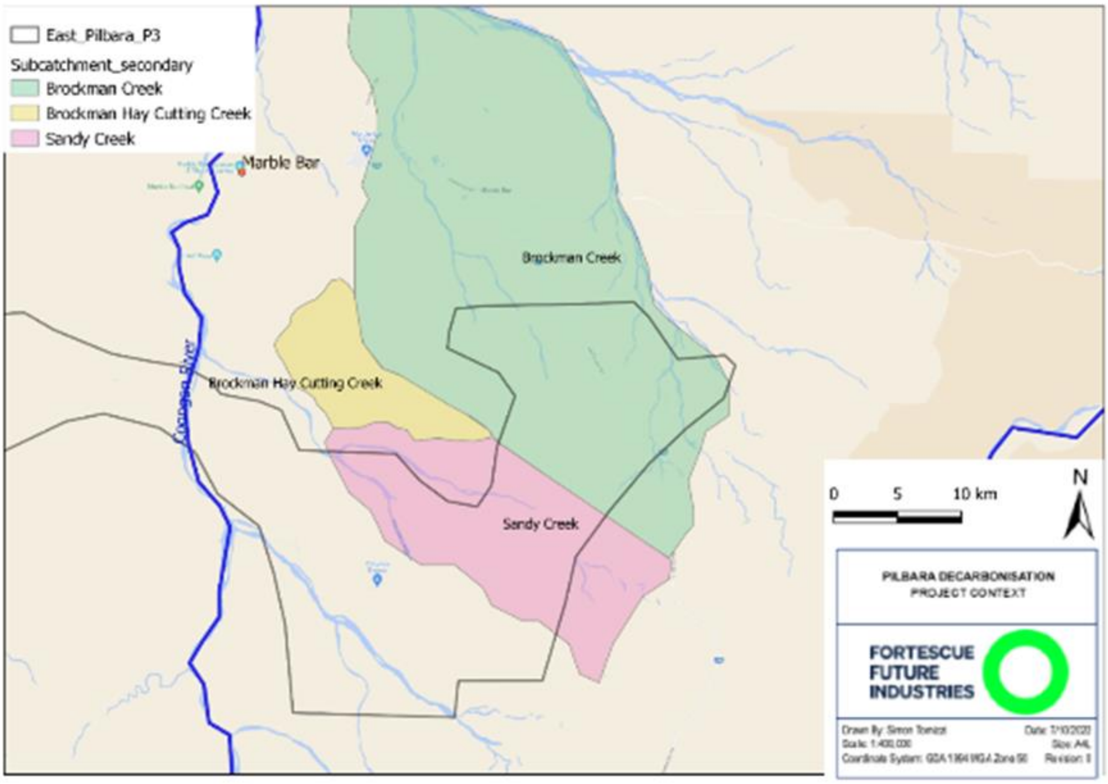
There has been a significant increase in annual rainfall during the 1995-2001 period, with seven years exceptionally wet, with a mean annual rainfall of 500 mm where WA experienced more tropical cyclones than average. Winter rainfall has decreased in the western Pilbara as cold fronts have not reached as far north since the mid-20th century (Figure 5).

2.2 Hydrology

Hydrology Regional surface flow gauging stations (BOM 2022) and include Marble Bar (4106), Marble Bar Comparison (4020), Nullagine (4027) and Redmont (4043) further to the southwest. Rainfall data stations exists at Marble Bar (4106) and Mount Edgar (4021), the closest. Nullagine station also records rainfall data.

In terms of catchment areas and surface water flows, the East Pilbara area is situated in two sub-catchment areas separated by the Warrawoona ridge, acting as a local surface water divide. To the south, are the Brockman Hay Cutting/Sandy and Camel creek with the Brockman Creek to the north (figure below).

Figure 6: Sub-catchment Areas around the Eastern Part of the East Pilbara Area, Southeast from Marble Bar



Note: In the above image, Brockman Creek Catchment area is to the north (green), with Sandy Creek catchment to the south (pink) and Brockman Hay Cutting Creek Sub-catchment wedged in between (yellow). Modified from Calidus, 2019

The southern sub catchments flow towards the Coongan river, some 25-30 km to the west from the East Pilbara area. The combined area for these is 502 km^2. To the north, the Brockman Creek flows towards the Talga River, located 35 km north with a catchment area of nearly 400 km^2 to discharge into the Coongan River. This instead discharges into the De Grey River approximately 100 km north from the project area.

Inspection of the 1:250,000 topography maps within these river basins show no permanent pools within the Brockman Creek sub-catchment nor to the southern sub-catchments.

Flow gauging data across the region indicates the Coongan River (and creeks nearby) are ephemeral with runoff limited to significant rainfall events. Typically, over three quarters of the annual streamflow occurs during January, February and March with local rivers usually drying up around July or August. The closest flow gauging station is on the Coongan River at Marble Bar. The station has an upstream area of nearly 3,750 km^2 and remains open since 1966. Data indicates variable annual and monthly flows with several order of magnitude differences between minimum and maximum values. The Coongan River median annual flow at Marble Bar is in the order of 144 GL/year which represents an average runoff yield of about 11% (Calidus 2019). The highest instantaneous flow of 2,529 m^3/s was recorded at Marble Bar in 1998

(December 16th) after heavy rainfalls earlier that month and includes a two-day rainfall of 239 mm.

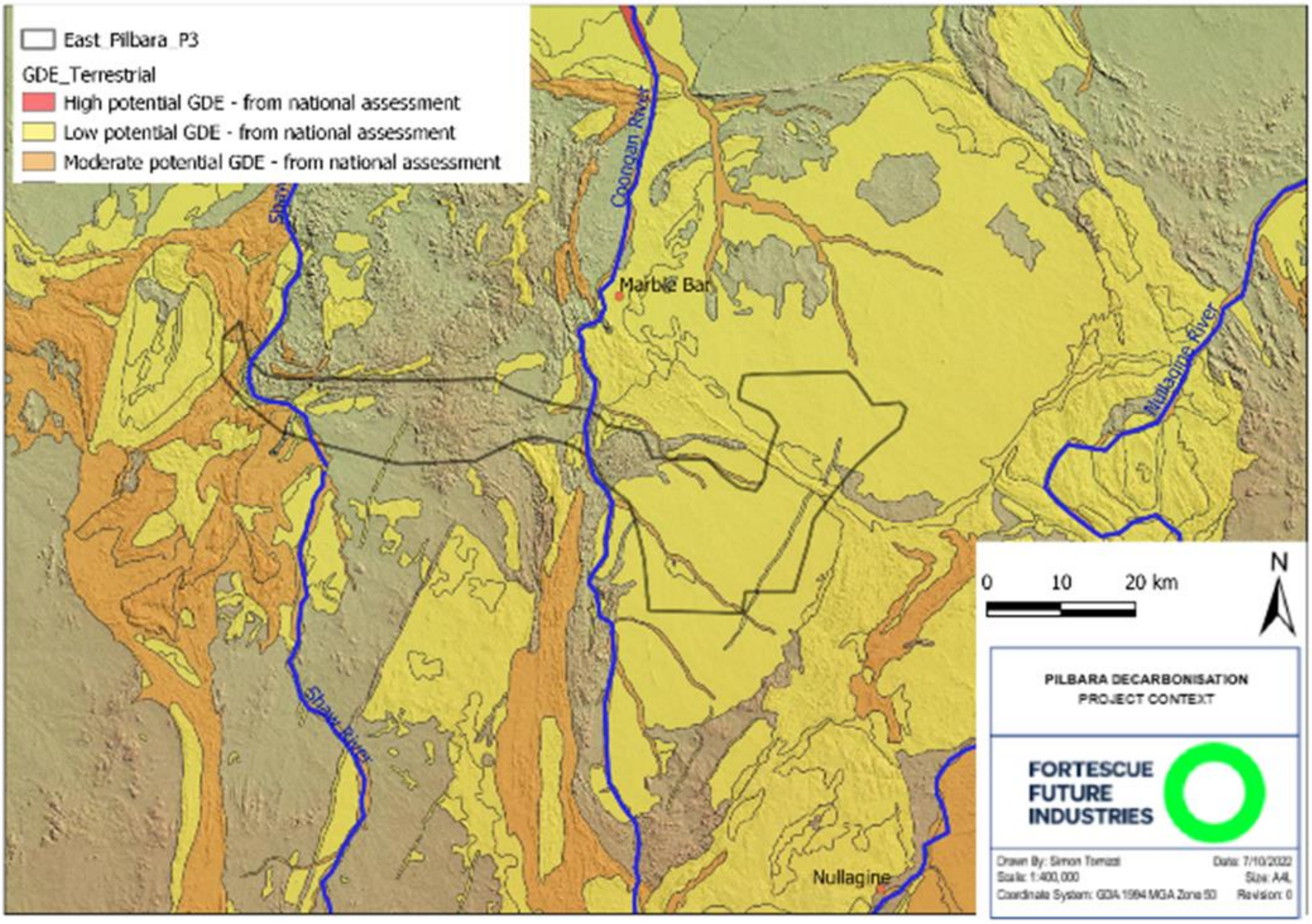
More regional in scale, and although no immediate pools occurring in the East Pilbara envelope a higher density of pools exists within the boundaries of the Coongan River Catchment (DWER 2022) that will likely need to be incorporated into an impact assessment.

2.3 Groundwater Dependant Ecosystems (GDE)

The Bureau of Meteorology cadastre the distribution of Groundwater Dependant Ecosystem (GDE) in the state. At the time of writing, there has been no environmental mapping or surveys to map the existence or distribution of GDEs within the East Pilbara Envelope. Therefore, it is not known whether it may include potential receptors. The area falls within a low potential GDE according to the BOM's national assessment (BOM 2022) (refer to figure below).

Permanent, semi-permanent and intermittent pools may be associated with current day drainage lines. However, no pools were identified during an initial site reconnaissance trip in April 2022 (AUS0311-0000-HG-MEM-0001).

Figure 7: GDE Distribution around the East Pilbara Envelope (Black Polygon).



Note: GDEs mostly of low potential (yellow) with only a slight moderate potential east from Coongan River along the creek.

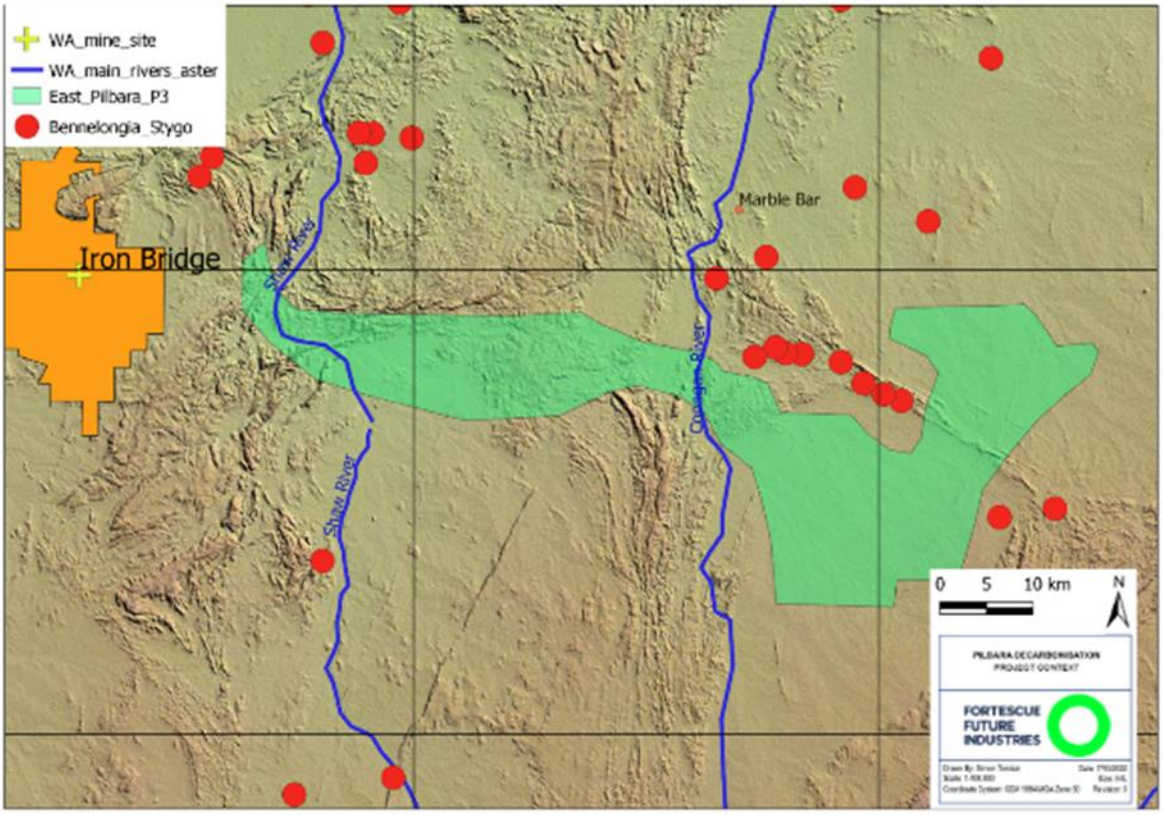
There are no other known significant groundwater receptors around the East Pilbara Envelope, but most likely a survey will be required to dilucidated this to meet DWER requirements.

2.4 Subterranean Fauna

Subterranean fauna is divided into troglofauna (invertebrate fauna living in the aerobic, unsaturated region above the water table and within weathered and mineralised BIF rock types and alluvials) and stygofauna (partially anaerobic, below water table organisms).

FFI Concept Project Team has engaged Bennelongia to conduct a subterranean fauna assessment in the region as part of the environmental approval process requirements. This desktop assessment (refer to the figure below) concluded that further surveying is necessary as there is a lack of data within the envelope. DWER will then evaluate the studies and inform of any tasks to be complete before approval. It is expected that an impact of drawdown analysis into the subterranean fauna (troglofauna, stygofauna) will be required, which will need drawdown calculations. This will be assessed in a separate document. Options for the assessment of a drawdown impact include: an analytical solution analysis where the influence of each bore is considered (high uncertainty, high risk, issues with bore interference unresolved, etc.) or the construction of a small-scale numerical groundwater model.

Figure 8: Subterranean Fauna Records Mapped on to Bedrock Geology



Note: East Pilbara is enveloped in green. Figure modified from Bennelongia, 2019.

A Subterranean Fauna desktop study was conducted in the East Pilbara Project area (Bennelongia, 2022). Most data used for the assessment fell outside the main project area and indicates the need for further detailed subterranean fauna sampling.

Note the overall lack of subterranean fauna except for two samples of stygofauna in the easternmost edge of the area and some troglofauna to the west of the envelope (Figure 8).

Results of the investigations for Stygofauna are summarized below:

- A database search around the project indicates the existence of a rich stygofauna with 914 records, representing 167 species
- The stygofauna community in the search area consists mainly of copepods, amphipods, and ostracods, which represents over 60% of the stygofauna recorded for the area
- Regional scale modelling of stygofauna distribution in the Pilbara related to geology and other environmental factors suggest that suitable habitats for stygofauna are likely to be widespread in the project area however, with the current available biological and geological information is not possible to quantify the stygofauna richness and distribution with confidence.

In terms of troglofauna, the following summarizes the report:

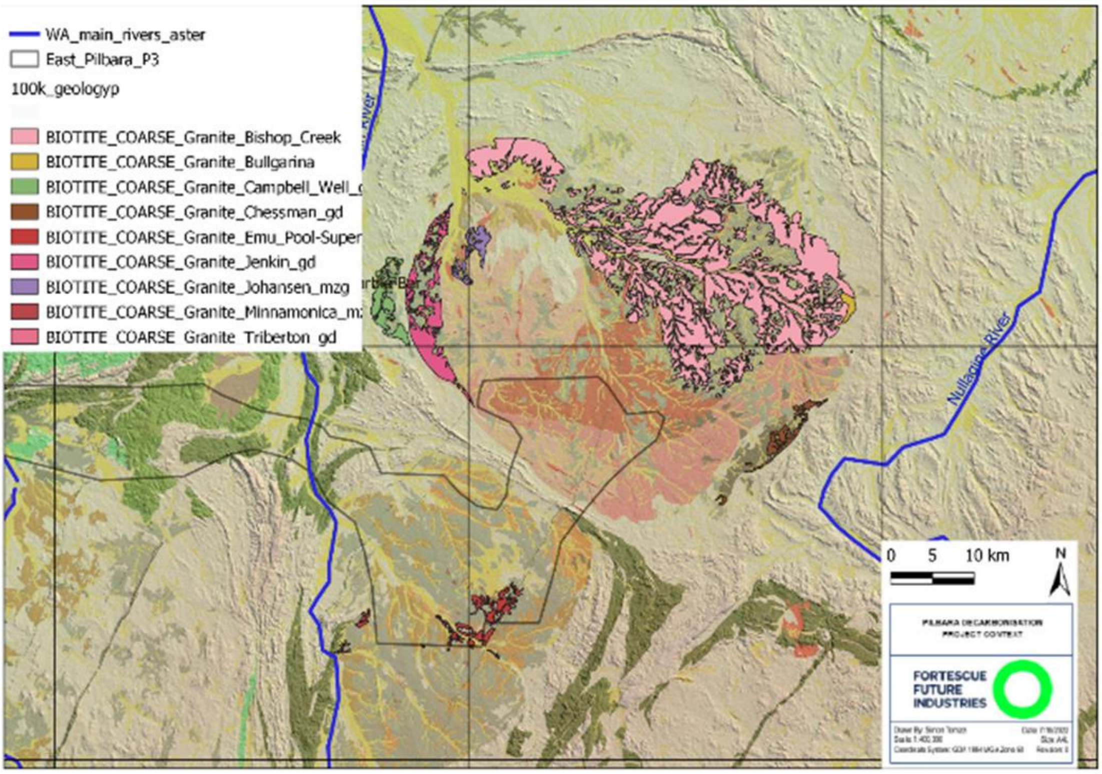
- The database search around the project area identified 346 records, representing 73 species.
- The main troglofaunal groups are cockroaches, beetles and millepedes; these represent more than 70% of troglofaunal recorded in the area.
- Geological characteristics and troglofauna records suggest the East Pilbara area represents suitable habitat for troglofauna. However, the kind of development that will be taking place in the project's envelope poses little threat to troglofaunal as operations will be limited to above ground activities. On this basis it is unlikely there will be a requirement for substantial amounts of troglofaunal survey.

Internal FMG's Approvals team is gathering all other necessary documentation to comply with the Environmental Authority including heritage survey, archaeology, ground disturbance permits, etc.

2.5 Basement and Surface Geology

The project is in the East Pilbara terrain of the Pilbara Craton which consists of a series of granitic complexes intruding greenstone belts formed by metamorphosed volcanic and sedimentary units (refer to figure below). More than half of the East Pilbara envelope towards the east is covered by granodiorites to monzodiorites (different units) and their weathered products (GSWA 1:100k Geology Map). In contrast, towards the west the area is dominated by metamorphosed volcanic sequence including the Kylena Formation and Mount Roe Basalt (massive, amygdaloidal and vesicular basalt and andesites with local komatiitic basalt).

Figure 9: Regional Geology 1:100,000 from the Geological Survey of Western Australia



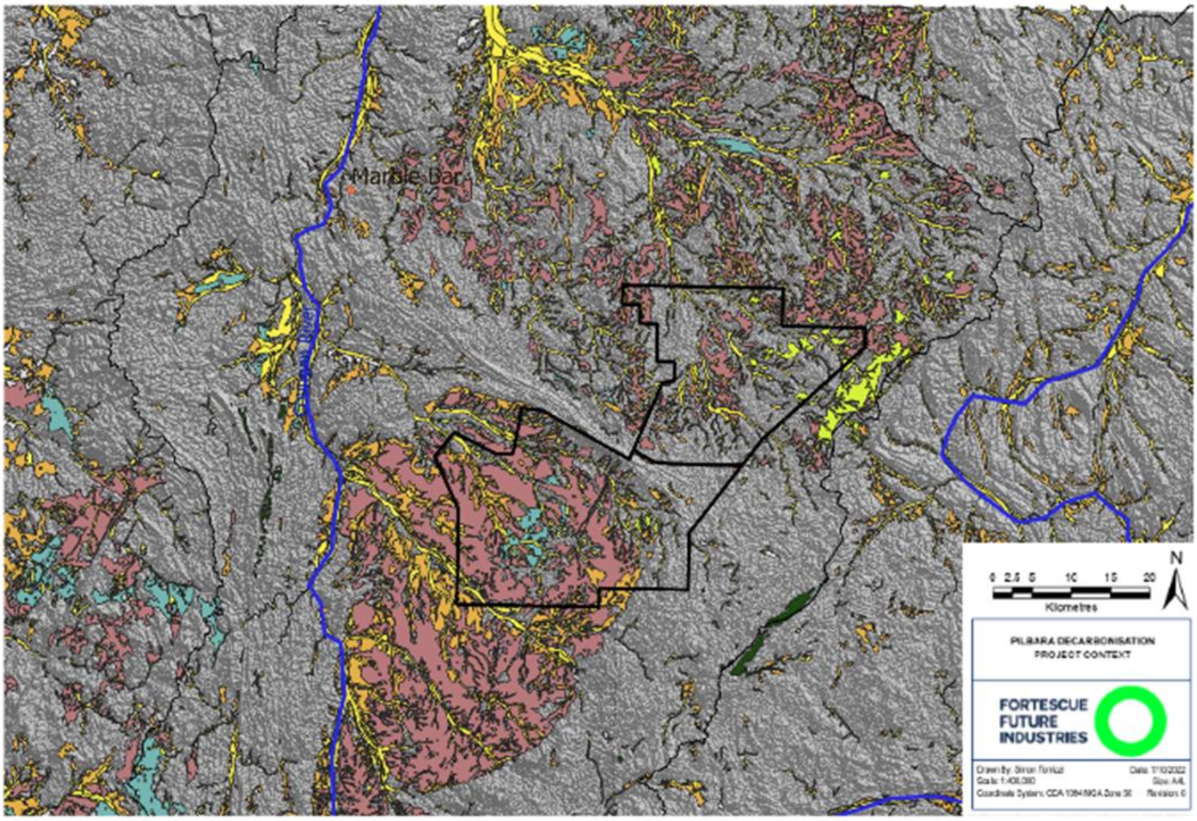
Note: The figure above shows the regional geology 1:100,000 from the Geological Survey of Western Australia highlighting metamorphosed volcanic succession (in green) with intrusive complexes located mostly towards the east and including different varieties of granodiorites to monzogranites (in red, pink) and reworked counterparts (weathered saprolite, in grey) with biotite and fine to coarse grained. Quaternary Alluvials in yellow. East Pilbara Envelope in black. Marble Bar located at the centre-left of the image.

The surface geology consists of Colluvium, formed by scree, gravel, sand and silt and form dissected talus and sheetwash aprons that flank elevated areas of exposed rocks. Younger colluvial and alluvial material form extensive areas of floodplain near the north coast.

Alluvial deposits occupy the present drainage channels, and they have also formed on the floodplains and deltas of major rivers (Ferguson and Ruddock, 2001). They consist of unconsolidated or partly consolidated clay, silt, sand and gravel. In many floodplains areas clayey silt forms an irregular rough surface called 'gilgai' (or crabhole) country characterized by numerous cracks and small sinkholes. Alluvial gravels and sands provide important sources of water for towns, mines, and pastoral stations.

A map showing the distribution of Alluvials, Colluvials is shown below.

Figure 10: Surface Geology Map around the East Pilbara Area



Note: The figure above shows Alluvials (yellow), Colluvials (orange), residual soils above granite (pink), calcrete (light grey) and sheetwash deposits (turquoise). The map sheet is from GSWA series 1:100k. Geology overlap on SRTM model.

3. GROUNDWATER ASSESSMENT

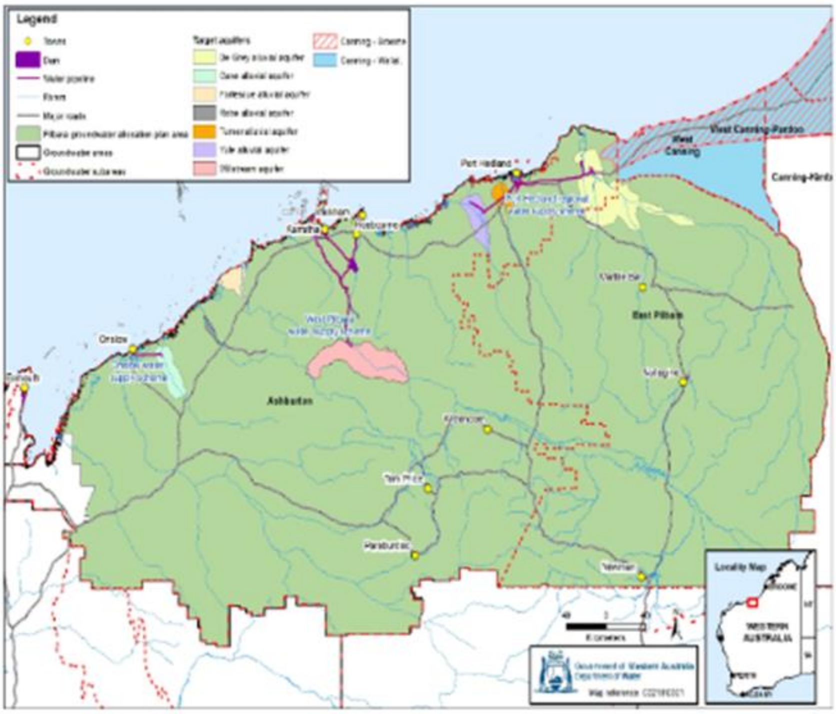
3.1 Hydrogeology

The East Pilbara region is situated within the regional Pilbara groundwater proclaimed area (refer to figure below). The groundwater resources in this area are mainly alluvial, sedimentary or fractured rock aquifers. The main aquifers can be grouped into:

- Tertiary Alluvials, following the larger river systems discharging into the northern Ocean (Fortescue, De Grey Aquifers)
- Fractured weathered bedrock, especially BIF formations within the Hamersley Basin and less explored, within the granite terrain in East Pilbara
- Intermediate depth sheared zones, within the greenstone belt that host metallic mineralization (e.g., Warrawoona)

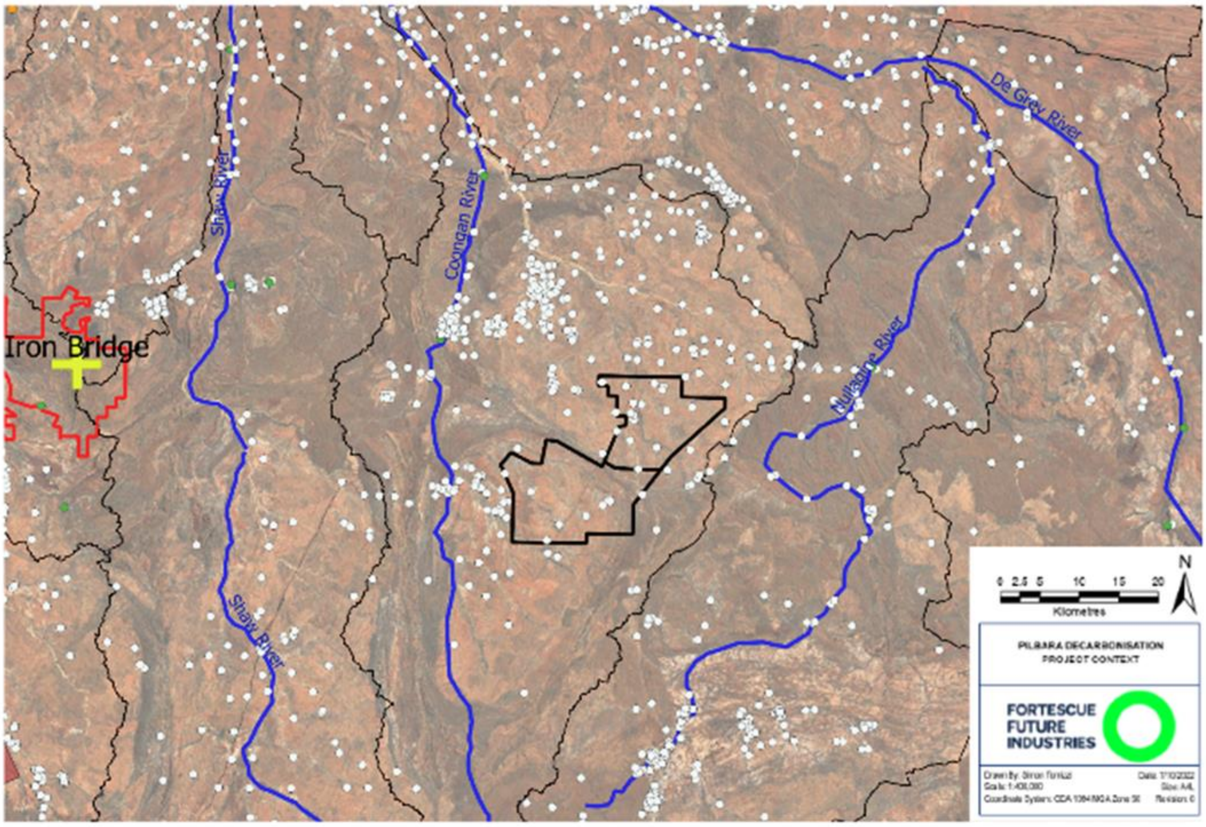
There is limited data related to groundwater resources around the East Pilbara Project area. Corunna pastoral station has a decent water bore distribution with partial information. Water levels at this station are usually found between 2 to 7 m below the ground surface. They are characterized by low yields, with occasional bores producing over 1-2 L/s. Although bore construction details are not known, it is expected they are screened into the shallow Quaternary alluvial aquifer.

Figure 11: Pilbara Groundwater Allocation Plan Area (Adapted from DWER 2022)



An inspection to the WIN database from the Department of Water website (DWER 2022) indicates up to 54 bores have been drilled within the East Pilbara Envelope (refer to figure below). Unfortunately, many bores have been destroyed or abandoned and there is limited groundwater data. From those bores with water level data (no accuracy as for a reference point), most of them show Static Water Levels (SWL) within 0-5 mbgl and fewer, within 5-10 mbgl. This suggests these bores are screened into the top alluvial cover. Salinity ranges from 500-1000 mg/L for bores with shallow SWL, whereas an increase in salinity is observed for bores with deeper SWL(1000-2000 mg/L), and generally towards the west of the East Pilbara Envelope. There are also bores with shallow SWL and higher salinities (2000 mg/L).

Figure 12: WIN Water Bore Database (DWER 2022) in Relation to East Pilbara Envelope



In the figure above, note the scarcity of existing locations within the envelope. Grey code indicates bore not in used.

3.2 Water Quality

A water quality survey was conducted within the East Pilbara envelope early in 2022 (FFI 2022) and four sites were sampled for chemical analysis. Water quality is fresh to brackish with measured electrical conductivity (EC) values ranging from 1,000 to 2,000 uS/cm. Field measurements were confirmed by laboratory Total Dissolved Solids (TDS) values ranging from 557 to 1,270 mg/L.

Most of the elements comply with the Australian Drinking Water Guideline except for Fluoride in one site (No18 well, WIN's ID) and Nitrate, most likely due to its stock purpose and possible contamination with livestock. Higher Uranium, Vanadium and Zinc were reported, but within the drinking water guidelines. They are attributed to local groundwater interaction with granitic basement and weathered granitic material. Total alkalinity is higher than 200 mg/L in all samples with TDS greater than 600 mg/L.

In terms of sub surface groundwater quality, downhole samples results obtained by Calidus indicate fresh to slightly brackish and slightly alkaline for bores drilled into the shear zone next to the pit envelope. Dissolved metals concentrations are generally low except arsenic and iron, attributed to local geology setting. Water in general is very hard and scaling may be a problem if drinking water is considered (Calidus 2019).

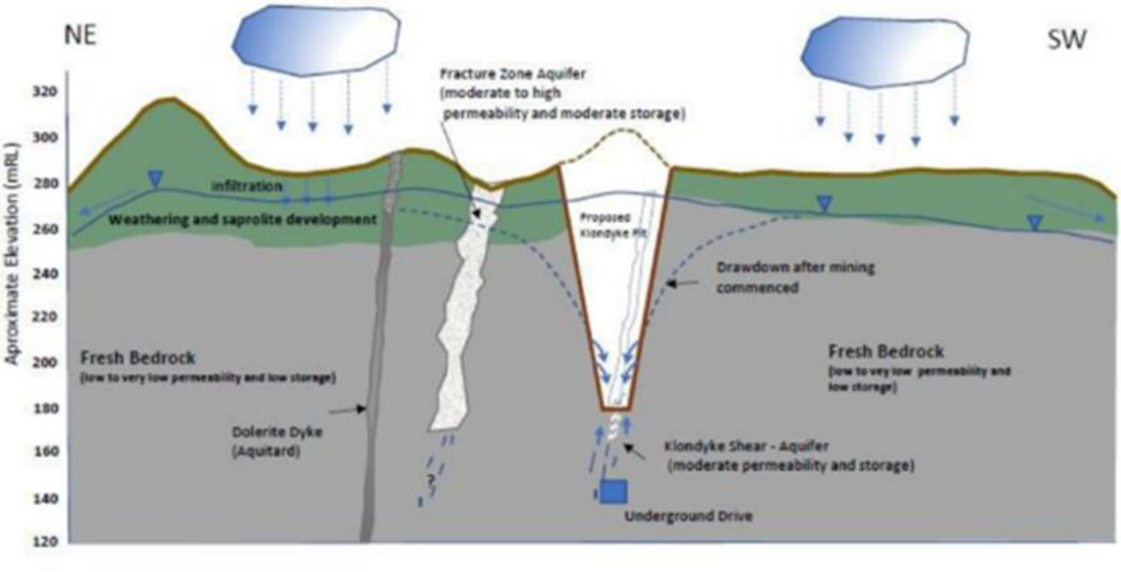
3.3 Hydraulics

A preliminary hydrogeological conceptualisation can be evoked from a nearby (<5 km away) mining project (Warrawoona Environmental Studies) aided with recent scientific advances into Fracture Rock Aquifers (FRA) systems elsewhere (Lachassagne et al 2021). As part of the environmental approval process, the Warrawoona Gold Project (WGP) has completed both surface and groundwater assessments including drawdown impacts after the life of mine.

A three layers model is considered (Calidus 2019) and is composed, from top to bottom, of: an alluvial cover of variable thickness (saturated or unsaturated), a transitional weathered zone within the granitic cover, also called saprolite and the bedrock beneath it (refer to the figure below). The bedrock zone was further divided into two units (upper, lower) for the groundwater numerical model (GRM 2019).

The following hydraulic conductivities were used: Weathering zone/saprolite 0.03 m/d; upper bedrock 0.02 m/d; lower bedrock 0.005 m/d; shear zones 0.3 m/d and high permeability structures 1 m/d.

Figure 13: Warrawoona Gold Project (WGP) by Calidus 2019



Note: the figure above shows the Warrawoona Gold Project (WGP) by Calidus 2019 representing the conceptual model for the mine site. This is located near the East Pilbara Envelope in a similar geological setting. Model comprise three layers: Alluvials, Weathering and saprolite horizon and Fresh Bedrock at depth. Modified from Calidus 2019.

This conceptual model includes a pit void but for comparison purposes, this can be thought to represent the bore field where the abstraction would take place.

The model shows the basic elements of the water balance; (episodic) infiltration taking place through the alluvial Quaternary cover with part of this rainfall water infiltrating into the deeper weathered granite rock (saprolite). Deeper fresh granite of very low permeability and storage except for secondary porosity resulting in fracture zones of moderate to high permeability and moderate storage by means of shear zones, next to dykes, granite/volcanic contacts and quartz veining. The depth of the profile is variable and therefore hard to establish a lateral continuity for the aquifer. These constitute prospective drilling targets, analysed further on in the section.

Drilling programs targeting fractured and sheared bedrock aquifers at the Warrawoona Project have resulted in limited bores able to produce significant yields. Out of a total of 24 bores completed during the hydrogeological investigations, 16 of them (67%) exhibited airlift yields less than 1 L/s with the remaining six (25%) being dry. Sustainable pumping rates are likely to be significantly lower than airlift yields and heavy dependant on rainfall recharge. This information has been used to build the Warrawoona's numerical groundwater model, with hydraulic parameters described in previous section. These parameters are in line with current research on the subject; hydraulic conductivities with values ranging from 0.08 to 8 m/d are not uncommon (Lachassagne et al 2021). Further detail on hydraulic behaviour of fracture rock aquifers is provided in Appendix C.

In terms of hydraulic permeability of these three layers and based on statistical summary of Pilbara-wide data derived from aquifer pumping tests (Kalaka 2020), alluvials have an average of 1.37 m/d while fracture rocks are widely variable with ~ 0.1-1 m/d. Although no testing conducted in the fresh granite rock is available, some data from dolerite sills indicate lower permeabilities averaging 0.74 m/d. These values are indicative only as there is little sample representation to obtain the mean.

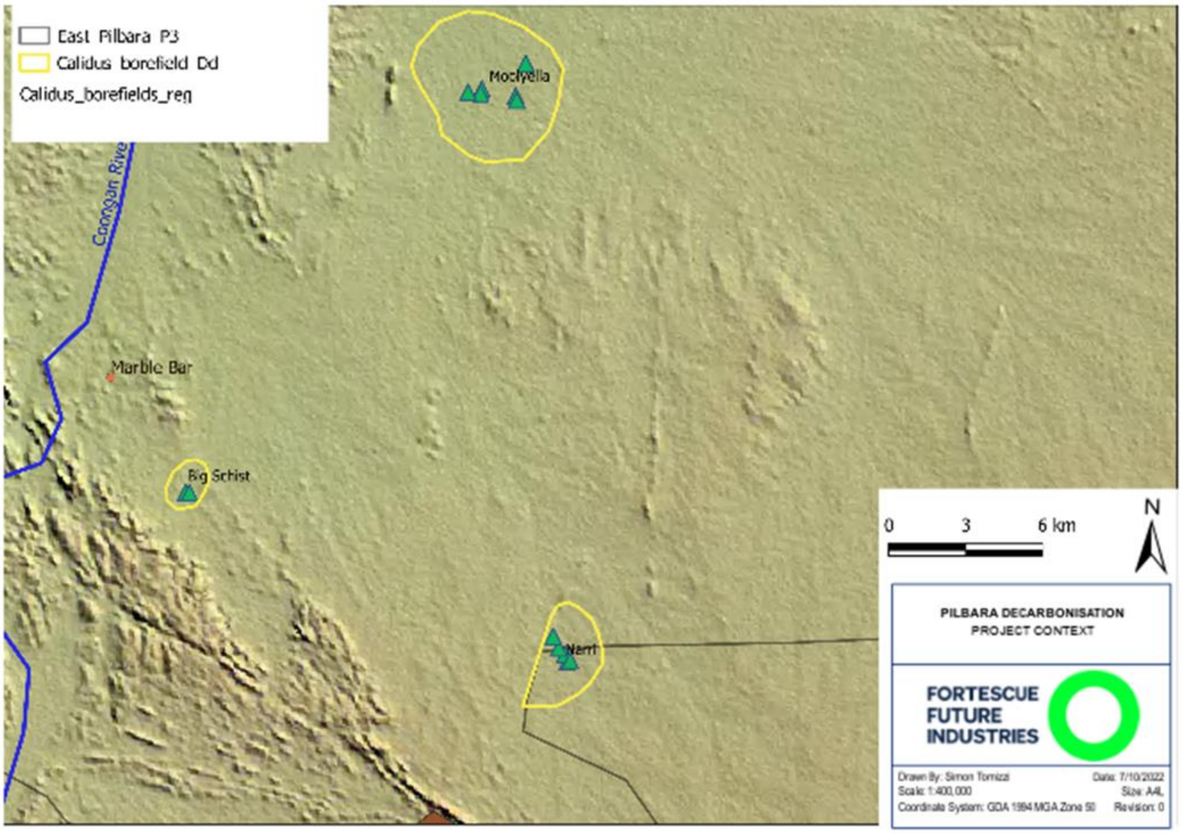
Predicted bore field drawdowns assessment show limited extent and never exceeding 5 km extent (Calidus 2019) due to the low permeability fresh country rock. The borefields are located up to 50 km to the north of the proposed pit (within the centre of the East Pilbara Envelope) and show maximum drawdowns of 5 km at Moolyella, 1.5 km at Big Schists and 2 km for the Narri Aquifer with different drawdown orientations for each of these (refer to the figure below) based on numerical groundwater modelling. Modelling also shows water levels nearly fully recovered at all three borefields within 40 years.

In Summary, drilling in fracture rock aquifer in Australia and elsewhere has been challenging however, relative success has been made to understand these systems to better target waterflow pathways within them. One of the latest reviews on the subject (Lachassagne et al 2021) succinctly described critical elements in these aquifers (Appendix H). A brief summary is presented in the table below.

Table 3: **Main Hydraulic Parameters in Fracture Rock Type of Aquifer (Lachassagne et al 2021)**

Layer	Storativity S	Transmissivity T (m^2/d)	Hydraulic Conductivity (m/d)
Iron crust/duricrust	None	Very low	Very low
Saprolite	1x10-7 to 5x10-6	0.04 to 0.08	
Granite	Highly variable	Highly variable	0.08 to 8

Figure 14: **Modelled Drawdown for Moolyella, Big Schist and Narri Borefields (All Shown in Yellow Polygons)**



Note: the borefields in the figure above supply the Warrawoona Gold Project (brown polygon, bottom). The East Pilbara envelope is shown in the black polygon.

3.4 Groundwater Recharge/Discharge

The groundwater system within the project envelope is limited in storage and is highly dependent on direct rainfall recharge to the local aquifers. The project area receives limited groundwater throughflow due to its location within the upper part of the catchment and a lack of permanent surface water features.

3.5 Potential Water Sources

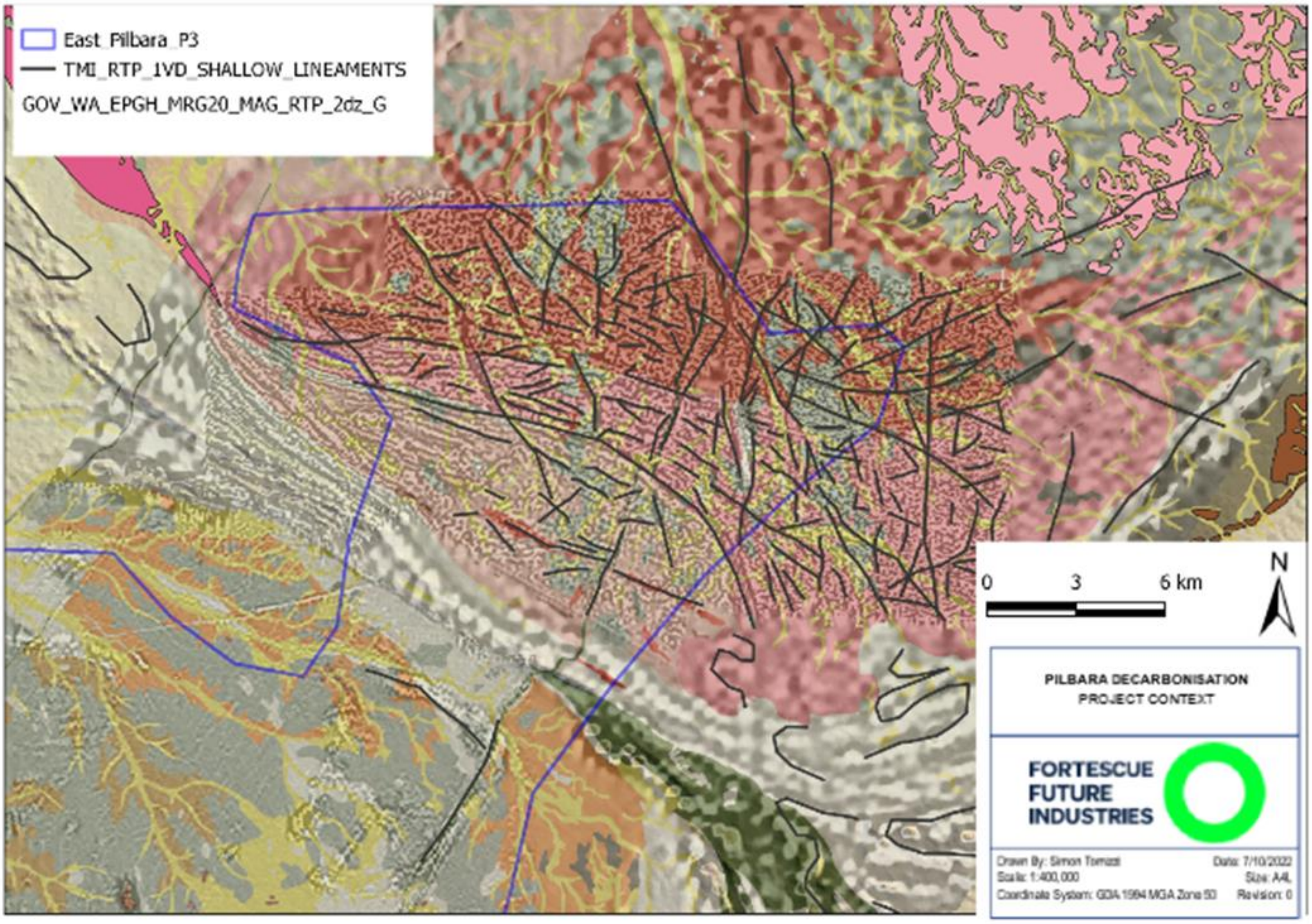
Most of existing data around the East Pilbara area comes from pastoral station water bores (Corunna Downs) plus data from a recently approved gold mine to be built nearby (Warrawoona gold mine). Regional aeromagnetic data flown by the Geological Survey of Western Australia provides further context in term of major structures and geological breaks. These data combined will be the base to infer possible water sources for the project.

One of the challenges of interpreting geophysical datasets in highly weathered regolith is the development of an electrically conductive (clay-rich) overburden which hides the subsurface signal. However, recent advances in instrumentation, data acquisition and data processing has resulted in promising results using SkyTEM method in the Pilbara Terrain to detect for structural features as well as paleochannels (Dauth 1997).

In summary, geophysics can be used as a two-stage targeting tool. A first stage involves an improved structural architecture mapping where potentially flowing structures are identified. This is achieved by using re-processed large scale aeromagnetic surveys (as in the figure below). A second stage (not conducted) involves the refinement of selected (and more regional) scale structural features (highlighted in the airmag survey) by conducting either a higher resolution local SkyTEM survey or a ground resistivity survey, capable of discriminating low resistivity zones (that could or not be correlated with fresh water) in the top 50 m. (e.g., by using ERT electric resistivity tomography). A cost/benefit analysis will help determining which one is best suited for the area.

When overlapping this geophysical vectoring highlighting anisotropies (that could be due to dyke intrusions, subvertical contacts, or large veining) with the distribution of biotite rich and coarse grained (as indicated to be more prone to generate fracturing with weathering) it is possible to identify potential water source that can then be drill-tested (see figure below). Note that a different suit of granodiorite rocks, with not much biotite and more variable grain size occurs at the centre of the image, where the Envelope changes from an east-west to a northern direction.

Figure 15: Re-processed GSWA Aeromagnetic Interpreted Lineaments (Dark Grey, Centre) over 1:100k Interpreted Structural Map (Black Lines)



Note: in the above image, surrounding favourable granitic suits (biotitic, coarse) are shown in shades of red while other granodiorites suites shown in transparency. East Pilbara is enveloped in blue.

WIN data indicates shallow drilling depths, shallow SWL with relatively fresh salinities towards the borders of these biotitic granodiorite suites.

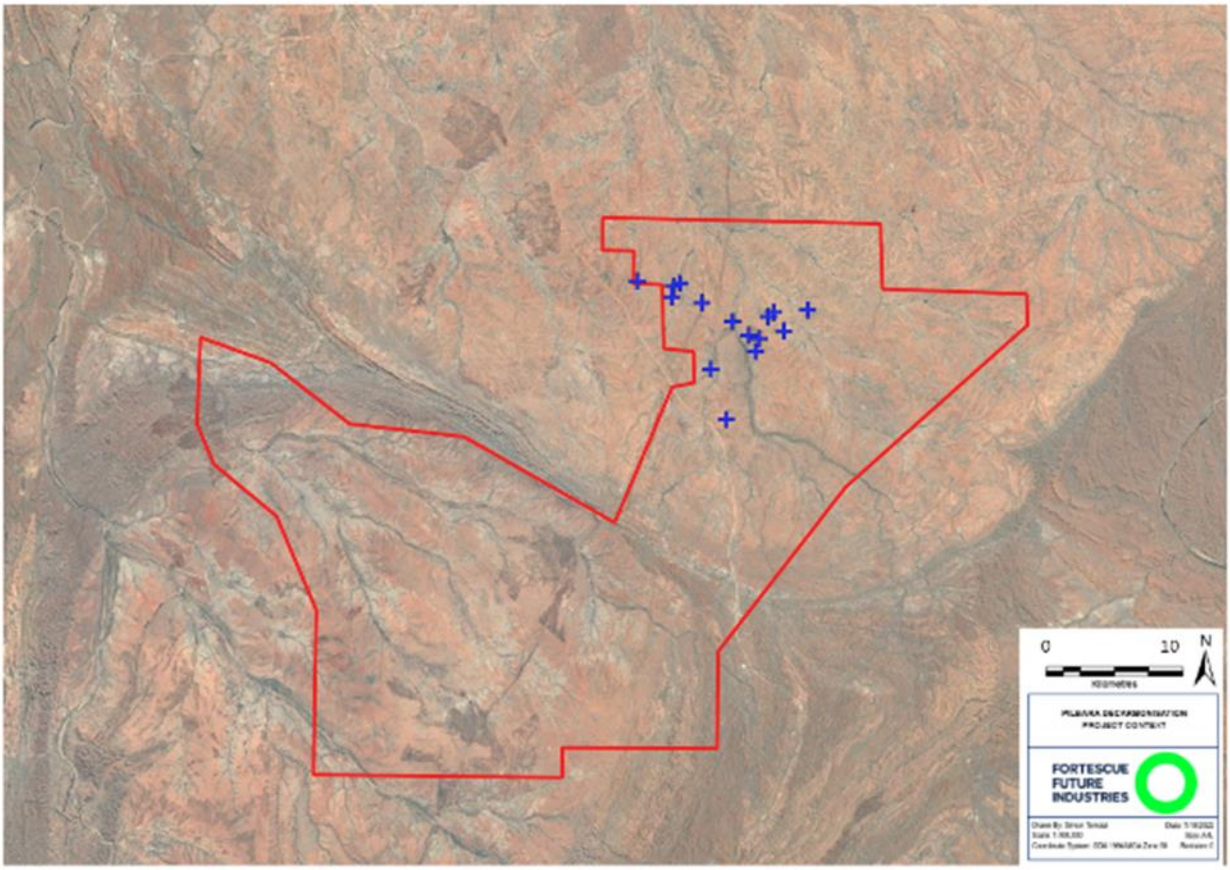
4. PRELIMINARY GROUNDWATER EXPLORATION

A cost estimate for a drilling campaign targeted at identifying reasonably good quality water source from shallow/deep aquifers is necessary to be used for supporting project construction demands (~ 0.6 GL/a). To note, this drilling design is preliminary in nature and based on limited amount of data

At this stage, drilling locations can be suggested but regarded as preliminary only since they include limited data with low resolution (geophysics) that has not been validated on site (e.g., SkyTEM data validated against existing downhole resistivity profiles, measured magnetic susceptibility of weathered and fresh granite on site, etc.). Drilling locations therefore can only serve an estimate cost for the project. They have been given priority and therefore budget estimates can be produced by selecting priority one targets first.

A preliminary drilling program is shown in the figure and table below to assist with indicative budgeting. As new data becomes available the locations and priorities will change. The program includes 15 bores for 1000 m.

Figure 16: Preliminary Drilling Locations for East Pilbara Envelope (Blue Polygon)



Note: in the figure above, locations are shown in red crosses. Overlays are selected 1:100,000 geology granitic units (granodiorites, monzogranites, etc. shown in red tones), weathered granite (grey shades) and alluvial/quaternary deposits (yellow).

Table 4: Preliminary Drilling Targets for the East Pilbara Envelope

Bore_ID	E	N	Depth	Priority	Geology
EP_MB001	813267	7643669	80	1	Weathered granite
EP_MB002	815280	7643387	60	1	Granite
EP_MB003	815639	7643547	80	1	Alluvial
EP_MB004	815189	7642785	60	1	Granite
EP_MB005	816867	7642464	60	1	Granite
EP_MB006	818575	7641412	80	1	Alluvial
EP_MB007	819475	7640649	80	1	Weathered granite

Bore_ID	E	N	Depth	Priority	Geology
EP_MB008	820055	7640466	60	1	Granite
EP_MB009	819856	7639749	80	1	Weathered granite
EP_MB010	820568	7641687	80	1	Alluvial
EP_MB013	821438	7640892	80	1	Weathered granite
EP_MB014	817363	7638755	60	1	Granite
EP_MB011	820867	7641935	80	2	Weathered granite
EP_MB012	822755	7642060	80	2	Alluvial
EP_MB015	818233	7635947	60	2	Granite

The proposed preliminary Priority 1 drilling program is summarised below with preliminary costing for the drilling. This is built upon the existing conceptual design provided by FMG Hydrogeology Team (AUD0311-000-HG-MEM-001):

- 15 x Pilot holes
  - Drilled using standard 6 inches (152.4 mm) RC drilling and
  - Constructed with 50mm ND class 9 PVC casing.
  - Assessed with small scale permeability testing using airlift and falling head methods.
  - An indicative cost (totalling 1000 m drilling) of approximately $250,000 to $300,000 is expected, assuming a slower penetration rate than elsewhere in the Pilbara and in the vicinity of 50m/day for an approximate $12,000 day rate plus mobilisation costs
- 5 x Production Bores
  - Constructed on select pilot bores showing the highest yields (from airlifting and slug tests) and reamed to a conservative 10'' diameter for an 8'' casing (FRP or steel).
  - Constructed with 200mm diameter slotted casing.
  - With submersible pumps installed
  - An indicative cost of $3M to $5M which will vary dependant on materials of choice, availability of water for drilling, access to areas, etc. A final figure will include a 10% from contingency days (downtime, mechanical issues, access issues, etc.)

Liaising with the FMG WWD team would help to narrow down this figure. Options for economic savings can be achieved by a careful selection of materials, depths, hole diameters, etc.

5. RISK ASSESSMENT

The following risks items have been identified as part of this desktop assessment:

- Secure water supply – operational supply may be difficult and may not be sustainable for Life of project
- GDE characterisation – need sub-terranean surveys, pools are present in catchment and might need to be characterised
- Drawdown assessments – will we underdrain pastoral bores or GDE.
- Access to tenure and drilling
- Cultural and heritage values
- Approvals process and timeline – unexpected delays or backlogs in the process could push project deadlines.

6. FORWARD WORKS PLAN AND SCHEDULE

The following schedule in the table below shows a suggested path to obtaining a license to drill for water bores; the first step is to conduct a brief site visit (1-2 days) to check for lithologies (calcrete outcrops, different granite compositions, texture, mineralogy, contacts, and weathering degree), identify and measure (length, thickness, strike, dip, etc.) any structural elements (regional dikes, quartz veins, brecciated zones, highly fractured grounds, and less likely evidence of fault displacement) and any relevant hydrogeological features (pastoral station' bores, any evidence of recent flows, vegetation changes around streams, etc.) with basic sketches (North oriented). Although necessary, it is not essential for the water resource team to conduct this: other teams gathering data around the area can be tasked to record these observations (e.g., geotechnical team).

Table 5: Suggested Schedule for Necessary Surveys to Obtain Water License

Deliverables	Timeline
Site visit	Mid October
Stage 2 geophysics (scoping, field work and results: either high res SkyTEM or Ground-geophysics)	Mid November (risky, as cyclone season kicks in and most companies cease to work until the dry season)
Drilling targeting completed (using ground geophysical targets)	Late November
DWER submission for 26D license	Early December

A second stage, aiming at reducing the drilling risk of not finding any water (not unlikely in these granitic aquifers), is to follow up with a local scale geophysical survey (either a higher resolution, low elevation SkyTEM over the area, or a ground resistivity profile in selected structural anomalies (i.e., or lines previously mapped using existing and reprocessed aeromagnetic datasets) to follow up.

There is likely to be a requirement for survey of stygofauna across the project, particularly where groundwater levels or quality could be affected by the project operations. Based on EPA guidelines for subterranean sampling, it appears that a detailed survey is necessary. This will provide sufficient information about stygofauna habitats and distributions to support environmental impact assessments.

This will enable the completion of a less risky drilling target lists, that can then be submitted to DWER to start with the license application process; first a 26D license to get to drill the targets followed by a 5C license to abstract water. A simple cost/benefit analysis might be needed to decide on the geophysical survey to follow up with, as a ground survey takes longer to complete, could be more expensive but it produces better results in terms of profiling sub-surface electrical contrasts (hence, better chances to find an aquifer).

Lastly, a Permit of Work must be lodged with DMIRS for initiation of works in any location in Western Australia (DMIRS 2022). These usually take three months before approval.

Note the ground geophysics component could potentially be taken off the schedule at the risk of failing to produce any significant water flowing bores out of a proposed drilling campaign. The cost benefit analysis must incorporate this.

7. CONCLUSIONS

The East Pilbara Envelope has been analysed in terms of its groundwater potential. There is limited site-specific data available, however the following conclusions can be made:

- The area is in granitic terrain with water potential restricted to limited weathered bedrock aquifers and thin pockets of tertiary alluvial material. There is potential for the project area to meet the construction water requirements, however long-term operational water supply is at risk due to the fractured rock nature and potential limited recharge.
- Department of Water 's water bore database (WIN) indicate that most bores within the envelope are inactive, and mostly target the alluvials and quaternary cover in the top 0-10 m of depth. They do not penetrate any lower horizons and therefore may not maximise the area's groundwater potential.
- Water levels are shallow and within 5 m deep, with a hard water chemistry, fresh to slightly alkaline water type (arsenic and iron rich). Brackish water appears to correlate with deeper bores and potentially screened into the upper weathered horizons.
- An H2 type of hydrogeological assessment is likely and therefore the need to apply for water extraction licensing must be acknowledged.

Drilling planning should commence during this time as most companies stop drilling when the wet season sets in (usually between December- February). The FMG Water Well Drilling team 2023's schedule is expected to have very few gaps or time windows to drill for FFI. Further liaising with this team is necessary to ensure real chances (and schedule it) of drilling with them. Alternatively, contacting other drilling companies must be considered.

8. RECOMMENDATIONS AND FORWARD WORKS

The following recommendations are suggested:

- To conduct a site reconnaissance visit (1-2 days), to identify key hydrogeological/structural elements and recharge zones that will be useful to plan/corroborate preliminary drilling locations
- To engage the FMG geophysical team to assist with selecting the best technique to follow up on existing regional interpretation from aeromagnetic datasets: SkyTEM or ground geophysics on selected anomalies.
- To ensure legal access to land and permits exists and comply with all regulatory aspects before conducting the survey (i.e., ground geophysics may trigger a ground disturbance permit process).
- To Scope a geophysical survey (decided above) and execute it in 2022Q4, ideally before the wet season starts.
- Having further geophysical vectoring towards potentially water flowing structures (or sub-surface horizons) will help to de-risk the drilling targets in granitic terrain and result in cost saving of drilling dry bores (not uncommon) in granitic terrains.
- Once definite drilling targets are set, the water license application process can be started. Licence 26D and 5C are expected to be lodged with DWER.
- Obtain a Permit of Works with DMIRS.
- Engagement with the FMG internal environmental team is required at this stage (unless outsourced) to complete an Operating Strategy, as required by the DWER with the licensing process to ensure abstraction is being monitored and properly managed during the requested period.
- Licensing processing time is at least six months, during that time advances into the drilling planning can be initiated. Options are doing it internally with the support of FMG WWD team or by external drilling contractor, in which case a SoW must be drafted, and a tender process arranged.
- Once 26D and 5C licenses are approved, the SoW is finalised and set for execution (by FMG or contractors)

- Initially 10-15 pilot bores are to be drilled, with a few them expected to be converted into production bores depending on the success and yields of the pilot holes.
- Drilling program costing is highly uncertain and further refinements will take place once more data gets generated.
- To consider alternative water supply for processing, e.g., closer to Coonan River.

9. REFERENCES

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Appendix A: WA Water Drilling License Process

Table A-1: Summary of 26D and 5C Water License Process and Requirements in WA

Stage	Requirements	Inputs	Outputs	Comments
A	Consider all water management components for project	Project description; conceptual water balance	Conceptual water balance: any water surplus; Critical issues	Water balance categories (significant deficit, deficit, neutral, surplus, significant surplus)
B	Scope of studies; determine level of hydrogeological assessment; EPA impact assessment correspondence; lounge application for 26D license to commence drilling	All available information regarding water resources and critical issues from Stage A	An agreed scope of investigations. A 26D license is issued.	To establish the feasibility of the project's program. Agreement of type of hydrogeological assessment (e.g., H1, H2 or H3) and water balance estimates.
C	Conduct hydrogeological assessment; prepare and submit application for a 5C license; EPA proposal for assessment	5C license application, EPA proposals	EPA's impact assessment resolution	
D	Finalise and submit operational strategy	5C license application and draft of operating strategy	Approved 5C license, nominal water balance	
E	Manage the taking and use of water through the project life	Operating strategy	Adaptive management cycle	
F	Project Closure and decommissioning; management of long-term impacts	Closure plan	Implementation of post-closure management actions	

A brief explanation on these stages is shown below and it is recommended these must be timely addressed when submitting a water license application in the future. Further details on each stage can be found in Appendix B.

Appendix A-2: Stage A

The proponent needs to consider each of the water management components for the project. The purpose is for the project proponent and the Department of Water to establish a common understanding of the proposed project's water requirements and challenges.

The department and the proponent will identify critical issues that may prevent a water license being granted. Key considerations at this stage include identifying:

- Regulatory requirements for abstracting and using water e.g., licensing or permitting requirements under the Rights in Water and Irrigation Act 1914

- Possible sources of water, and their quantity and quality
- Legal requirements for access to water sources
- Water volume and quality needs for the proposed operation, including whether water will be taken for consumptive (processing) or non-consumptive (e.g., dewatering) purposes
- Management of dewatering volumes and use of surplus (either on-site or off-site)
- Broad ecological, social and cultural values that may be impacted by water abstraction, including potential impacts on other local water users
- Need for efficient use of water
- Risks of major flooding.

During this stage, the main input is a description of the proposed project including an initial conceptual water balance. The project description should contain a similar level of detail for the information provided for an EPA referral. The main output includes the proponent's conceptual water balance indicating whether the project is expected to produce any water surplus, identifying critical issues and the proponent awareness of water regulation requirements relevant to the project.

The water balance at this stage should be general and it should include the predicted water balance into one of the following general water demand categories:

- Significant deficit (demand much greater than extractive requirement)
- Deficit (demand greater than extractive requirement)
- Neutral (demand equals extractive requirement)
- Surplus (demand less than extractive requirement)
- Significant surplus (demand much less than extractive requirement)

Appendix A-3: Stage B

The proponent and the department define regulatory requirements under the RIWA 1914 (e.g., 26D license, 5C license or permit requirement) and confirm the scope of studies and investigations for the proposed project.

This stage corresponds with the scoping phase of the Environmental Protection Authority's environmental impact assessment process and approvals required by other government agencies.

Investigative work required by the department, to enable assessment of a 5C license application may be aligned with the information and formatting requirements of lead regulatory agencies to eliminate overlap and duplications. The information to be gathered should allow the proponent to develop adequate management arrangements to address any of the identified water-related issues and provide baseline data for comparison at later stages to determine impacts.

In Stage B, the proponent works with Department of Water to determine the level of hydrogeological or hydrological assessment needed to support a 5C license application, as per Operational policy no.5.12- Hydrogeological reporting associated with a groundwater well license.

The hydrogeological assessment and any additional investigations should be broadly targeted around:

- Understanding the water resource and regime, and potential life of project impacts on the resources, the environment and other water users
- Potential for re-injection, if required
- Establishing baseline information to be used for future assessment of changes
- Informing management strategies such as monitoring and contingencies
- Constructing a hydrogeological model, where required.

Further information on this stage is provided in the Appendix (A2). The proponent may need to lodge one or more applications for 26D licenses to allow commencement of drilling for investigative purposes. The 26D licences to undertake hydrogeological assessment are usually granted, unless drilling poses a risk to the aquifer or the environment, the proposed project is incompatible with a public drinking water source area, or the water resource is fully allocated. Clearing and native tittle issues and access to land are usually addressed by the granting of mining tenements by Department of Mines and Petroleum under the Mining Act 1978. Note that a 26D license for exploration/investigation is not a guaranteed Department of Water will grant a 5C license.

There may be a requirement for 5C license applications to be made for small-scale water abstraction to undertake preliminary investigative works or pump testing. Where this license is required to support exploration/investigation, it would be granted at this stage. Assessment of 5C license applications for the taking of water in the construction and operational stage of the project cannot be completed in most cases until the EPA has completed its environmental impact assessment process.

In this Stage, the proponent is establishing the feasibility of the project proposal- as investigations to determine the sustainability of the water resource, the interactions with water-dependent ecosystems, and impact assessment processes have not been undertaken yet. At the end of stage B, the proponent understands the investigations to be undertaken and the timelines for their completion.

The inputs at this Stage are all available information regarding the water resources and the critical issues identified in Stage A. The outputs, an agreed scope of investigations and regulatory requirements. Section 26D licenses for exploration/investigation are granted to enable hydrogeological assessment. Agreement should be reached between the proponent and the department of the level of hydrogeological assessment and other investigations required, with a timeline for completion of these investigations and a predicted water balance.

Appendix A-4: Stage C- Water License Application and EPA Assessment

In this stage, the proponent conducts the hydrogeological assessment and other investigations agreed upon in stage B. The proponent prepares and submits an application for a 5C license to DWER for the project stage. The application needs to be supported with all relevant documentation before the assessment may be undertaken. When a proposal has been submitted to the EPA for assessment, the EPA may require environmental review documents (e.g., water management plans and/or other requested documents) to contain information on the hydrological and hydrogeological setting and how any water issues will be managed to prevent significant environmental impacts.

The department provides input into the EPA's assessment process and where possible, the department will align assessment of the water license application with the relevant agencies (EPA, DEC) where there are shared water-related issues. Department of Water is constrained from making decisions on water licences and permits that allow the project to be implemented (e.g., granting a 5C license for the operational stage or a project), while the proposal is undergoing EPA assessment.

When preparing information to support the EPA's environmental impact assessment process and the water license application (e.g., the hydrogeological assessment), the proponent needs to outline what the water management objectives and outcomes are, and how the water resources will be managed over the life of the project. The information regarding water management objectives and outcomes may be requested by the department, in support of the license application, where:

- The project has complex water requirements across the life of the mine
- It is required by the EPA and/or other regulatory agencies (e.g., environmental review documents and mine closure plan submitted to support the mining proposal application)
- The proponent needs to demonstrate the basis of contingencies to address impacts on water resources or adopt leading-practice water management
- There are benefits for both the proponent and the department, in developing and communicating water management objectives and outcomes, including:
- It provides clarity on the water management approach for the life of the project, including any regulatory requirements or commitments, which can be used in the finalisation of the operating strategy in Stage D
- It outlines monitoring requirements and adaptive management mechanisms, including trigger, response and contingencies, and the reasons for them.

A checklist of issues to be considered during this stage is presented in the Appendix (A3). This stage C marks the beginning of the assessment process for a 5C license under the RIWA 1914. The proponent needs to submit 5C license applications for the project during this stage. Applications for a 5C license that do not meet the department's requirements cannot be assessed, and the department may ask proponents for further information, reject their applications, or return them for not supplying sufficient information (refer to Operational Policy no.5.11-Timely submission of required further information, Department of Water 2009b).

Proponents can reduce the risk of delay or no-approval or projects by engaging with the EPA, DEC and the department in stages A to C, and following the guidelines presented. The proponent may consolidate the reports submitted by incorporating the water balance and the water management objectives into the hydrogeological assessment. The information will contribute to the finalisation of the operating strategy and the water license decision in stage D.

Applications for 26D licenses, preliminary water abstraction licences associated with investigations and infrastructure setup will continue to be considered and assessed when required by the department.

The input during this stage includes section 5C license applications for the mining project (and section 11/17/21A permit applications, where necessary). In stage C, the proponent undertakes the investigations and submits the required information and reports (e.g., hydrogeological, environmental and/or social impact assessments) that were scoped in stage B. The main stage C output (i.e., the completion of the EPA's environmental impact assessment process and the EPA's decision on the proposal) is dependent on the required information and reports being submitted by the proponent so an assessment may be undertaken.

Defining the water management objectives and outcomes is an essential output of this stage, providing a framework for adaptive management of the life of project.

Appendix A-5: Stage D- Development of an Operating Strategy and Final License Decision

In this stage the proponent finalises and submits an operating strategy, incorporating relevant conditions and commitments under ministerial statements (based on the EPA's assessment in the previous stage) and setting out in detail how water will be managed over the life of the project. The operating strategy needs to include a detailed water balance and dewatering schedule and incorporate a monitoring and reporting program against set water management objectives and triggers. Water efficiency, contingency and mitigation strategies also need to be identified in the required document.

Information on infrastructure (e.g., pipelines and water distribution systems) and project plans is required to provide a baseline from which Department of Water can review and assess reports submitted by the proponent. Accurate measurements of abstraction and water use data across the mine site enables the department to reconcile the water balance and assess targeted and actual performance. The Department of Water will assess the proponent's operating strategy and may negotiate changes to ensure it adequately addresses agreed water management objectives and outcomes, including EPA or other regulatory agency decisions.

After approving the operating strategy, the department finalises the assessment of the 5C license application, considering information provided in supporting documents, including the operating strategy. The operating strategy is related to the license and is legally enforceable through license conditions. The operating strategy and water balance provides clarity on the mine operations until the end of the project and needs to be based on the best currently available information. The water balance should be updated when actual data is obtained from mine operations, leading to adaptive management and improved knowledge of water resources. This will assist progression into the closure stage, by ensuring actual effects can be related to predicted impacts and recovery rates.

Stage D inputs include 5C license applications (and permit applications, where relevant), all supporting information, including water management objectives and outcomes, and a draft operating strategy. Outputs include approved 5C license(s) with licence conditions (and permits, where relevant) granted under the Rights in Water and Irrigation Act 1914, the approved operating strategy, and a nominal water balance.

Appendix A-6: Stage E- Construction, Operation and Closure Planning

During this stage, the proponent manages the taking and use of water, in accordance with the license and the approved operating strategy, throughout the life of the project. This typically involves regular monitoring, reporting by the proponent to Department of Water and other agencies, as required, and using adaptive management practices.

Before the end of the project life, the proponent will need to review and finalise the closure plan, where necessary. This is the stage where monitoring data will enable ongoing analysis of impacts and confirm whether the required management outcomes are met. The proponent will need to consider the water requirements, if any, for the post-mining stage of the project and apply to amend or relinquish the 5C licenses to take water when active abstraction ceases.

Stage E inputs are the operating strategy and license conditions finalised in stage D. Among the outputs are an adaptive management cycle for the life of the project, including reports at agreed intervals, and proposed changes to the operating strategy and monitoring programs, where necessary. By the end of the operational stage, the output is the project closure plan and an agreed scope of works for decommissioning the project's water-related assets and rehabilitating the site.

Appendix A-7: Stage F- Final Closure and Decommissioning

In this stage, the proponent scales down operations and manages long-term impacts of the operation beyond the life of the project. The proponent is responsible for implementing the closure plan, undertaking monitoring and decommissioning, rehabilitating the site and adaptively managing the post-closure impacts on the surrounding water resources and environment. The proponent will review their water licensing requirements for undertaking project closure and rehabilitation works and apply to amend or relinquish any water licenses relating to the operational stage.

Management of impacts active the project has ended is an important component. Longer term management of environmental impacts is continued by the EPA, DEC and/or DMP based on the commitments and actions in the closure plan. The main concerns for the Department include:

- Verifying water resources, neighbouring water users and the environment are not impacted unduly by the project, as evidenced by baseline monitoring
- Ensuring the proponent has a strategy for decommissioning water bores and closure of water storage facilities and dams when no longer required
- Ensuring impacts on water resources from the containment of tailings (e.g., seepage, runoff or erosion) are managed by the proponent.

In many cases, proponents may negotiate with pastoral lease holders or other nearby mining companies or irrigators for use of surplus water beyond the mine life. However, if an agreed outcome with a third party cannot be reached, water will need to be disposed of in a way that will not cause any detrimental impact to the water quality of the surrounding catchment or groundwater area.

Inputs at this stage is the closure plan and scope of works to be implemented for closure, decommissioning and rehabilitation. Amendment of water licenses relating to the operational stage would be required when the active mining stage ends. The output is the implementation of the post-closure management actions.

FORTESCUE FUTURE INDUSTRIES

Appendix B: Water Licensing Preliminary Consultation Guide-Stages A-F

Table B-1: Preliminary Consultation Guideline

Component		Preliminary Consultation
A.1	Water Demands	Consider the potential water demands for the mining project. Consider: • Intended scale • Estimates of water use • Duration of project
A.2	Water Source Options	Consider the potential water sources, and water quantity and quality requirements for the mining project. Options include: • Groundwater • Surface water • Recycled or reused water • Surplus water (e.g. from dewatering) • Third-party supply (e.g. from other mine operations) • Desalination • Scheme water supply • Local or remote supply • Non-potable or potable water, noting that public drinking water source areas and/or drinking water source protection plans may exist or be required to protect drinking water supply
A.3	Water Access Options	Consider the legal requirements for access to each water source option, including: • Access to the land • Public drinking water source areas • Native Title Act 1993 requirements • Ecological and cultural assets and wetlands • Appropriate tenure (mining tenements) under the Mining Act 1978 • Pastoral leases
A.4	Water Quality	Consider the water quality risks. Potential concerns include, but are not limited to: • Mining in areas where pyritic overburden or waste occurs • Mining in areas where ores with sulphides are evident • Water level changes in acid sulphate soil environments • Potential for solutes to be released through non-acidic reactions • Mining in areas where saline groundwater or surface water is present • Impact on receiving water body due to discharge of surplus water
A.5	Water-dependent Ecosystems	Identify and map the location of potential water dependent ecosystems, extending beyond the mine footprints to capture the potential drawdown area. Both mapping and values assessment is necessary for the proponent to capture any critical risks to water-dependent ecosystems. Risks should be considered in terms of the effect of the mining activities on the ecosystems and on ecosystem value. Water dependent systems include but are not limited to: • Surface water and surface expressions of groundwater (wetlands, watercourses, floodplains, lakes, salt lakes, springs, seeps and soaks, river base flow, river pools) • Vegetation (e.g. groundwater or surface water dependent, riparian, terrestrial) • Cave and aquifer ecosystems (e.g. stygofauna) The *Australian groundwater-dependent ecosystems toolbox* (Sinclair Knight Merz 2011) provides further guidance.

Component		Preliminary Consultation
A.6	Other water-dependent values	Identify and map the location of water-dependent social, cultural and economic values of the project area, near the mine footprint and its water resource. This includes but is not limited to: • Sites of Indigenous value • Sites of other social, cultural or historic value • Public drinking water source areas • Other water users and industries (such as agriculture)
A.7	Critical risks to water-dependent values	Consider existing information on the features that are present and their significance. Identify the knowledge gaps for which field survey and/or consultation will be needed to fulfil Stage B. Consider the potential risks to each use from the proposal, including: • Drawdown impacts (including changes in water level) • Water quality impacts (including to public drinking water source areas) • Through-flow impacts • Discharge impacts
A.8	Cumulative impacts	Consider the potential cumulative impacts of the proposed project and other operations. Consider: • Other mining operations within the catchment • Other water users in the area • Proposed operations within the catchment (where publicly available information exists (e.g. public environmental reviews) • Opportunities for cooperation
A.9	Baseline Information	Consider what information is already available in the area (all sources), to use as baseline data, and identify critical information gaps. Where critical information or data is lacking, consider establishing monitoring as soon as possible. Consider: • Existing hydrological and hydrogeological information • Existing environmental, social and cultural information • Meteorological data • Drilling information • Pre-development water regime of water-dependent values • Risk of major flooding
A.10	Water Balance	Consider the likely balance of water use and potential water supply, at a conceptual level, noting estimates may be indicative as the proposal is still undergoing feasibility studies. Consider: • Potential quantity and quality of the water • Dewatering requirements, and if the mine site is expected to produce mine dewatering surplus • Major water uses • Supply options (where mine dewatering does not meet demand)
A.11	Allocation Plans (Department of Water)	For areas where allocation plans have been developed, refer to them for information about water allocation and local licensing policies (e.g. related to water-dependent ecosystems). Allocation plans are available at the department's website and further information can be attained from the appropriate regional office.
A.12	Other Regulatory Agencies	Identify what issues are to be dealt with by the department and which are the responsibilities of other agencies. Consider the role of the: • Office of the Environmental Protection Authority • Department of Mines and Petroleum

Component		Preliminary Consultation
		• Department of Environment and Conservation • Department of Indigenous Affairs • Department of State Development (state agreements) • Department of Regional Development and Lands (Pastoral Lands Board) • Economic Regulation Authority (licensing of water service providers) • Department of Health (public health relating to water quality) • Department of Agriculture and Food (potential reuse of mine dewatering surplus)
A.13	Stakeholder Consultation	Identify any critical stakeholders for consultation. Consider: • Water service providers • Indigenous groups • Community groups • Local water users (other mines or different industries) **Note:** Public review and comment provisions occur under the *Environmental Protection Act 1986* and *Rights in Water and Irrigation Act 1914.*

Appendix C: Preliminary Consultation Guide- Stage B

Table C-1: Project Scoping Guideline

Component		Preliminary Consultation
B.1	Water Access	Investigate the access options for all water infrastructure related to the mining project. Consider: • Points of abstraction, including the estimated volumes (per annum) to be taken from each location and water source • Infrastructure pathways (pipeline and road impact on streams) • Taking of water in water source protection areas • Land access • National parks or other estate • Potential monitoring sites • Public drinking water source areas • Native title areas (claims and determinations)
B.2	Exploration for Water Sources	Assess requirements for a 26D license. Licensing is required for all confined/artesian bores across the state, and for all bores in proclaimed groundwater areas, unless an exemption applies. A 26D license is required for: Constructing a bore or well (see note below for monitoring bores) Altering a bore or well (see note below for monitoring bores) Constructing bores for re-injection purposes. **Note:** non-artesian monitoring bores are currently exempted from licensing based on the Rights in Water and Irrigation Exemption (Section 26C) Order 2012. Considerations include: Refer to report Minimum construction requirements for water bores in Australia (National Uniform Drillers Licensing Committee 2012) for best practice guidance on bore construction and/or decommissioning a bore. Investigations including exploration drilling and testing may be needed to locate and characterise aquifers, confirm yields and determine the effects of the proposed abstraction, to support a 5C application and the assessment processes undertaken by other regulatory agencies. The proponent should be identifying key groundwater or surface water features where triggers, thresholds or limits may be applied to characterise water interactions with the environment, and develop water management objectives and mitigation strategies in the next stage of the assessment process.
B.3	Water Source	Investigate the sustainability of the water source options for the project. Consider: • Local and regional hydrogeology and hydrology of sources • Groundwater and surface water connectivity • Recharge • Reliability • Water quality • Impacts of abstraction regimes on bore pressures of adjoining water users, including community water supply and stock bores • Minimisation of impacts on the water resource and the environment • Regulatory requirements for abstraction • The relevant water allocation plan for the area • Drinking water source protection plans, where relevant • Requirements of Operational policy no. 5-12 – Hydrogeological reporting associated with a groundwater well licence (Department of Water 2009c) • Reusing mine dewatering surplus on-site, or off-site where availability exceeds demands

Component		Preliminary Consultation
		• Alternative sources of supply to maximise reuse and efficiency
B.4	Fit-for-Purpose Water Use	Investigate lower quality water-use options for the project. Consider: • Minimum standards of water quality for different purposes • Infrastructure changes enabling the use of lower quality water • Benefits such as security of supply and avoidance of adverse effects at other sources • The availability of fit-for-purpose water • Water efficiency, refer to Operational policy no. 1.02 – Policy on water conservation / efficiency plans – achieving water use efficiency gains through water licensing (Department of Water 2009a) • Any opportunities to re-use or recycle water
B.5	Alternative Sources	Investigate alternatives to the traditional surface and groundwater sources. Consider: Suitability of non-potable supplies Opportunities to reuse or recycle water at all stages of the mine operation (e.g. treated wastewater for processing, dust suppression) Possible provision by a third party Trading options, as per Operational policy 5.13 – water entitlement transactions for Western Australia (Department of Water 2010).
B.6	Dewatering	Investigate dewatering needs for mining below the watertable, if applicable. Consider: • Planned dewatering schedule and estimated volumes • Impacts of abstraction regimes, including reduction of water levels on existing users, such as community water supply and stock bores • Local and regional hydrogeology and hydrology of sources • Groundwater and surface water connectivity • Minimisation of impacts on the water resource, environment and other water users
B.7	Optimising Water Use	Investigate water optimisation options for mines, with surplus water from dewatering. Consider: • Mitigation of environmental impacts, considering the suitability of the receiving aquifer (i.e. aquifer re-injection, or surface water/GDE maintenance) • Efficient on-site use (including processing and dust suppression) • Opportunities for use by other mining or non-mining projects
B.8	Water Use Efficiency	Investigate infrastructure methods to achieve water use efficiency. Consider: • Major infrastructure options • Phasing of different water use activities • Engineering alternatives • Alternative bore field configurations to minimise water wastage • Minimising water use for dust suppression • Use of mine voids for water storage • Methods to prevent water losses due to evaporation or leakage • Refer to Operational policy no. 1.02 – Policy on water conservation/efficiency plans: achieving water use efficiency gains through water licensing (Department of Water 2009a)
B.9	Integrated Water Management	Investigate the opportunities for integrated water management at: • Port operations • Rail operations

Component		Preliminary Consultation
		• Mine operations • Other supporting infrastructure • Non-mining projects (e.g. agricultural land or pastoral leases)
B.10	Water Dependent Ecosystems	For the water dependent ecosystems identified at stage A, investigate: • The pre-mining condition of water-dependent ecosystems • Investigations, monitoring or consultation undertaken to fill any knowledge gaps • The water regime required to maintain values (e.g. pre-abstraction regime) • Changes to the water regime from the mining proposal • Impact of the predicted water regime on the values • Options to minimise or avoid impacts • Consultation or agreements with local communities and landowners • Approvals from other agencies for unavoidable impacts (or offsets) • To identify impacts on water-dependent ecosystems and support the reporting requirements, consider the design of hydrological and hydrogeological investigations and models. • This may require: • Hydrogeological conceptual models showing the interconnectivity between groundwater and ecosystems (e.g. exact locations of no-flow boundaries, absoluteness of confining layers at a local scale) • Identifying if the groundwater model is fit for purpose for GDE impact assessment • Discussion of the reliability or uncertainty of groundwater modelling results and their effect on the GDE impact assessment **Note:** Information on water-dependent ecosystems and values may need to be reported to the EPA as part of the environmental
B.11	Other Water-Dependent Values	For the water-dependent Indigenous, social, cultural or economic values identified at stage A, investigate: • The significance of sites and values (a socio-economic study may be required – these sites and values may need to be reported to the EPA as part of the environmental impact assessment process) • Water regime (water levels or flows) required to maintain values (e.g. pre-abstraction regime) • Changes to the water regime from the mining proposal • Impact of the predicted water regime on the values • Impacts on other water users and industries (current and prospective), including the impact on water availability in the area • Options to minimise or avoid impacts • Consultation or agreements with local communities and landowners • Approvals from other agencies for unavoidable impacts Note: approval under the Aboriginal Heritage Act 1972 is required before an Indigenous site can be disturbed. Proponents should consider water-related and spiritual values of these indigenous heritage sites.
B.12	Water Quality Impacts	Investigate potential impacts of operations on water quality. Consider: • Public drinking water source areas and drinking water quality protection requirements to avoid potential contamination from high-risk activities (e.g. fuel storage or tailings facilities) • Any presence of acid-forming material • Source materials or conditions (including metals and sulphate) that may lead to contaminant discharge or non-acidic drainage • Tailings facility design and management • In situ leaching o recovery design • Turbidity, salinity and acidity impacts • Baseline water quality of receiving water bodies (and relevance of ANZECC guideline for water quality during operations noting that some background levels may exceed the ANZECC guidelines)

Component		Preliminary Consultation
		• Buffering and mitigation capacity of the receiving environment or water bodies that receive water of a different quality or pH • Designing baseline monitoring programs (to provide definition of local water quality and triggers) • Defining water quality triggers for operations and emergencies • Water quality protection notes are also available at the department's website and provide information about how to protect water quality. **Note:** DEC is the primary regulatory agency for point source pollution and contaminated sites, based on the Environmental Protection Act 1986 and the Contaminated Sites Act 2003.
B.13	Water Release or Reuse Options	Investigate the options for release or reuse of mine surplus water. Consider: • Relocation for use nearby • In-pit storage (for reuse or infiltration) • Sub-surface re-injection or managed aquifer recharge • Controlled discharge • Uncontrolled discharge • Catchment or aquifer modification • Stream realignment • Local rules or policies in the relevant water allocation plan Refer to Department of Water's Strategic policy 2.09 – Use of mine dewatering surplus (2013).
B.14	Releasing Water	Investigate the potential impacts of releasing water to the environment. Release of water from the mine stie needs to be planned, controlled, monitored and communicated, including proposed emergency actions during extreme weather events or floods. Consider: • Minimising the volume of water for discharge, through separation of clean and dirty water on-site • Likely releases, including the location of release points • Receiving-water-points water regime • Monitoring requirements (pre-, during, and post-mining) to determine the impact of releases on the receiving environment • Changes in water release regime throughout the life of the project • Ecosystem impacts • Likely stream morphology changes • Seasonal changes • Flood events (taking into account predictive climate models in the design of mining, infrastructure, such as tailings, dams to accommodate a greater scale of storm events on-site) • Sensitivity of receiving water-dependent environments • Scale of impact downstream • Cultural and social impacts of release, and Aboriginal Heritage Act 1972 legal requirements Note: DEC usually regulates dewatering discharge through the licensing provisions of the Environmental Protection Act 1986. In circumstances where DEC does not have regulatory control, the Department of Water may recommend dewatering discharge is managed, so the quality of water being released is fit for the receiving environment.
B.15	Cumulative Impacts	Investigate the potential scale of cumulative impacts on the water regime that may occur as a result of the project. Cumulative impacts investigations requires data sharing between water users during the same water resource (e.g. to develop groundwater or surface water models). Consider: • Multiple areas of potential abstraction • Overlapping water use impacts (e.g. areas of drawdown or mounding, impacts on nearby or downstream users)

Component		Preliminary Consultation
		• Dewatering discharge locations • Distribution of ecosystems within the project area • Catchment-scale groundwater levels • Alternatives to avoid or manage the cumulative impacts • For discharge of surplus dewater into salt lakes in the Goldfields, refer to Development of framework for assessing the cumulative impacts of dewatering discharge to salt lakes in the Goldfields of Western Australia (Outback Ecology 2009).
B.16	Post-Closure Planning and Management	Investigate the consequences and outcomes of various post-closure water management options. Consider: • Conceptual final landform design, and the extent to which pits are filled (e.g. backfilling to watertable or creation of pit lakes), providing rationale where site is not returned to pre-mining natural conditions • Regional aquifer and hydraulic connections • Potential impacts of mine voids on water resources (e.g. salinity, acidification or mobilisation of soluble metals), and the potential to reactivate old mine voids as a water source or for future mining • Rehabilitation water requirements and duration • Catchment scale and temporal outcomes • Rehabilitation or reconstruction of surface water features • Climate change impacts on closure outcomes
B.17	Water Balance	Develop a predicted water balance, showing major uses and sources of water, and identifying the period the water balance relates to (e.g. a year or month). An itemised water balance is an essential requirement in the assessment process, and during the operational stage of the mining project, for reporting and adaptive management. The water balance needs to include the predicted volume of water: • Needs, at a coarse scale • Required from available sources, at a course scale

Appendix D: Preliminary Consultation Guide – Stage C

Table D-1: Preliminary Consultation Guide – Stage C

Component		Preliminary Consultation
C.1	Adaptive Management Framework	Describe the adaptive management framework that will operate at the mine. If the project is being formally assessed by the EPA, then the EPA/s objectives relating to water should be included in the water management objectives for the mining project. Consider: • What are the water management objectives of the project? • What regulatory conditions/requirements need to be met? • What are the strategies for achieving the water management objectives? • What is the process for determining or measuring whether the water management objectives are being met? • What contingencies plans or measures are in place? • How and when will an evaluation of the water management objectives take place?
C.2	Water Sources	Describe and justify the water supplies chosen for the life of the project, for consideration in a future operating strategy, including any water-related outcomes or conditions from the EPA's environmental impact assessment. The description needs to include: • Location (including map) and hydrogeology/hydrology of the area • Longevity of the project water requirements and sources • Site-specific water constraints (the environment, cultural values and other users) • Variability of the sources • Reliability (quality and quantity), given process needs and variability of supply, and contingency sources or measures • Identify and assess the benefits and effects of using the chosen source
C.3	Abstraction	State the abstraction volumes and pumping rates required to supply the operation for the life of the project, including dewatering requirements and pumping regimes. Hydrogeological investigations may be necessary to verify recharge rates of the water resource and ascertain whether the yield will be sustainable. The description needs to include estimates of pumping rates and abstraction volumes, and the expected duration of pumping, for: • The initial construction of the mine • The operating life of the mine (including anticipated expansions) • After-closure requirements
C.4	Fit-for-Purpose Water Use	Describe how the operator will ensure the quality of water to be used for different aspects of the operation will be appropriate to the needs of those aspects, noting circumstances where low quality or recycled water is available or unavailable. The description needs to include: • The quality needs of each purpose • The sources chosen to meet those needs • Specific justifications for any proposed use of potable water for purposes that need only low-quality water.
C.5	Water-Dependent Ecosystems	Undertake and report on investigations on the water-dependent ecosystems described in stages A and B. Outcomes are to: • Establish management objectives for these ecosystems

	Component	Preliminary Consultation
		• Describe the key features of the mitigation, offsets, monitoring and adaptive management framework that will ensure that impacts do not exceed agreed/approved levels. Details may be incorporated at stage D in the operating strategy. Significant impacts – such as those extending beyond the boundary of the mining project – should be referred to the EPA for assessment. The project proponent would need to develop management measures with nearby landowners.
C.6	Water-dependent Social and Cultural Values	Undertake and report on investigations on the sites of Indigenous, social. Cultural and economic value described in stages A and B. Outcomes are to: • Establish management objectives for these sites • Describe the key features of the mitigation, offsets, compensation, monitoring and adaptive management framework to be used to ensure impacts do not exceed approved levels. Details may be incorporated at stage D in the operating strategy. Significant impacts (such as those extending beyond the boundary of the mining project) should be referred to the EPA for assessment. The project proponent would need to develop management measures with nearby landowners.
C.7	Water Quality	Describe the proposed methods for managing any possible effects on water quality of the source and aquifer during the life of the mine, during the closure process and after the operation is closed down. The description needs to include management of: • Water-dependent ecosystems • Water storage management, including measures to manage potential leakage or run-off from tailings storage facilities • Discharges of water • Acid, non-acid and metalliferous drainage, solute generation and releases • Public drinking water source areas to avoid contamination risk • Salinity
C.8	Use and Release of Surplus Water	Describe and justify the options chosen for the release or re-injection of water at water surplus mines. The description needs to include: • Site-scale management regime • Management outcomes agreed with the department • Potential impacts on the receiving environment • Sharing arrangements and proposals for re-use of mine dewatering surplus by other mining or non-mining projects
C.9	Water Use Efficiency	Describe the mechanisms proposed for maximising water use efficiency for the mining project. Give the reasons for the choices and state the targets chosen for efficiency of water use in these operations. The description of targets needs to include: • Baseline water demand at each point of operation • Measures implemented to reach targets • Measures not used and an explanation why • Forecast water use after the application of measures • Targets for improved efficiency Note that where additional groundwater supplies are required, evidence of efficient water use will need to be provided.
C.10	Cumulative Impacts	Describe the measures taken to manage cumulative impacts to the water regime. The description needs to include: • Changes from previous resource targets for areas of cumulative impact

Component		Preliminary Consultation
		• Individual arrangements for addressing any cumulative impacts • Cooperative arrangements with other water users in the area that are likely to have an impact on the water regime.
C.11	Interference with Stream Beds and Tanks	Identify locations where interference to bed or banks of watercourses, by infrastructure or operations, will occur. Mining tenements granted under the Mining Act 1978 are subject to licensing and permitting requirements under the Rights in Water and Irrigation Act 1914. An application for a section 11/17/21A permit to interfere with bed and banks would be required in proclaimed areas for: • Activities that involve the taking or diversion of water, including diversion of the watercourse • Any activity on a general purpose lease, which interferes with the bed or banks of the watercourse The permit requirements include a description of the proposed techniques for minimising disturbances to riparian areas. These include: • Consolidation of infrastructure requiring a creek crossing with existing creek-crossing alignments or previously disturbed areas • Avoidance of high-velocity sections and bends on the watercourse • Use of best practice rehabilitation and bank stabilisation techniques (e.g. use of geo-chemically compatible material) The permit requirements also include a statement of: • Possible changes to flow in the watercourse during the life of the mine • Where exemption to vegetation-clearing regulations may occur
C.12	Post-closure Planning and Management	Describe the mechanisms proposed for managing the long-term, after-closure changes to the water regime resulting from mine operations. This is likely to be conceptual, as operations have not commenced and closure planning is iterative during the mine life. The description needs to include: • Recovery of abstraction drawn down and timing of closure, factoring in predicted climate change • Prediction of changes in water quality of any planned pit lake over time • Prediction of long-term impact on downstream water quality and flow regimes from modifications to surface water features • Water management objectives for the affected water resources and decommissioning of water assets (e.g. bores) • Future re-use options for water storage facilities • Management of water quality issues in nearby water resources from the containment of tailings (e.g. due to seepage, run-off or erosion)
C.13	Water Balance	Describe the estimated water balance. The description needs to include identification of all: • Water uses and associated volumes • Water sources and associated volumes

Appendix E: Preliminary Consultation Guide – Stage D

Table E-1: Preliminary Consultation Guide – Stage D

Component		Preliminary Consultation
D.1	Area of Impact: Project Area	Provide a brief description of, and appropriate maps for, the project area. Include: • Project area, including the extended footprint • Geographic context and interaction with other water users • Water-related outcomes, commitments or conditions from the EPA's impact assessment (e.g. ministerial statement) • Climate effects on the water regime
D.2	Area of Impact: Aquifer	Provide maps and a description of the affected water resources (groundwater and surface water) with reference to hydrogeological and hydrological information source. Include: • The level of knowledge of the aquifer or surface water resource • Dewatering schedule including estimated volumes and zone of drawdown • Use of the department's Operational policy no. 5.12 – Hydrogeological reporting associated with a groundwater well licence (Department of Water 2009c) for guidance on the level of information required • Identification of potential interactions with other water users
D.3	Areas of Impact: Ecological and Cultural Values	Provide detail on the adaptive management framework described in stage C for water-dependent ecosystems and locations of Indigenous, social, cultural and economic value. The framework must ensure impacts do not exceed approved levels. This will involve: • Including appropriate maps and descriptions • Identifying measurable water management thresholds expected to maintain ecosystems and sites • Establishing a trigger and response system that articulates the actions to be taken in response to measurable triggers, including an early warning system that thresholds are approaching • Describing contingency plans to be enacted if thresholds are reached • Describing the approved mitigation, offsets or compensation strategies for unavoidable impacts
D.4	Area of Impact: Water Quality	Provide a description on how water quality will be managed. Water quality impacts need to be considered in terms of risk to the water resources and the receiving environment. Assessment will include consideration of baseline pre-mining conditions, and impacts at storage sites, mining boundaries and discharge points. Consider the relevance of the Australian and New Zealand guidance for fresh and marine water quality (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand 2000) for establishing a baseline monitoring criteria. In public drinking water source areas, water quality needs to be managed in accordance with Australian drinking water guidelines criteria (National Health and Medical Research Council and the National Resource Management Ministerial Council 2011). Include: • Acid rock, non-acidic and metalliferous drainage • Salinity and other solutes (e.g. sulphate, iron, arsenic, etc) • Possible contamination risk to the water source and receiving environment • Special land use considerations such as public drinking water source areas and conservation reserves

Component		Preliminary Consultation
		• Potential impacts due to interaction with other water users
D.5	Area of Impact: Infrastructure Requirements	Provide a description, including maps and schematic diagrams, of the location of any water-related infrastructure to determine the basis of water abstraction and water use on the mine site for water balance calculations. Include: • Groundwater bores or wells • Types and installation details of pumps • Surface water extraction points and infrastructure (e.g. dams) • Water storage areas • Diversion points including diversion of water and/or watercourse • Discharge points • Types and installation details of water meters (refer to current meter order – Rights in Water and Irrigation Act 1914 (Approved Meters) Order 2009 • Water distribution systems • Options to consolidate infrastructure and implement water conservation and/or efficiency measures • Schedule of water-related infrastructure maintenance (e.g. maintenance of pumps and flow meters, checking pipe work for water leak detection) and any other requirements
D.6	Abstraction and Water Use	List the proposed water abstraction volumes, usage volumes and discharge or re-injection (if applicable) volumes, as both monthly and annual figures. Include and, where possible, tabulate: Estimates of volumes and flow rates for the mining project Abstraction from each groundwater well or surface water source Individual uses such as dust suppression, process water and any other possible usage Each point of discharge/re-injection Operating and dewatering schedules, where variations in abstraction are expected Estimates of mine dewatering surplus Water efficiency measures on the mine site Project timeline, including expected date of mine closure
D.7	Water Balance	Provide a mine site water balance and quantitative water balance diagram, highlighting where significant volumes of water are abstracted and released and identifying the period the water balance relates to (e.g. year or month). Include: • Where all water is sourced and predicated volumes • A map showing location of flow meters within the project area • How water is used, recycled and disposed of, and predicted volumes • Discharge points and predicted volumes • Effect of climatic, recharge and discharge changes on the water balance model • Continual improvement and adaptive management cycle
D.8	Water Release Management	Provide a description of water releases to the environment. Include and, where possible, tabulate: • Release regime (quantity, timing, volumes) • Receiving water bodies • Final quantity of released water and baseline quantity of receiving water bodies • Length of affected downstream stream water environment • Measures to ensure management of water quality changes • Potential impacts due to interaction with other water users

Component		Preliminary Consultation
D.9	Water Use Efficiency Management	Provide a water use efficiency plan demonstrating best practice in water efficiency across the mine site. This should be incorporated as an integral part of the operating strategy. Include and, where possible, tabulate: • Water use efficiency targets • Methods to achieve water use efficiency targets • Water recycling strategies and programs • Fit-for-purpose uses of waste and recycled water • Water optimisation offsets where efficiency gains are not desirable • Monitoring requirements to assess whether targets are met • Auditing requirements to identify efficiency improvements
D.10	Cumulative Impact Management	Provide a detailed description of strategies used to mitigate cumulative impacts on the water regime, considering groundwater and/or surface water resources as relevant. Include: • Arrangements for shared monitoring, where appropriate • Arrangement for shared modelling, where appropriate • Site-scale management strategies • Catchment-scale management strategies • How the proposed strategies relate to the regional and mine water management objectives • Mechanisms for ensuring compliance with the water management objectives
D.11	Post-closure Planning and Management	Provide a strategy for post-closure water management, planned to be undertaken when mining operations cease. Include: • Commitments and triggers that need to be met until the end of the project (e.g. water level, water quality, vegetation, rehabilitation, erosion or run-off management) • Monitoring program to evaluate trends and recovery of the water resource • Mitigation strategies for impacts that continue post-mining • How the strategies will meet regional and mine water management objectives • Site rehabilitation and post-mining water requirements • Decommissioning requirements for water assets (e.g. bores, dams, etc) • Management provisions for unforeseen closure or change to care and maintenance • Adaptive management approach to review and report on changes to management objectives
D.12	Monitoring	Provide a detailed monitoring program, including methods, procedures and schedules for monitoring commitments for water use activities. Monitoring requirements include: Reference sites to assess background levels and set triggers Abstraction volumes and rates from individual wells Water sample analysis from individual wells, as detailed in Operational policy no. 5.12 – Hydrogeological reporting associated with a groundwater well licence (Department of Water 2009c) Water levels (e.g. at water table and in aquifers to determine impacts from mining and/or dewatering activities)
D.13	Reporting	Provide a detailed schedule of reporting, including information that is to be included in any required report (e.g. annual or triennial review of monitoring data, or a focused monitoring regime of key and divergent data in a quarterly review). Include as a minimum:

Component		Preliminary Consultation
		Reporting of monitoring data, including key and divergent data, historical data and graphs of trends (abstraction volumes should be reported as monthly and annual figures) Actual water balance against that in the operating strategy Breaches of conditions, including breaches of operating strategy commitments as well as actions taken Time frames for notification to the department in cases where the commitments in the operating strategy cannot be met, including reasons why and actions proposed Time frames for notification to the department of any emergency situation, relating to a Rights in Water and Irrigation Act 1914 licence, so permission to take immediate action can be obtained.
D.14	Defining Triggers and Thresholds	Clearly define environmental impact triggers to aid the implementation of contingency measures. Triggers may relate to the EPA's environmental impact assessment process and project approval commitments. Define the triggers based on benchmarks and investigation results. Consider: • Is there potential to affect other water users? • Is there potential to affect water-dependent ecosystems? • Is there potential for quality of the water resource to be degraded after activities start? Where there are no potential impacts, no triggers are required. Where an impact is possible, a trigger is required and where an impact is likely, staged triggers are also required as an early warning system that a trigger is at risk of being breached. Examples of triggers include, but are not limited to, percentage of reduction (increase) of vegetation, water quality parameters, erosion levels, and groundwater or surface water levels. **Note:** in public drinking water source areas, water quality needs to be managed in accordance with Australian drinking water guidelines criteria (National Health and Medical Research Council and the Natural Resource Management Ministerial Council 2011).
D.15	Contingency Measures	Provide detailed contingency measures that include actions to reduce environmental risks and mitigate adverse changes to the water regime. Define contingency measures for environmental risk and operational risk: • Is there potential to affect other water users? a) Non – no required measures b) Possible – design monitoring to quantify impact c) Likely – describe appropriate contingency actions • Is there potential to affect water-dependent ecosystems? a) None- none required b) Possible – review monitoring c) Likely – contingency actions • Is there potential for the degradation of water quality of the resource? a) None – none required b) Possible- review monitoring c) Likely – contingency actions Examples of contingency measures include, but are not limited to, alternative discharge points and extraction points, reducing pumping rates and increased monitoring.
D.16	Administrative Requirements	Provide the administrative requirements for an operating strategy. Include:

Component		Preliminary Consultation
		• The water year (the licensed water entitlement relates to) and a summary of all monitoring, reporting and contingency commitments listed in the operating strategy • A list of references and related documents, including any relevant hydrogeological reports, relevant company policies and EPA-approved management commitments or plans • Intended date of submission of reporting documents, such as annual and triennial aquifer reviews • Opening strategy review date • Details of persons responsible for ensuring operating strategy commitments and Rights in Water and Irrigation Act 1914 licence conditions are met • Sharing arrangements to manage water regime interactions with other water users (e.g. surplus water, where relevant)

Appendix F: Preliminary Consultation Guide – Stage E

Table F-1: Preliminary Consultation Guide – Stage E

Component		Construction, Operation and Closure Planning
E.1	Reporting	Changes in impacts need to be reported against: • Commitments made in the operating strategy • Water management objectives and outcomes in this guideline • Mine closure plan (if appropriate) • Ministerial commitments made by the EPA
E.2	Evaluating the Management	On a regular cycle, assess all of the management actions against the management objectives. Have the management objectives been met? • If yes, is current management suitable to continue? Are there lessons to inform better management? • If no, were planned responses to triggers implemented? Were they adequate?
E.3	Evaluating the Impacts	On a regular cycle, assess the condition of the water resource. Have the water resource objectives been met? • If yes, is current management suitable to continue? Are there lessons to inform better management? • If no, were planned responses to triggers implemented? Were they adequate?
E.4	Updating Management	Establish a system of review and continuous improvement as part of the adaptive management process over the life of the mine. Based on evaluation of mining operations and auditing of water use, implement any required changes to management. Changes can include: • Improving the adaptive management framework • Improving mine site practices • Reviewing the monitoring program • Reviewing water efficiency targets • Implementing water efficiency improvements • Reviewing the water balance and making changes • Reviewing the operating strategy and recommending changes • Submitting the updated operating strategy to the department for approval
E.5	Updating the Monitoring Program	On a regular cycle, review and compare the monitoring program to monitoring objectives. That review can include: • Assessing reliability and applicability, to support decisions • Reviewing appropriateness of methodology and scale • Improvement based on ongoing analysis of impacts, to allow for overall integration, including mine closure plan finalisation
E.6	Post Closure Planning and Management	Review and finalise the mine closure plan using the results of data collated during mining. The plan should describe the mechanisms for managing the long-term after-closure changes to the water regime, resulting from the mine operations. The description needs to include: • Mitigation strategies for impacts that continue post-mining • How the strategies will meet regional and mine water management objectives • A proposed monitoring program to verify predicted trends • Water management objectives for mine closure for the affected water resources and decommissioning of water assets (e.g. bores)

Component		Construction, Operation and Closure Planning
		• A prediction of changes in water quality of any planned pit lake over time • A prediction of long-term impact on downstream water quality and flow regimes, from modifications to surface water features • Future reuse options for water storage facilities • Water quality issues related to containment of tailings (e.g. managing seepage or runoff to nearby water resources) • Approach to review and report on changes to management objectives

Appendix G: Preliminary Consultation Guide – Stage F

Table G-1: Preliminary Consultation Guide – Stage F

Component		Final Closure and Decommissioning
F.1	Post Closure Management	Implement post-closure water management for the mine site, based on water-related commitments, outcomes and actions provided by the proponent in the mine closure plan and the operating strategy. Include: • Monitoring and reporting against baseline data to determine water resource recovery and assess the effectiveness of mitigation strategies for post-mining impacts • Revegetation in the rehabilitation of inclined areas, where appropriate, to manage runoff and erosion • Decommissioning of water assets • Adaptive management processes to review and make changes to post-closure strategies to meet the required water management objectives and outcomes
F.2	Decommissioning of Bores	• Bores that have to intended future use beyond closure must be decommissioned in accordance with the publication *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

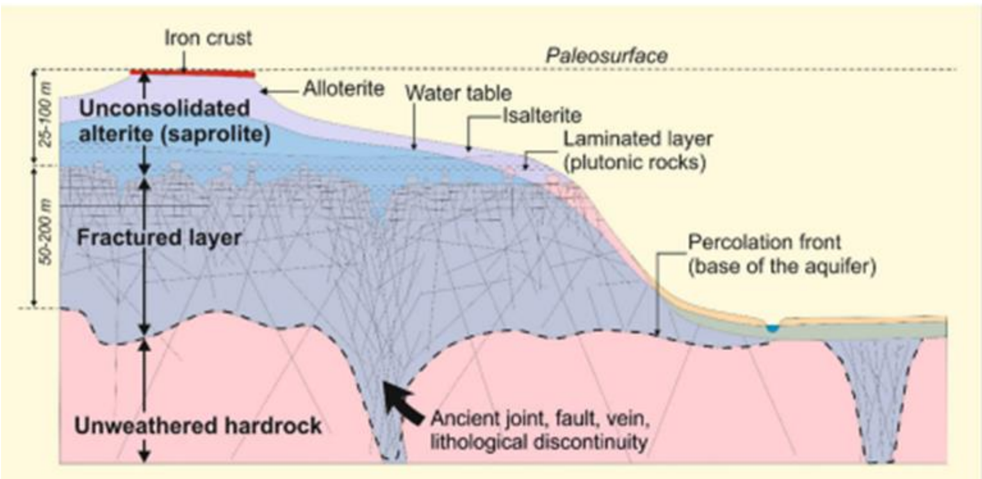
Appendix H: Hydraulic Properties of Fracture Rock Aquifer

The weathered granite model comprises three layers with an iron crust present or not, at the top of the profile (Figure 10). Below is the unconsolidated saprolite (alterite), characterized by low storativity (a mean of 2x10-6 m/s with values ranging from 1x10-7 to 5x10-6 m/s). This horizon has transmissivities in the order of 5x10-8 to 10-7 m/s. A fracture layer (SFL) is situated below, with variable T, S values. It is characterized by dense fracturing in the top few meters and decreases in density with depth. Fractures are mostly sub horizontal in granite rocks, or vertical in foliated rocks. They are randomly dipping in metamorphic and folded rocks. They usually have a thickness twice the thickness of the saprolite horizon (where the saprolite is not eroded) and it could reach up to 100 m thick.

The unweathered hardrock, of very low storativity has a low density of fractures and negligible storativity for any catchment scale studies.

The challenge in finding good water flowing fractured zones in this type of aquifer is represented in the fact that when analysing productive bores, only a maximum of four or five fractures are permeable enough to be detected as 'water strikes' during drilling, with the remaining being dry (Lachassagne et al 2021). These maximum four to five fractures ensure the discharge of the well. Sometimes there are no permeable fractures hence there is a large variability of borehole discharge even for close boreholes. Drilling a dry hole next to a productive one and vice-versa is not rare. Consequently, the standard deviation of hydrodynamic parameters (i.e., hydraulic conductivity) is very high. A good homogeneity for hydraulic conductivities obtained in granites shows values from 10-7 to 10-4 m/s (0.08 to 8 m/d).

Figure H-1: Conceptual Model of a Partly Eroded Paleo-Weathering Profile on Hard Rock with Erosion Shown to the Right of Figure. Modified from Lachassagne et al 2021.



In terms of vectoring towards potential areas of high fracture in granite, some consideration to the mineralogy of the rock is necessary. Mineralogy and texture are the main controls of differential weathering with biotite-rich and coarse rocks being more weatherable (as opposed to more felsic, fine-grained suites). Other factors affecting the weathering profile include morphology, erosion rate, duration of tectonic stability and the presence of water. Due to the crystalline structure of biotite and when coarse in size, expansion upon weathering may result in better changes to develop fractures. Out of the many different intrusive units conforming the Pilbara cratonic region, only a few of them have characteristic biotite composition and are described as coarse grained. These are: Bishop Creek granite, Bullgarina granite, Campbell Well granodiorite, Emu Pool Supersuite monzogranite, Jenkin granodiorte and Johansen Monzogranite in the vicinities of Marble Bar. From these, only Emu Pool Supersuite monzogranite, in the southeasternmost area is within the East Pilbara Envelope. Other granites do outcrop that are also within the envelope (and towards the north) but have not been described favourably in terms of composition and textures.

By combining this information with geophysical surveys of high resolution in this area it will help to target the most potential places for fractures that may or not transmit water.

Ferric oxide occurs in present-day tropical areas with a long dry season. Absence of duricrust at top of a lateritic profile is due either to erosion of the profile surface before burial by sediments or to rehydration of the hematitic duricrust to iron hydroxides (goethite and limonite) within a latosol (Lachassagne et al 2021).

Appendix I: Geophysical Considerations

Exploration in Archaean granite/greenstone terrain is hindered by the deeply weathered regolith profile. Regolith profile can obscure the underlying bedrock geology. Use of appropriate geophysical techniques can assist in mapping the regolith. The variable nature of the weathering, and the consequent development of electrically conductive overburden and the formation of ferruginous zones enriched in iron oxides which includes the magnetic iron oxide maghemite, contribute to limit the effectiveness of geophysical methods for detecting anomalous signature (e.g., water, mineralization, etc.) (Dauth 1997).

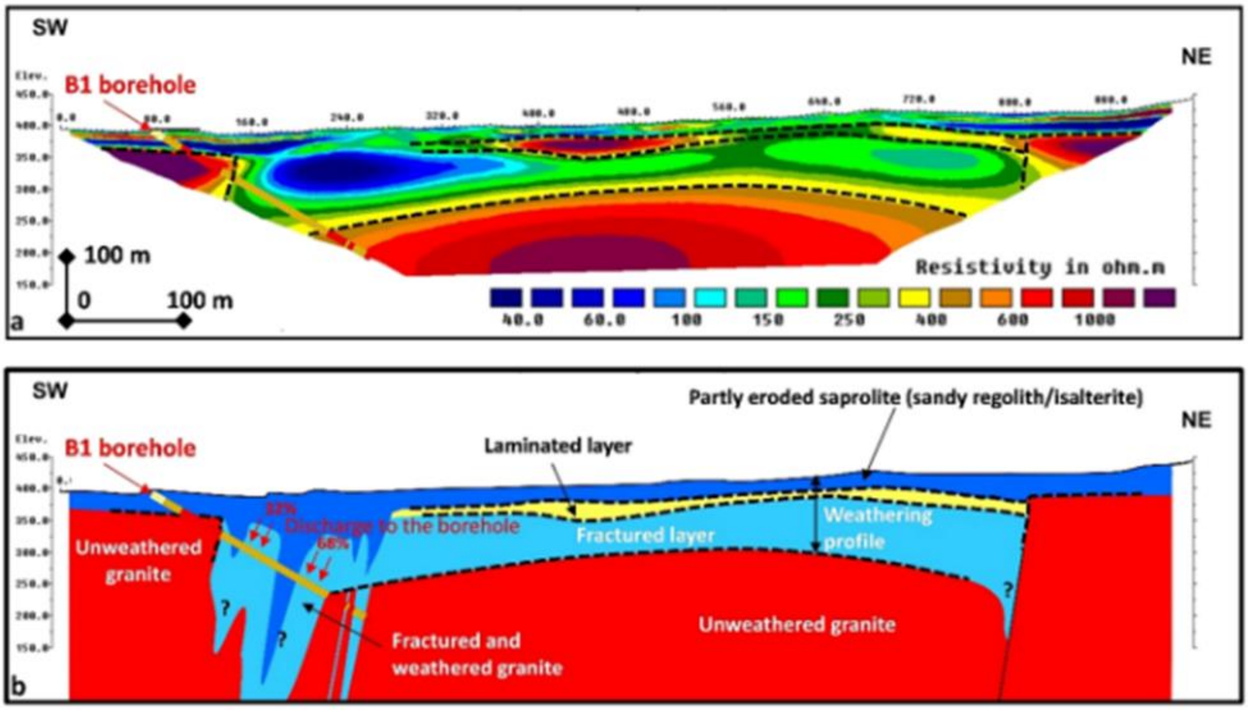
Aeromagnetic method has been proven effective to identify magnetic greenstone units, such as mafic to ultramafic sill and dolerite horizons, faults as disruptions crossing Proterozoic dykes, and paleochannels containing ferriginous gravel. Patterns in filtered gravity data reflect subtle density differences between rock units, regolith features, and weathered fault zones that cannot be detected by airmag.

The airborne electromagnetic (AEM) response is dominated by conductive clays, predominantly in situ as saprolite, and saline groundwaters in the regolith that follow litho-dependant weathering of bedrock units. Cross-faults are mapped as disruptions of the conductive units and may be either conductive or resistive.

In terms of the best geophysical methodologies for targeting fractured zones electric and magnetic methods have shown good results (Lachassagne et al 2021).

A specific electric method known as Electrical Resistivity Tomography (ERT) has gained popularity worldwide as an effective way to track fractured rock within granitic terrains. This method is widely used in the world to investigate electrical resistivity variations within the subsurface. In this method, apparent resistivity data are acquired using a multi electrode array laid out at the surface. Electrical current injections are produced in the soil using two electrodes, with the resulting electrical potential being measured with two other electrodes. Varying the lengths and positions of both current and potential dipoles, it is possible to investigate the subsurface laterally and in depth. Field data are gathered into an apparent resistivity pseudo-section. This data set is then inverted using conventional inversion procedures. The inversion model results in a cross-section model (Figure 11) of calculated resistivity also called ‘calculated resistivity’ considering a 2D geometry.

Figure I-1: **Example of an Electrical Resistivity Tomography Geophysical Profile in Granitic Weathered Hard Rock and its Interpretation (b)**



Note: the figure above contains pole-dipole array with 'standard horizontal' inversion parameters. Modified from Lachassagne et al 2021.

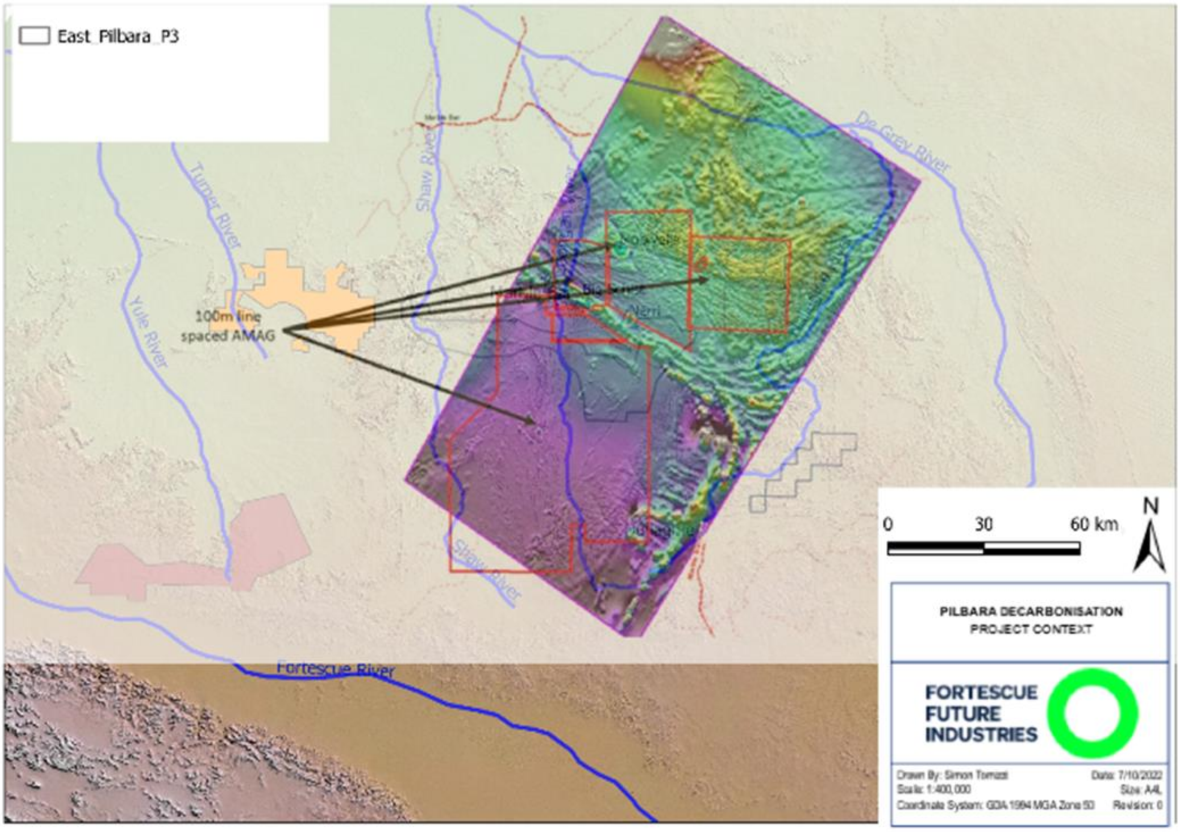
The magnetic method, frequency electromagnetic (FEM) uses a couple of transmitters (Tx) and receiver (Rx) coils, carried by one or two people. Within the Tx coil, an alternative electrical current flow at a frequency adapted to the Tx-Rx separation to maintain the so-called low induction number conditions. The eddy currents induced in conductive zones in the ground generate a secondary field that is proportional to the electrical conductivity (inverse of electrical resistivity). The penetration depth depends on the separation between Tx and Rx. The Standard is 10 m using a Geonics EM34 instrument. Several profiles allow to draw an apparent conductivity map. Apparent conductivity is not equivalent to the bulk conductivity of the ground (except in homogenous medium). It is rather a combined value of individual bulk values of several layers in the ground.

In summary, geophysical 'pattern mapping' from such surveying is relatively inexpensive when compared to drilling. It increases success rates by identifying fluid pathways at the early stages of an exploration program and should be routinely applied in brownfield projects too.

A suggested strategy to increase success rate when drilling into fracture aquifer terrain is to first assess the area by using any existing aeromagnetic survey (or proposed if none exist) to understand the structural architecture of the area, then followed up by either a more local SkyTEM (to cover more ground, faster) or a ground survey (slower, better imaging of subsurface features) to better define preliminary targets out of the regional aeromagnetic data.

The Geological Survey of Western Australia (GSWA) has flown several small high resolution aeromagnetic surveys (with a 100 m line spacing) around the East Pilbara Envelope together with the larger regional survey at 400 m line spacing data (Figure 12). Both datasets have been incorporated into the 2020 GSWA state-wide magnetic merge (GSWA 2022). A simple reprocessing of this dataset has been completed internally by FMG's geophysics team and used to identify anomalous features that could indicate structural discontinuities (dykes, thin intrusions, contacts, or fractured zones, Figure 12). The set of products used to interpret structures includes the first vertical derivative (dz), second vertical derivative (2dz), intensity with sun-shading from the north (000), intensity using linear (lin) colour stretch and an intensity grey map (G).

Figure I-2: Reprocessed GSWA State-wide Aeromagnetic Dataset over the East Pilbara Envelope



The later map, grey intensity is particularly good at identifying shallow from deep magnetic elements/anomalies. A quick scan over the re-processed image shows the southern granite terrain is a lot more subdue and devoid of shallow structural features compared to the northern mottled textures. This allows to focus efforts on those parts with salient shallow features within the northern granitic suites (Figure 13).

A last geophysical consideration is the validation of any airborne magnetic data with subsurface electrical data: downhole geophysics with electrical conductivity profile of the shallow horizons. As any aerial survey they can only measure a combined, or bulk conductivity coming from the air, soil, and top horizons. Only then, it will be possible to calibrate aeromagnetic datasets with the in-situ formation conductivities.