ELYWANA MINING PROJECT

HYDROGEOLOGICAL CONCEPTUAL MODEL REPORT

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1.0 INTRODUCTION

This report has been prepared for Fortescue Metals Group (Fortescue) by Golder Associates Pty Ltd (Golder) in response to a Request for Proposal (RFP) by Fortescue. The RFP was issued by Mr Jordin Barclay (Fortescue) to Michael Bartlett (Golder) by email on 21 December 2016 for hydrogeological services to carry out a dewatering and near mine water supply assessment for Stage 1 of the proposed Eliwana Mining Project area. This work has been carried out in accordance with the scope of services outlined in our proposals P1671484-001-P-Rev0 and P1671484-002-P-Rev0 dated 25 January 2017.

This report presents the conceptual hydrogeology outlining the use of key information collected by Fortescue and how it has been interpreted to present the current knowledge base for a hydrogeological assessment. It is the second report of a phased study approach following on from the Basis of Study (Golder, 2017) report completed in February 2017. The hydrogeological assessment will be used to inform dewatering and near mine water supply assumptions to progress to a numerical representation of the groundwater system within the next phase of the study.

2.0 BACKGROUND

Fortescue is assessing the potential development of a new iron ore mining area located approximately 140 km west of their existing Solomon Mine. The mining area comprises several iron ore deposits, which when mined would collectively be known as the Eliwana1 Mining Project (the Project, Figure 1). The proposed pit shell locations and preliminary depths of mining have been provided, however no mine plan or vertical advance rate has been resolved. The majority of pits are above water table (AWT), with notable below water table (BWT) pits including Westend Broadway East, Broadway West and Talisman. The Westend pit encounters bedded Brockman Iron Formation ore whilst the Broadway and Talisman pits comprise Marra Mamba Iron Formation bedded ore.

Fortescue requires a hydrogeological assessment of the Project to assess mine dewatering and depressurisation requirements as well as near mine water supply options. Golder understands that the results of this assessment will be used as part of a Public Environmental Review and to support the pre-feasibility assessment for the Project.

A hydrogeological program of work was initiated in mid-2016 by Fortescue to collect data including regional geological mapping and literature review, exploration drill hole data, assay results and exploration water supply monitoring data/information. This data was used to plan further hydrogeological drilling studies which comprised the drilling of 10 production bores and 11 monitoring bores, followed by a program of test pumping, single well slug testing and downhole geophysical surveying.

3.0 CLIMATE

According to the Köppen climate classification system the Pilbara Region has a dry arid to semi-arid climate, with two distinct seasons; hot summers with seasonal periodic rainfall and high evaporation rates and warm winters. Climate statistics from the Bureau of Meteorology for Site number 5005 – Hamersley, located 46.8 km north northwest of Tom Price, and approximately 50 km northeast of Flying Fish, indicate mean annual rainfall of 385.4 mm (1912-2015). Bureau of Meteorology generated local gridded rainfall data was reviewed and presented similar rainfall data at Eliwana and Flying Fish as the Hamersley site. The Bureau of Meteorology website (www.bom.gov.au) indicates Class A pan evaporation is around 3,200 mm/annum, which is an order of magnitude greater than annual rainfall.

For a more detailed summary of climate information see MWH (2011).

1 Note the term Eliwana is also a geographic location used to describe the western half of the greater Eliwana Mining Project area.
4.0 HYDROLOGY

Regionally, the project is located within the Duck Creek catchment of the Ashburton River Drainage Basin. Drainage lines extend downhill and through valleys into the Boolgeeda and Pinarra Creeks (Figure 1). The Boolgeeda Creek flows westward from Mount Brockman, whereas the Pinarra Creek (a small drainage system) drains south into the Boolgeeda. The Boolgeeda eventually flows into Duck creek some 23 km downstream from its convergence with Pinarra Creek (MWH, 2011).

The Project is situated within the headwaters of mainly local catchment drainages that feed into the main systems described above. Local drainage across the Project area is shown in Figures 2A-2C. A catchment divide is located in close proximity to the easternmost proposed Brockman deposit, where tributaries of the Boolgeeda Creek flow south east and the Pinarra Creek drains to the west (Figure 2B). The tributaries that flow south and east into Boolgeeda Creek generally cover the Flying Fish area, and have an upper catchment provenance that includes rock types of the Fortescue Group (see Section 6.1). The west flowing Pinara Creek has a provenance of mainly Hamersley Group sediments and is associated with the Eliwana area.

Surface runoff from hillslope catchments comprise fast flowing, fresh (water quality) run-off with a short response time. At present, there are no known pools or springs in the proposed Project area (MWH, 2011).

5.0 VEGETATION

Fortescue supplied detailed flora maps of local vegetation assemblages. This mapping is most beneficial from a conceptual hydrogeology perspective as the maps delineate the location of vegetation assemblages that may be groundwater dependent\(^2\) based on the species observed. Trees accessing groundwater can impact the conceptual water balance, groundwater discharge and groundwater quality. In turn, the trees could be impacted by any development that draws down groundwater levels at a rate or to a reduced level outside the bounds of natural variation.

Potential groundwater dependent vegetation (GDE) types within the Project’s valley environment comprise riparian vegetation assemblages. Two main assemblages were mapped; one comprising *Eucalyptus xerothermica*, *Corymbia hamersleyana* and *Acacia aptaneura* woodland over open shrubland and grassland in the east Flying Fish area; and *E. victrix* and *E. xerothermica* woodland over acacia shrubland and spinifex tussock or hummock grassland in the west along Pinara Creek and Eliwana East (Figure 2A-C).

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\(^2\) In this instance groundwater dependence is assumed to include either phreatophytes that access groundwater directly or vadophytes that access the vadose zone above the water table.
POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEM (GDE):

CLIENT:
FORTESCUE METALS GROUP

LEGEND:
PIT SHELL
POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEM (GDE)
CAMP SITE
ACCESS ROAD / TRACK
DRAINAGE

NOTE:
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
2. VEGETATION DATA MAPPING AND DRAINAGE SUPPLIED BY CLIENT
3. INSET IMAGE AND TOPOGRAPHY SOURCED FROM GEOSCIENCE AUSTRALIA

REFERENCES:
1. AERIAL IMAGERY AND ROADS © WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2018)
2. VEGETATION DATA MAPPING AND DRAINAGE SUPPLIED BY CLIENT
3. INSET IMAGE AND TOPOGRAPHY SOURCED FROM GEOSCIENCE AUSTRALIA

GOLDEN
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

REFERENCES:
1. AERIAL IMAGERY AND ROADS © WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2018)
2. VEGETATION DATA MAPPING AND DRAINAGE SUPPLIED BY CLIENT
3. INSET IMAGE AND TOPOGRAPHY SOURCED FROM GEOSCIENCE AUSTRALIA
The two vegetation assemblages were mapped in four separate areas by Fortescue and these comprise from west to east:

- An 8 km section along Pinara Creek from east of EWPB004 to Badock Bore.
- A 4 ½ km section running west to east from Ren’s bore to the Fortescue tenement boundary along an unnamed creek (most likely the GDE persists beyond the tenement boundary).
- A 2 km length of unnamed creek running north to south, west of FFPB003, bounded again by the Fortescue tenement boundary to the south.
- A 6 km section of unnamed creek running from NE to SW past Grunters and cutting across the Brockman ridge into the internal syncline valley and Boolgeeda Creek. There is a small tributary from the north that joins the creek west of Grunters that is also labelled as a potential GDE.

Along Pinara Creek (in the east), the depth to groundwater at EWPB004 is in the order of 30m and it is unlikely this section, or areas further up gradient to the east, could be groundwater dependent given this depth. At EWPB006 depth to groundwater is around 24 m, allowing for the invert of the creek and even potential mounding along the creek it is unlikely that the vegetation would be groundwater dependent. However further west at Badock Bore depth to groundwater varies between 5 to 9 m and the potential for riparian groundwater dependent vegetation is reasonable for an approximately 2 km length of Pinara Creek upstream from where the creek turns south and cuts through the Brockman ridge.

Based on assessment of available groundwater levels (Section 8.4.1), the 4 ½ km section of mapped potential GDE along the west to east trending creek from west of Ren’s Bore, past Kenny’s Bore to the tenement boundary is unlikely to be supported by groundwater given the depth to groundwater is 35-40 m along the length of this riparian zone.

The 2 km length of mapped GDE along the N-S trending unnamed creek has no associated monitoring bores nearby. The creek cuts through the Marra Mamba Iron Formation ridge in the north creating a relatively steep gorge; however depth to groundwater would still be in excess of 20 m based on current knowledge. South of the gorge from the centre point of the valley to the edge of Fortescue’s tenure depth to the groundwater may be as shallow as 3 m, corroborating the potential for a riparian type GDE.

The 6 km section of potential GDE along the unnamed NE to SW creek has a complicated depth to groundwater. In the first 1.5 km from its western extent upstream to the northeast, groundwater is in the order of 10 -12 m below ground level (bgl). Prior to abstraction in the area, the depth to groundwater at Grunter’s Bore was in the order of 7 m bgl. Over the next upstream kilometre the groundwater level drops by ~10 m and depth to groundwater is at least 25 m bgl. Further upstream to the northeast again the groundwater level is 25 m higher and near to surface for the subsequent 1.8 km (~<15 m bgl).

### 6.0 GEOLOGY

The basement geology of the Brockman Syncline comprises the three Groups from the Mount Bruce Supergroup; namely the Fortescue, Hamersley and Turee Groups. These groups are arranged in a large syncline structure with a broadly east-west axis. The Project area lies on the northern limb of the syncline and as such all the bedded stratigraphy dips to the south at between 30-45°, with the oldest bedded metasediments to the north, progressively through overlying younger metasediments to the south towards the centre of the syncline.

A brief description of each Group’s constituent Formations and formation Members, where relevant, is provided below in order from oldest to youngest rocks.

#### 6.1 Fortescue Group

##### 6.1.1 Jeerinah Formation

Whilst the official nomenclature for the Fortescue Group has been confused by the simultaneous mapping of non-contiguous maps sheets across the Pilbara (GSWA, 1990) the nomenclature adopted here is that of MacLeod and de la Hunty (1966). The uppermost member of the Fortescue Group is the Roy Hill Shale.
Member comprising dark grey to black shale, commonly with spheroidal pyrite concretions. An abundance of dolerite sills is a common feature of the upper units of the Fortescue Group, and this is particularly the case around the Brockman Syncline.

6.2 Hamersley Group

6.2.1 Marra Mamba Iron Formation

The Marra Mamba Iron Formation is separated into three constituent members; Nammuldi, Mount MacLeod and Mount Newman Members. Within the Hamersley Range, the uppermost Mount Newman Member is most commonly enriched with iron ore by supergene enrichment.

6.2.1.1 Nammuldi Member

The lowermost Nammuldi Member comprises cherty, banded iron formation interbedded with thin shales. The un-mineralised Nammuldi Member is between 75 and 100 m thick, with the hard, resistant cherty nature of the banded iron generally forming the high points of Marra Mamba ridges that parallel the higher peaks of the Brockman Iron Formation.

6.2.1.2 Mount MacLeod Member

The Mount MacLeod Member conformably overlies the Nammuldi Member and comprises banded iron, chert and carbonate along with interbedded shales. The Mount MacLeod Member when un-mineralised is 25 to 45 m thick. The upper most beds contain the most shale units, closely spaced together that give a characteristic gamma signal distinguishing it from the upper Mount Newman Member.

6.2.1.3 Mount Newman Member

The Mount Newman Member conformably overlies the Mount MacLeod Member and comprises banded iron interbedded with carbonate and shale. It is commonly the most iron enriched unit within the Marra Mamba Iron Formation within the Hamersley Range. The un-mineralised Mount Newman Member is between 45 and 60 m thick. There are eight identified shale bands within the Mount Newman Member, the most significant being the twin bands of shale known as NS3 and NS4, that owing to their thickness, generally prevent the supergene enrichment of banded iron in the lower Mount Newman Member.

Both the proposed Talisman and East Broadway pits are located within the Mount Newman Member with the majority of mineralisation occurring below the groundwater water table.

6.2.2 Wittenoom Formation

The name Wittenoom Formation was proposed by Simonson, et. al, (1993) in preference to the term Wittenoom Dolomite in recognition of the heterolithic nature of the Formation. The Wittenoom Formation is separated into three type members, the West Angela, Paraburdo and Bee Gorge Members.

6.2.2.1 West Angela Member

The West Angela Member is often colloquially referred to as the West Angela Shale, however, shale is a misleading term. The West Angela Member contains predominantly massive to laminated dolomite interbedded with shaley dolomite with pyrite and chert. Chert is a minor component in the upper part of the member but increase with depth (Blockley, et. al. 1993). The shaley dolomite comprises thinly bedded grey crystalline dolomite interbedded with carbonaceous shale and siltstone. The member conformably overlies the Mount Newman Member of the Marra Mamba Iron Formation and is between 30 and 50 m thick.

6.2.2.2 Paraburdo Member

The Paraburdo Member was first proposed by Simonson et. al, (1993) and comprises a majority of dolomite with minor amounts of chert and argillite (clay, mudstone, shale). The dolomite layers are generally no more than 1 m thick, whilst the argillaceous inter-beds are measured in centimetres. Chert layers within the Paraburdo Member are observed to be restricted to specific horizons up to 2 m thick. The exact thickness of the Paraburdo Member is not well known, Simonson et. al., (1993) suggest that it may be between 260 and 420 m thick; however, weathering and dissolution of carbonate rock has resulted in significant thinning in the Brockman Syncline.
6.2.2.3 Bee Gorge Member

The Bee Gorge Member was also first described by Simonson, et. al. (1993). It is described as a thinly laminated fissile argillite. Besides the argillite, it contains subordinate thickness of carbonate, chert, volcaniclastic and iron formation. It also contains distinct marker beds, the most recognisable being the Main Tuff Interval, comprising a 4 to 16 m thick sequence of pyroclastic turbidite, with the coarsest sediments known within the Wittenoom Formation (Simonson, et. al., 1993). The Bee Gorge Member ranges in thickness from 100 to 227 m. Again dissolution of the thin carbonate beds has resulted in thinning of the Bee Gorge Member around the Brockman Syncline.

6.2.3 Mount Sylvia Formation

The Mount Sylvia Formation conformably overlies the Wittenoom Formation and consists of three prominent banded iron formation (BIF) bands, separated by laminated mudstone and minor chert and dolomite (Seymour, et. al., 1988). The most prominent BIF band lies at the top of the Mount Sylvia Formation and is known colloquially as Bruno’s Band, the two lower bands are known as the “tram tracks” and these form recognisable regional markers beds on the slopes of the Hamersley Range. The thickness of the Mount Sylvia is variable from 30 to 45 m.

6.2.4 Mount McRae Shale

The Mount McRae Shale conformably overlies the Mount Sylvia Formation and comprises thinly laminated, fissile shale with minor subordinate amounts of chert, dolomite and BIF. Where unweathered it comprises a black graphitic and chloritic shale (Tyler, et. al., 1991). The unweathered Mount McRae Shale also contains significant pyrite, and represents a potential spontaneous combustion and acid forming material risk when exposed.

6.2.5 Brockman Iron Formation

The Brockman Iron Formation comprises four members, the Dales Gorge, Whaleback Shale, Joffre and the Yandicoogina Shale Members. The Brockman Iron Formation hosts the largest and highest grade bedded iron deposits first mined within the Pilbara at Mount Whaleback and Tom Price. The iron ore is mostly hosted within the Dales Gorge and Joffre Members.

The banded iron formations of the Brockman Iron Formation are typically hard, fine grained and have well developed vertical joint systems. Their resistance to weathering results in them forming cliff faced gorges and high ridge lines where superimposed drainage patterns impact the topography.

6.2.5.1 Dales Gorge Member

The Dales Gorge Member conformably overlies the Mount McRae Shale and comprises an alternating sequence of BIF and shale macro-bands. The BIF bands comprise of centimetre thick bands of chert and iron rich material in a chert matrix. The shale bands comprise of shale like material, which is primarily volcanogenic and carbonate turbidite. The thickness of the Dales Gorge Member type section is up to 142 m; it is less where thinning due to mineralisation has occurred.

6.2.5.2 Whaleback Shale

The Whaleback Shale conformably overlies the Dales Gorge Member and is approximately 50 m thick. This member consists of thinly bedded shales with thicker chert or BIF bands. The Whaleback Shale is often weathered along with the supergene enrichment of the BIF bands both above and below it.

6.2.5.3 Joffre Member

The Joffre Member conformably overlies the Whaleback Shale Member. The Joffre member is characterised by its homogeneity, with approximately 330 m of alternating banded iron formation and shale bands. The banded iron comprises interbedded chert and iron rich material. The Joffre Member of the Brockman Syncline is noted for a significant dolerite sill within the upper half of the member.
6.2.5.4 Yandicoogina Shale
The Yandicoogina Shale conformably overlies the Joffre Member and comprises alternating chert and shale up to 60 m thick. The Yandicoogina Shale has also been intruded by a number of dolerite sills.

6.2.6 Dolerite dykes
Dolerite dykes are ubiquitous across the Pilbara and in particular across the Brockman Syncline. The dykes generally trend NW-SE, NNW-SSE and NE-SW. The dykes are generally believed to be near vertical and intruded post the D3 Panhandle Orogeny (Müller, et. al., 2005). Associated with or post-dating the Panhandle Orogeny, reactivation of NW striking faults coupled with NW striking SW dipping normal faults formed horst and graben structures in the syncline around Paraburdoo (Dalstra, 2006). Evidence for these types of structures occur on the southern limb of the Brockman Syncline and are apparent in the Project area to the west of the proposed Talisman pit and potentially further east around Flying Fish. Within these NW faults dolerite may also be intruded.

6.3 Regolith
The Hamersley Range is recognised for its persistent regolith surface that comprises a range of rock types in a number of different landform settings as a consequence of erosion and deposition occurring on geological timescales. Located over bedrock surfaces and underlying Cainozoic valley fill sediments is a residual hard cap zone of hydrated material from in-situ surface weathering, referred to colloquially as the detritals. Intersections of the detritals are noted in the lithological logs and are variously described as “Cemented Detrital”, “Manganese Hardcap”, “Goethite and Shale” and “Hardcap Detrital”.

6.3.1 Cainozoic sediments
6.3.1.1 Pisolite
Pisolitic rock types are common throughout the Pilbara infilling ancient river channels. In some locations they are sufficiently ferruginised that they constitute high grade goethite-hematite ores. These pisolitic deposits are also referred to as Channel Iron Deposits (CID) and reference to this lithology is made in Project area bore holes as descriptions associated with the term “Clayey Detrital”, “Manganese Hardcap”, “Goethite and Shale” and “Clay and Gravel”.

6.3.1.2 Lignite/Siderite
Lignite and siderite (Fe carbonate) from lacustrine deposition have been recognised more widely in the Hamersley Province over the last decade. Although not laterally continuous, these lacustrine beds pose a potentially acid forming material risk at number of below water table deposits. Currently this lithology is not recognised in drilling around the Project area, however these beds, or equivalents, have been intersected around the Brockman Syncline.

6.3.1.3 Calcrete/Silcrete
Calcrete (or dolomite) and silcrete is commonly found along drainage lines and buried within valley sediments. The Oakover Formation was first used by Noldart and Wyatt (1962) and was re-used to describe the dolomitic and calcrete deposits in the Oakover River valley in the northeast Pilbara by Williams & Trendall, 1998. It is also nodular, contains secondary pisoliths or ironstone and laminar carbonate, containing an upper siliceous unit 3-10m thick overlying a carbonate unit up to 45 m thick. In the Project area it has been referred to as “reworked calcrete” and “silcrete” in logs from bore holes BGMB001, FFPB001 and EWMB001.

6.3.1.4 Unconsolidated Colluvium and Alluvium
Overlying the calcrete and silcrete are mainly poorly sorted, unconsolidated gravels, comprising banded iron, ironstone or dolerite in a clay matrix. The unconsolidated material is generally considered colluvium and alluvial sheet wash from the surrounding hills. Whilst the age of these sediments is uncertain they will be

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3 It is noted there is no rigorous application of consistent nomenclature for lithology used within the Eliwana Mining Project bore register logging supplied.
referred to here as Quaternary age as they post-date and have reworked the older calcrete, silcrete and CID material. The colluvium is referred to as “Clayey Detrital” and “Clay” in the lithological logs.

The unconsolidated colluvium is locally dissected by modern drainage with alluvium beds of unconsolidated sand to boulder size banded iron, ironstone, dolerite rock minor calcrete.

7.0 DRILLING AND CONSTRUCTION

Fortescue conducted a hydrogeological drilling and test production bore construction campaign in the Project area in 2016. Production bore drilling was completed via open hole and dual rotary drilling methods by Easternwell in some instances, and by mud rotary drilling method by Foraco. The test production bores were completed with 200 mm ND Class 12 PVC blank and 1 mm slotted casing. A summary of the production bore construction details are compiled in Table 1, which also includes older drilling water supply bores completed with 100 mm ND PVC with limited information on final construction details.

Table 1: Eliwana Mining Project test production and water supply bore summary

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Total depth cased (m bgl)</th>
<th>Initial SWL (m RL)</th>
<th>Casing &amp; ND (mm)</th>
<th>Slotted Interval (m bgl)</th>
<th>Drilling Method</th>
<th>Formation Screened</th>
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<tbody>
<tr>
<td>EWPB001</td>
<td>82.6</td>
<td>519.7</td>
<td>PVC C12 200</td>
<td>52.6 - 82.6</td>
<td>DR</td>
<td>Wittenoom</td>
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<td>128</td>
<td>510.2</td>
<td>PVC C12 200</td>
<td>110 - 128</td>
<td>DR</td>
<td>Wittenoom</td>
</tr>
<tr>
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<td>122</td>
<td>465.4</td>
<td>PVC C12 200</td>
<td>70 - 82 &amp; 92 - 122</td>
<td>DR</td>
<td>Wittenoom</td>
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<td>72 - 156</td>
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<td>61 - 103</td>
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<td>56 - 100</td>
<td>DR</td>
<td>Wittenoom</td>
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<td>72 - 150</td>
<td>DR</td>
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<tr>
<td>Ren Bore</td>
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<td></td>
<td></td>
<td>50 - 80</td>
<td></td>
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<tr>
<td>Badock Bore</td>
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<td>Grunters</td>
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<td></td>
</tr>
</tbody>
</table>

Note gaps in table represent missing data; DR = dual rotary; MR = mud rotary; RC = reverse circulation

The accompanying monitoring bores were completed using reverse circulation drilling method by Foraco. Bore constructions comprise 50mm ND Class 18 PVC blank and 1mm slotted casing. A summary of monitoring bore construction details are compiled in Table 2.
**Table 2: Eliwana Mining Project monitoring bore summary**

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Total depth cased (m bgl)</th>
<th>Initial SWL (m RL)</th>
<th>Casing &amp; ND (mm)</th>
<th>Slotted Interval (m bgl)</th>
<th>Drilling Method</th>
<th>Aquifer Screened</th>
<th>Date completed</th>
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<td>22 - 34</td>
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<td>28.8 - 58.8</td>
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<td>Detrital</td>
<td></td>
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<td>PVC C18 50</td>
<td>104.1 - 122.1</td>
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<td></td>
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<td>510.2 PVC C18 50</td>
<td>110 - 128</td>
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<td>9/12/2016</td>
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<td>DR</td>
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<td>25/10/2016</td>
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<td>497.7 PVC C18 50</td>
<td>51 - 117</td>
<td>DR</td>
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<td>14/10/2016</td>
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<td></td>
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<tr>
<td>EW1870</td>
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<td>30 - 36</td>
<td>RC</td>
<td>Wittenoom</td>
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<td>114</td>
<td></td>
<td></td>
<td>RC</td>
<td>Wittenoom</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note gaps in table represent missing data; DR = dual rotary; RC = reverse circulation; DH = diamond core

Bore completion logs and construction diagrams for production and monitoring bores as provided by Fortescue are included within Appendix A.

### 8.0 HYDROSTRATIGRAPHY

The following interpretation has been based on the Fortescue leapfrog geological model, airborne total magnetic intensity interpretation, Fortescue’s 2016 hydrogeological drilling campaign and close spaced drilling of mineral (exploration) holes conducted over the area to delineate orebody extents. Downhole geophysical surveys conducted within these mineral holes provides detailed definition of groundwater levels across the strike length where resource mineral drilling has occurred. The information was used to construct a pre-mining water table surface that will aid in defining the groundwater balance (inflow/outflow) and as a calibration measure for subsequent numerical calibration of the steady state groundwater model. The final lithology intersected within these mineral holes was used in hydrostratigraphic classification of aquifers and provide preliminary information on the potential for elevated pore pressures in the stratigraphy adjacent to the proposed below watertable (BWT) pit shells.
8.1 Aquifers

8.1.1 Mineralised Brockman aquifer

The mineralised Brockman Iron Formation is considered to be an aquifer, and will herein be referred to as the “Mineralised Brockman Aquifer”. The model for bedded mineralisation in the Hamersley Basin involves hypergene enrichment of the parent banded iron formation resulting in an increase in porosity and permeability.

As the mineralisation process is of chemical weathering, it can impact all members of the Brockman Iron Formation, as such the Whaleback Shale Member will be assumed part of the aquifer where it is also weathered/mineralised (until proven otherwise). FMG has provided a 40% iron cut-off shell that will be representative of the weathered zone and extent of the higher permeability Mineralised Brockman Aquifer.

The bore yields experienced in the test production bores completed in the Project area within the mineralised Brockman Aquifer appear modest in comparison to experience elsewhere. Whilst the cause for this is uncertain, careful review of proposed well designs and drill methods is recommended prior to any future investigation phase.

8.1.2 Wittenoom aquifer

The “Wittenoom Aquifer” will be defined as comprising all members of the Wittenoom Formation where weathered. Where the overlying detritals and Cainozoic sediments are saturated and in hydraulic connection with the groundwater contained in the Wittenoom Formation these sediments will be included within the definition of the Wittenoom Aquifer, given that the Wittenoom Formation occupies the valley floor basement.

8.1.3 Mineralised Marra Mamba Aquifer

The “mineralised Marra Mamba Aquifer” will be defined as comprising the upper Newman Member of the underlying Marra Mamba Iron Formation. As noted in Section 7.2.2.1 the West Angela Member, comprising shaley dolomite and interbedded band iron formation could be included as part of the Wittenoom Aquifer when weathered, consistent with experience across the Hamersley Basin. Often mineralisation of the Marra Mamba Iron Formation at depth is limited by the occurrence of the twin NS3 / NS4 shale band separating the upper Mount Newman Member from the lower Mount Newman Member. To account for this the Newman Member will be parameterised separately from the Wittenoom Aquifer to test the sensitivity of dewatering and water supply to this conceptualisation.

8.2 Aquitards

Un-mineralised banded iron formations generally represent low permeability formations or aquitards across the Hamersley Basin province. As such, any un-mineralised Brockman Iron Formation, Marra Mamba Iron Formation, Mount Sylvia Formation and fresh unweathered members of the Wittenoom Formation will be considered aquitards.

The Mount McRae Shale (MCS) is also considered an aquitard for this conceptual model. There is evidence from other sites that fresh MCS acts as a “no flow” boundary that partitions the Mineralised Brockman Aquifer from the Wittenoom Aquifer. A 3-D representation of predicted groundwater levels within the MCS may be required for pore pressure analysis of pit walls for the proposed Westend pit (given the absence of observational data on head change with depth) and for this reason the MCS will be represented as an aquitard rather than no flow.

The Brockman Syncline is somewhat unique for the prominent dolerite sill that occurs within the J3 band of the Joffre Member. On the southern limb of the Brockman Syncline, this sill creates significant head differences between groundwater south of the sill in the lower Joffre and Dales Gorge Members and groundwater north of the sill in the upper Joffre Member, despite iron mineralisation occurring either side of the sill. The sill will be inferred as an aquitard given the head difference (4 m) apparent between the proposed Westend and the Westend J6 pits. This will also allow for a 3-D representation of head for use in a pore pressure grid if required (as above).
The Hamersley Group basement of the Brockman Syncline is known to have geological structures that partition or compartmentalise the flow of groundwater from one area to another along strike. In particular the NW-SE and NE-SW trending dolerite dykes aligned with structures associated with the D3 Panhandle Orogeny (Müller et al., 2005) consistently form hydraulic barriers, sometimes with significant discrepancies in groundwater level elevations either side of the structure, elsewhere in the Brockman Syncline. These boundaries become more apparent once dewatering or groundwater abstraction occurs. Examples of this occurring in the Project area are provided in the discussion below, however the distribution of these potential dyke boundaries is not well understood everywhere. Those dykes that clearly (or are inferred to) impact groundwater level elevations, where identified, will be defined as aquitards until proven otherwise (i.e. observational evidence of groundwater flow via large scale pumping/dewatering).

Whilst there may be conjecture that some of the above units could be classified as no flow boundaries, including them as aquitards allows for a sensitivity analysis on hydraulic conductivity to be performed until such time as their true nature is clearly understood.

8.3 No flow boundaries

No flow boundaries relate to those formations that prevent the flow of groundwater from one aquifer to another (or from part of an aquifer to another part). These formations will be excluded from any numerical groundwater model to represent the limiting extent of an aquifer (or aquitard) within an analytical model set up.

The no flow boundary in the north will comprise the contact between the Fortescue Group and the Hamersley Group. This allows for the lower Marra Mamba Iron Formation below the upper Newman Member to be represented as an aquitard so it can be included in any numerical model to test sensitivities on assumptions if it is to be intersected by proposed pit walls. The upper Fortescue Group makes a sensible no flow boundary given the abundant dolerite sills within the Roy Hill Shale Member.

The southern no flow boundary will be represented by the contact between the Brockman Iron Formation and the Weeli Wolli Formation. The unweathered/fractured Weeli Wolli Formation can be considered a no flow boundary owing to the regular dolerite sills and fine grained siliceous banded iron formation. This assumption allows for testing the sensitivity of the Yandicoogina Shale, if it is to be intersected within the Westend J6 southern pit wall, within the model set up.

The far western no flow boundary will be given by the approximate location of a dolerite dyke that has a 65 m head difference either side of its location. To the west of the dolerite where groundwater is observed at 393 mRL will be excluded from the any numerical or analytical model set up, unless explicitly requested to be included within the scope of the Project.

8.4 Groundwater occurrence

8.4.1 Average groundwater levels

Groundwater levels have been established from depth to groundwater measurements obtained in mineral exploration boreholes. These measurements are derived from downhole resistivity profiling; where resistivity values decrease dramatically as the resistivity tool enters the saturated part of the borehole. Approximately 775 measurements were used to generate an average water level surface for the Project area. Of these, less than 0.5% were considered unreliable due to a combination of the following factors.

- Measurements are made shortly after drilling and before water levels have recovered in the borehole;
- The drillhole has collapsed and measurements are made near the base of the collapse where saturated mud is ‘trapped’ and can result in an interpretation of water table;
- Measurements are made near the base the hole where saturated mud can result in an interpretation of water table; and
- Measurements have been made in shallow holes near creek lines following rainfall events
A regional water level surface has been established from the downhole resistivity measurements. A comparison of this surface with conventional water level measurements in water bores in the Project area is illustrated in Figure 3. An R-squared value of 0.98 has been obtained, suggesting the derived water level surface is a reasonable representation of water levels across the Project area.

8.4.2 Groundwater sub catchments

Groundwater resources occur across the Project area within the Mineralised Brockman Aquifer and the Wittenoom Aquifer in discrete, groundwater sub catchments. For ease of discussion the groundwater sub catchments along the valley have been named as per Figure 4 (long section plan).

As can be seen in the cross section of Figure 5 (long section), the groundwater (level) elevation falls from 572 mRL in the far east via a series of sharp changes occurring across dykes, to a minimum groundwater level of 497 mRL where the surface drainage trends south through the Brockman Iron Formation ridge towards Boolgeeda Creek. The one anomalous step between a series of NW SE trending dolerites occurs where three mineral holes return a groundwater level of ~545m RL, before groundwater rises to 553 mRL in the adjacent sub catchment to the west where Grunters is located; further west again the groundwater level continues to decline (Figure 6).

West of the 497 mRL sub catchment groundwater levels begin to step up to an elevation of ~520 mRL within the sub catchment containing Ren Bore (Figure 7). Within this groundwater sub catchment, there is a surface water divide between the east flowing un-named creeks and the west flowing Pinara Creek. Further west, the groundwater levels begin to decline, with a series of sharp changes which occur across the dykes that separate each groundwater sub catchment, to a minimum of 459 mRL at Broadway East (Figure 8). The Pinara Creek alignment then shifts due south and cuts through the Brockman Iron Formation ridge to join Boolgeeda Creek within the internal syncline valley. West of Broadway East there is another significant NW-SE trending, dolerite filled structure; west of this structure the groundwater level is 393 mRL.

Differences between the groundwater level of the Mineralised Brockman Aquifer and the Wittenoom Aquifer are subtle, despite the Mount McRae Shale aquitard. Three sections have been prepared in the locations.
given in Figure 8. From Broadway East sub catchment the Wittenoom Aquifer has a groundwater level of ~459 mRL, whereas at the proposed Westend pit north of the sill, south of the Mount McRae Shale has a groundwater level of 457 mRL. South of the dolerite sill the groundwater in the proposed Westend J6 pit is 454 mRL (Figure 9).

Between the Broadway East and Talisman groundwater sub catchments of Section C (Figure 8) there is a NW-SE trending strike slip fault that may juxta-pose the mineralised Dales Gorge Member in the east against the Wittenoom Aquifer to the west. It is uncertain from the Leapfrog model and information to hand whether either block has shifted vertically with respect to the other. Regardless, the fault structure appears to be filled with dolerite that prevents hydraulic connection along the Wittenoom Aquifer, given by the significant head difference from 474 mRL to the east and 459 mRL to the west.

Further east there are similar NW-SE strike slip faults that likewise reflect juxta-position of the Dales Gorge Member adjacent to the Wittenoom Aquifer in the Flying Fish area; however, investigation of the impact of these structures will be hampered by tenure access as they are associated with RTIO’s proposed Brockman Syncline No.1 (BS1) tenements. It is not known whether they are dolerite filled and thus limiting groundwater flow or open and thus allowing connection between the Wittenoom Aquifer and the Mineralised Brockman Aquifer (at RTIO’s below water table BS1 deposit). Given the groundwater elevations are comparable at BS1 and the Wittenoom Aquifer it tends to support the latter hypothesis.

Given the above discussion the hydraulic relationship between most groundwater sub catchments is considered to be “no flow”. This is supported by the relatively consistent down hole resistivity groundwater levels recorded within each defined sub catchment, followed by substantial changes in groundwater level. Furthermore, test pumping results confirm the presence of dykes with negligible impact from testing at FFPB003 where a 45m head difference occurs either side of NNW-SSE trending dolerite dyke, and FFPB002. The groundwater hydraulic gradient within each discrete sub catchment is considered negligible. Whilst there is some variation in groundwater levels within each sub catchment, these variations are not consistent, are generally small in magnitude (<1m), and may be the result of drill hole depth or small measurement errors. Small hydraulic gradients may persist where groundwater is lost to evapotranspiration along low lying drainage channels.

8.4.3 Pore pressures
Currently there are no multi-level piezometers within boreholes which could be used to ascertain vertical head gradients from within aquifers or from aquifers to aquitards that may be intersected by pit walls. Hence a further review of the mineral exploration downhole resistivity data (Section 8.4.1) has been conducted as a proxy indicator.

From the four proposed below water table pits the aquitards that may be intersected within pit walls comprise the Mount McRae Shale, unmineralised Brockman Iron Formation, dolerite dykes and sills and the Nammuldi and Mount MacLeod Members.

The Mount McRae Shale is most likely to be intersected in pit walls below the water table on the northern wall of the proposed Westend pit. By filtering the bottom hole stratigraphy intersected in mineral and diamond holes and comparing relative groundwater levels from resistivity data there are 29 mineral holes that intersect the Mount McRae Shale with groundwater levels. There is only one representative mineral hole in Westend pit that intersects the Mount McRae Shale and has an anomalous (higher head) when compared with surrounding holes, e.g. EW1146, drilled to 108 mbgl, has a head of 460 mRL (+3m). There is another mineral hole completed in the Shale with a head significantly lower (442.9 mRL, EW0030 drilled to 180 mbgl). Otherwise mineral holes completed within the Mount McRae Shale are comparable with the general head of 457 mRL across the orebody and comparable with groundwater levels in adjacent groundwater sub catchments.

From the information provided it was not possible to ascertain whether higher heads are indicative of elevated pore pressures within the unmineralised Brockman Iron Formation.

Dolerite dykes or sills were represented as the final bottom hole stratigraphy intersected by 19 mineral holes and one monitoring bore, EWMB006. Of the 19 mineral exploration holes only five intersected groundwater.
Of these, two mineral holes had somewhat anomalous groundwater levels in comparison to the sub catchment in which they were drilled, but there was very little surrounding data to support this assumption. EWMB006 on the northern wall of Westend J6 sub pit has a groundwater level comparable with groundwater levels remainder of Westend pit north of the sill, that is, 3 m higher than the Westend J6 sub pit groundwater level.

The Nammuldi and Mount MacLeod Members are most likely to be intersected in either the Talisman or Broadway East below water table pits. However neither of these pits are proposed to be overly deep below the water table. The Nammuldi and Mount MacLeod Members were represented as the bottom hole stratigraphy intersected by 260 mineral holes, of which only 22 intersected groundwater. Of those 22 only one mineral hole had a head significantly (25 m) higher than the surrounding valley, EW0554. This hole only intersected lower Newman and then MacLeod below the water table indicating that there are potentially elevated vertical hydraulic gradients present between the Mount MacLeod aquitard and Wittenoom Aquifer. Most of the other holes intersected the Wittenoom Aquifer above the MacLeod allowing for equilibrium of potentiometric heads to occur through the annulus of the mineral exploration hole.
Eliwana Project – Hydrogeological Conceptual Model

Conceptual Long Section – Wittenoom Aquifer

Legend
- Inferred Dyke/Fault
- Wittenoom Aquifer
- MacLeod Member
- Nammuldi Member
- Groundwater Table (m AHD)

Vertical exaggeration: 15x

Scale: 1:20,000

See Legend

Fortescue Metals Group

MJB

WD

15/03/2017

15/03/2017

FIGURE 5
CROSS SECTIONS A TO C – MINING AREA – WESTERN HUB

SECTION A

SECTION B

SECTION C

LEGEND
- Jeerinah Formation
- Numnudl Member
- MacLodd Member
- Mt Norman Member
- West Angelus Member
- Paraburadoo Member
- Bel Gorge Member
- Yondooloo Shale
- Inferred Dyke/Fault
- Pit Shell
- Groundwater Table

Elevations (m AHD)

Mt Silvia Formation
Mt McRae Shale
Dates Gorge Member
Whaleback Shale
Joffre Member
Dolerite

A3

Fortescue Metals Group

Eliwana Project – Hydrogeological Conceptual Model

Cross Sections – Mining Area

MJB
15/03/2017

WD
15/03/2017

FIGURE 9

1671484-002-R-Rev2
8.5 Groundwater chemistry

Groundwater chemistry in terms of major ions and physical parameters were provided for 15 monitoring and production bores across the Project. The major ions were plotted on a piper trilinear diagram (Figure 10) to understand the hydrochemical facies present. It was determined from the piper diagram that the Eliwana groundwater is of magnesium bicarbonate type, whereas the Flying Fish groundwater was of a mixed type bordering on chloride anion dominant groundwater. Overall the alkaline earth metals (Mg, Ca) are more dominant than sodium potassium alkalis. The high alkalinity results in laboratory pH in all groundwater were analysed to be above 7.8. Groundwater in the east of the Project area was clearly more brackish than groundwater in the west, being generally greater than 1200 mg/L up to 1700 mg/L TDS. Groundwater in the west was generally fresh, although still above Australian Drinking Water Guidelines (ADWG) for human consumption for aesthetics (taste) at between 500 to 800 mg/L TDS. Groundwater in the east of the Project area also exceeds ADWG for health for Boron in every bore sampled, Eliwana production bores were at the recommended guideline limit for health for Boron in most instances.

Figure 10: Piper trilinear diagram of groundwater major ions
9.0 PUMPING TESTING ANALYSIS

Fortescue has completed a pumping testing program on test production bores and a number of older drilling water supply bores established within the Project area. The testing program comprised eight step rate tests with four steps in each test with step durations of either 30 or 60 minutes as detailed in Table 3.

### Table 3: Step rate pumping testing summary

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Pumping Duration (mins)</th>
<th>Pumping rates (L/sec)</th>
<th>Screen interval (m bgl)</th>
<th>Stratigraphy Aquifer</th>
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<td>EWPB005</td>
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<td>68 – 98</td>
<td>Newman Member</td>
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<td>1.5, 3.8, 6.5, 8.8</td>
<td>131.5 – 179.5</td>
<td>Whaleback &amp; Dales Gorge Members</td>
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<td>16, 20, 24, 28</td>
<td>70 – 82 &amp; 92 - 122</td>
<td>Bee Gorge &amp; Paraburdo Member</td>
</tr>
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<td>EWPB006</td>
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<td>17, 22, 27, 32</td>
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<td>56 – 100</td>
<td>Paraburdo Member</td>
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<td>Paraburdo Member</td>
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Detailed analysis of the step rate tests will be conducted during the next phase of investigations accompanying water supply and dewatering planning work, as the testing provides insight on individual bore’s characteristics rather than aquifer parameters. In circumstances where the results of constant rate test analysis indicated that well loss impacted the curve fitting, reviews of the step tests were conducted to confirm whether the discrepancy in curve matching of the production bore could be justified by well loss.

Constant rate pumping testing was conducted on nine of the test production bores and two of the drilling water supply bores, with minimal construction details available on the latter. Bore identity, observation bores used, constant rates, pumping durations and aquifer for each test are detailed in Table 4. Observation data was recorded both manually and via downhole automated loggers in most instances.

### Table 4: Constant rate pumping testing summary

<table>
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<th>Bore ID</th>
<th>Observation Bores</th>
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<th>Duration (min)</th>
<th>Final Drawdown (m)</th>
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<td>21.9</td>
<td>Wittenoom</td>
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<td>28</td>
<td>4320</td>
<td>6.6</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>EWPB004</td>
<td>EWMB004, EWMB003, EWMB005, EWMB009, EWMB001d&amp;s</td>
<td>32</td>
<td>7200</td>
<td>1.2</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>EWPB005</td>
<td>EWD007, EWD019, EWMB006</td>
<td>5.9</td>
<td>2880</td>
<td>12.3</td>
<td>Mineralised Brockman</td>
</tr>
<tr>
<td>EWPB006</td>
<td>EWMB008, EW1871, EWMB009, EW1870, EWMB004</td>
<td>31</td>
<td>4320</td>
<td>5.3</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>EWPB007</td>
<td>EWD019, Dirty Nick, EWMB006, EW007, EWPB005</td>
<td>6</td>
<td>7200</td>
<td>14.7</td>
<td>Mineralised Brockman</td>
</tr>
<tr>
<td>FFPB001</td>
<td>FFBMB001, Flying Fish, Grunters</td>
<td>30</td>
<td>4320</td>
<td>11.0</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>FFPB002</td>
<td>FFBMB002, FFMB003, FFPB003</td>
<td>32</td>
<td>4320</td>
<td>2.1</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>FFPB003</td>
<td>FFMB003, FFPB002, FFMB002</td>
<td>20</td>
<td>4320</td>
<td>19.2</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>Kenny Bore</td>
<td>none</td>
<td>3.3</td>
<td>2880</td>
<td>11.4</td>
<td>Wittenoom</td>
</tr>
<tr>
<td>Dirty Nick</td>
<td>none</td>
<td>1.2</td>
<td>480</td>
<td>1.0</td>
<td>Mineralised Brockman</td>
</tr>
</tbody>
</table>
Detailed description of the pumping testing analysis assumptions and methods applied for the constant rate testing is provided in Appendix B.

9.1 Aquifer parameters

A summary of the aquifer parameters derived from the pumping testing analyses is presented in Table 5. The most transmissive aquifer encountered was the Wittenoom Aquifer with hydraulic conductivity ranging from 3 to 48 m/day. Within the Wittenoom Aquifer itself, the weathered Paraburdoo Member consistently had the highest hydraulic conductivity derived from testing (15 to 48 m/day). Where the Paraburdoo Member was not weathered and comprised fresh, crystalline dolomite (EWPB002), hydraulic conductivity was lower (6 m/day) in comparison to the weathered Paraburdoo Member. The one production bore completed in the Mount Newman Member resulted in a hydraulic conductivity of 5 m/day. The test pumping results also indicate that there is heterogeneity within the broader “Wittenoom Aquifer”.

The Mineralised Brockman Aquifer had a range in hydraulic conductivity of between 1 and 6 m/day which is consistent with similar orebodies elsewhere in the Hamersley Province.

Specific yields are estimated to range from 1 x 10⁻³ to 0.07. As some of the tests completed did not generate drawdown in monitoring bores, observed storage parameters were not able to be derived for every test. For the most part unconfined aquifer conditions were prevalent across the area and assumed within pumping testing analysis. The observations from test pumping were also in broad agreement with the conceptualisation outlined in Section 8.
### Table 5: Summary of aquifer parameters from pumping testing analysis

<table>
<thead>
<tr>
<th>Screened Aquifer</th>
<th>Screened Stratigraphy</th>
<th>Bore</th>
<th>Aquifer Thickness (m)</th>
<th>Aquifer Type</th>
<th>T (m²/day)</th>
<th>K (m/day)</th>
<th>S</th>
<th>Ss (1/m)</th>
<th>Sy</th>
<th>Kz/Kr</th>
<th>Analysis Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wittenoom Aquifer</td>
<td>No data</td>
<td>Kenny Bore</td>
<td>76</td>
<td></td>
<td>235</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cooper-Jacob (pumped bore only)</td>
</tr>
<tr>
<td>Upper Brockman Iron Formation</td>
<td>Joffre Mbr</td>
<td>EWPB005</td>
<td>52</td>
<td>Unconfined</td>
<td>300</td>
<td>5.8</td>
<td>0.005</td>
<td>9.6E-05</td>
<td>0.07</td>
<td>0.1</td>
<td>Neuman (bounded aquifer)</td>
</tr>
<tr>
<td>Brockman Iron Formation</td>
<td>Joffre and Dales Gorge Mbrs</td>
<td>Dirty Nick</td>
<td>77</td>
<td></td>
<td>127</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cooper-Jacob (pumped bore only)</td>
</tr>
<tr>
<td>Mineralised Brockman Aquifer</td>
<td>Whaleback Shale and Dales Gorge Mbrs</td>
<td>EWPB007</td>
<td>88.7</td>
<td></td>
<td>95</td>
<td>1.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cooper-Jacob (pumped bore only)</td>
</tr>
<tr>
<td>Wittenoom Aquifer</td>
<td>Bee Gorge and Paraburdoo Mbrs</td>
<td>EWPB003</td>
<td>60</td>
<td></td>
<td>1180</td>
<td>19.7</td>
<td>1.50E-05</td>
<td>2.5E-07</td>
<td>0.0013</td>
<td>0.003</td>
<td>Neuman (bounded aquifer)</td>
</tr>
<tr>
<td>Wittenoom Aquifer</td>
<td>Paraburdoo Mbr</td>
<td>EWPB002</td>
<td>24</td>
<td>Confined</td>
<td>4.5</td>
<td>8.4E-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Moench (slab blocks) – fracture flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWPB004</td>
<td>134</td>
<td>Unconfined</td>
<td>6500</td>
<td>48.5</td>
<td>0.04</td>
<td>0.1</td>
<td></td>
<td></td>
<td>Theis (bounded aquifer)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWPB006</td>
<td>54</td>
<td></td>
<td>850</td>
<td>15.7</td>
<td>0.0025</td>
<td>4.6E-05</td>
<td>0.07</td>
<td>0.1</td>
<td>Neuman</td>
</tr>
<tr>
<td>Wittenoom Aquifer</td>
<td>Paraburdoo Mbr</td>
<td>FFPB001</td>
<td>89.7</td>
<td></td>
<td>2330</td>
<td>26.0</td>
<td>0.001</td>
<td>1</td>
<td></td>
<td></td>
<td>Theis (bounded aquifer)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFPB002</td>
<td>110</td>
<td></td>
<td>4460</td>
<td>40.5</td>
<td>0.009</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFPB003</td>
<td>62.6</td>
<td>Unconfined</td>
<td>300</td>
<td>4.8</td>
<td>0.0011</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T – transmissivity, K – hydraulic conductivity, S – storativity, Ss – specific storage, Sy – specific yield, Kz/Kr – vertical to radial hydraulic conductivity ratio
9.2 Slug testing

Fortescue completed 11 pneumatic and one water injection slug tests across the constructed monitoring bores and one production bore EWPB001. All the tests were completed within the Wittenoom Aquifer with the exception of EWMB006 where the slots were installed against a dolerite sill. All slug test analyses were undertaken using the AQTESOLV software package (HydroSOLV Inc.). The tests were analysed using a combination of the Springer-Gelhar, Bouwer-Rice or Hvorslev methods depending on conditions encountered. Details of the AQTESOLV output are provided in Appendix C and a summary of indicative hydraulic conductivity values derived on the basis of the testing is provided in Table 6.

Table 6: Summary of slug testing

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Test type</th>
<th>Aquifer</th>
<th>Aquifer model</th>
<th>Analysis method</th>
<th>Derived hydraulic conductivity (m/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWMB001S</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Confined</td>
<td>Bouwer-Rice</td>
<td>1.2</td>
</tr>
<tr>
<td>EWMB001D</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>4.2</td>
</tr>
<tr>
<td>EWMB002</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Hvorslev</td>
<td>1</td>
</tr>
<tr>
<td>EWMB003</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Horslev</td>
<td>1</td>
</tr>
<tr>
<td>EWMB004</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>5.3</td>
</tr>
<tr>
<td>EWMB005</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>6.8</td>
</tr>
<tr>
<td>EWMB006</td>
<td>pneumatic</td>
<td>Dolerite</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>4.7</td>
</tr>
<tr>
<td>EWMB008</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>3.8</td>
</tr>
<tr>
<td>EWMB009</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>4</td>
</tr>
<tr>
<td>EWPB001</td>
<td>water injection</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Hvorslev</td>
<td>0.2</td>
</tr>
<tr>
<td>FFMB001</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>4.8</td>
</tr>
<tr>
<td>FFMB002</td>
<td>pneumatic</td>
<td>Wittenoom</td>
<td>Unconfined</td>
<td>Springer-Gelhar</td>
<td>16.3</td>
</tr>
</tbody>
</table>

The estimates of hydraulic conductivity derived from analysis of the slug testing data are in reasonable agreement with those derived from the test pumping of the Wittenoom Aquifer. The estimated hydraulic conductivity based on the test carried out at EWMB006 is higher than expected.

10.0 CONCEPTUAL GROUNDWATER BALANCE

A conceptual groundwater balance has been developed and is based on the assumption of quasi-steady state; that is inflow is equal to outflow and there is negligible change in storage. Given the compartmentalised nature of groundwater Project area, individual storage calculations and water balances have been resolved for each groundwater sub catchment listed in Table 7. The mean groundwater levels for each sub catchment used in Table 7 is consistent with those presented on Figure 4. Groundwater throughflow is considered negligible in most instances, unless otherwise stated.

10.1 Groundwater storage

Groundwater storage has been calculated based on the area of each groundwater sub catchment, the saturated profile given local bore information, or in the absence of information an estimated saturated profile, and a range of assumed specific yields given the lower and upper values derived from the results of test pumping analysis. This range was notionally set at between 1% and 7%; it is somewhat problematic to assign these values at a sub-catchment scale given that they are based on short term test pumping. It will not be possible to resolve the accuracy of the specific yields until sustained (i.e. 12 months) and larger scale abstraction (i.e. pit dewatering) has commenced.
The northern boundary for each groundwater sub catchment in the valley comprises the Jeerinah Formation, the southern boundary comprises the base of the Mount McRae Shale, as derived from the Fortescue Leapfrog model provided. The east and west boundaries are given by inferred dolerite dykes that cross the valley from either extension of mapped dolerite outcrops in the adjacent basement hills or total magnetic intensity anomalies, or both, and consistent with where changes in groundwater levels were apparent from mineral hole resistivity observations.

Within the Mineralised Brockman Aquifer the east and west boundary extents have been continued until an obvious structure has been identified (dolerite dyke), and thus the area includes mineralised aquifer and non-mineralised low permeability basement which may over-represent groundwater storage at the higher specific yield and saturated thickness applied (i.e. the 7% estimate and 130 m). At the proposed Westend pit the northern boundary is the top of the Mount McRae Shale while the southern boundary is given by the base of the dolerite sill outcrop. At Westend J6 pit the northern boundary comprises the top of the dolerite sill and the southern boundary is given by the extent of the proposed pit outline.

Table 7: Indicative groundwater stored in each groundwater sub-catchment

<table>
<thead>
<tr>
<th>Groundwater sub catchment</th>
<th>Aquifer</th>
<th>Mean groundwater level (m RL)</th>
<th>Estimated Saturated thickness (m)</th>
<th>Groundwater Stored Volume (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1% Sy</td>
<td>3% Sy</td>
</tr>
<tr>
<td>572*</td>
<td>Wittenoom</td>
<td>572</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>570*</td>
<td>Wittenoom</td>
<td>570</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>545</td>
<td>Wittenoom</td>
<td>545</td>
<td>110</td>
<td>2</td>
</tr>
<tr>
<td>Grunters</td>
<td>Wittenoom</td>
<td>553</td>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>544</td>
<td>Wittenoom</td>
<td>544</td>
<td>80</td>
<td>6</td>
</tr>
<tr>
<td>497</td>
<td>Wittenoom</td>
<td>497</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Kenny Bore</td>
<td>Wittenoom</td>
<td>500</td>
<td>70</td>
<td>3</td>
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<tr>
<td>Ren Bore</td>
<td>Wittenoom</td>
<td>517-519</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>EWPB002</td>
<td>Wittenoom</td>
<td>510</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>502*</td>
<td>Wittenoom</td>
<td>502</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>Talisman</td>
<td>Wittenoom</td>
<td>474</td>
<td>100</td>
<td>11</td>
</tr>
<tr>
<td>Broadway East</td>
<td>Wittenoom</td>
<td>459</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>Westend</td>
<td>Min Brockman</td>
<td>457</td>
<td>130</td>
<td>11</td>
</tr>
<tr>
<td>Westend J6</td>
<td>Min Brockman</td>
<td>454</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

*No bore information to support the estimated saturated thickness available for this groundwater sub catchment

Based on the cumulative volumes from each groundwater sub catchment in Table 7, the total volume of groundwater stored within the Project area is estimated to vary between 67 GL up to 467 GL from the western edge of Broadway East sub catchment to the eastern end of Flying Fish, dependent on assumptions applied.

10.2 Groundwater recharge

In order to resolve the conceptual water balance an examination of long term groundwater level monitoring is required to understand potential input from rainfall recharge and or losses from the system. The longer the monitoring record the more confidence that could be attributed to the assumptions on groundwater recharge. Hydrographs extending longer than 12 months are more relevant as they contain an entire climatic season, hydrographs with multiple years of observations will capture the effect of climate variability from year to year. Currently in the Project area, Fortescue have eight bores with multi-year records and eleven monitoring bores with short term, six hourly level observations as part of the pumping testing observation data set collected from late December 2016 to mid-February 2017. The long - term monitoring hydrographs are
presented with monthly rainfall data in Figures 11, 12 and 13. The short-term six hourly hydrographs are presented in Figure 14, 15 and 16.

An assessment of the eight hydrographs indicate that responses to rainfall are not evident at Ren Bore, Talisman or Dirty Nick (Figure 11) or at Kenny Bore (Figure 12). Ren Bore groundwater levels have also been captured within the 6 hourly logger data set and again no rainfall-recharge is apparent, levels reflect pump on / pump off over printing a gradual decline in groundwater level owing (most likely) to the pumping. At Kenny Bore and Ren Bore depth to groundwater is around 40 mbgl and at Dirty Nick and Talisman depth to groundwater is over 65 mbgl. The groundwater level at Reef Bore was measured at 17 mbgl and the absence of a response to rainfall events is related to sampling frequency (there are only 6 observations over a two year period).

Groundwater levels respond to rainfall recharge at Badock Bore and Flying Fish (Figure 13), where depth to groundwater is less than 15 m bgl. Whilst at Grunters the groundwater level is within a similar range, its hydrograph appears to be overprinted by a steady decline in response to pumping for drilling water supply. From November 2007, the groundwater level at Grunters has fallen around 5.5 m in total. Groundwater recovery may have occurred following the 370 mm of rainfall recorded in the month of March 2015; however, insufficient observations have been provided.

Within the 6-hourly logger data set rainfall recharge is apparent from February 6th 2017. From 2nd to 15th February 131mm was recorded at Eliwana Camp rainfall gauge, with 40mm falling between 4th and 5th February. Monitoring bores EWMB003, EWMB004 (Figure 14) and FFMB002 (Figure 15) show slight 10-20 cm increase in groundwater levels. EWMB008 (Figure 14) has a 50 cm increase in groundwater level up to the 13th February, following which its groundwater level is impacted by test pumping at nearby EWPB006. The former three monitoring bores all have depth to groundwater in the order of 30 m, whilst at EWMB008 depth to groundwater is 25 m. No responses are discernible from FFMB001 (Figure 15), EWMB002 or Ren Bore (Figure 16) that had data loggers installed over the period. EWMB006, EWPB007 and EWD007 had their loggers removed prior to the rainfall event and are not presented.

Whilst the sampling frequency of groundwater and rainfall observations is somewhat inadequate to make a definitive assessment of the type of events that produce recharge, a broad assumption is that at least 100 mm/month is required before a response in groundwater levels is to be observed, when they are within approximately 30 m of the surface based on the hydrograph and rainfall data presented. On a daily basis rainfall likely needs to exceed 20 mm for a response in groundwater levels to occur. The shallower the groundwater the greater and more immediate the response to a rainfall event. It is recommended that data loggers recording daily levels for groundwater observations and rainfall are implemented in the Project area as soon as practical.

Recharge was calculated for a sub catchment where the groundwater was within 30 m of the surface based on the supplied 10 m elevation contours and the assumed mean groundwater relative level (RL) in each sub catchment. Annual average rainfall of 384 mm (BoM, Hamersley Station 5005) was assumed for the general area. Within other catchments, where depth to groundwater is >30 mbgl the unsaturated zone is assumed to possess sufficient moisture deficit such that no recharge is discernible. Further long term monitoring may prove this assumption to be overly conservative; but given the absence of data at this stage it is considered a reasonable assumption.
Long term groundwater level & monthly rainfall observations

**Ren Bore**

**Talisman**

**Dirty Nick**

File Location: Level 3, 1 Havelock St
West Perth WA 6005
Ph: +618 9213 7600
Fx: +618 9213 7611

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Long term groundwater level & monthly rainfall observations

Reef Bore

Kenny Bore
Long term groundwater level & monthly rainfall observations
Eliwana short term groundwater level & daily rainfall observations with recharge

Figure 13
Flying Fish short term groundwater level & daily rainfall observations no recharge
FIGURE 16

Eliwana West short term groundwater level & rainfall observations no recharge

**Hydrogeological Conceptual Model - Eliwana**

**File Location:**

**Scale:** A4

**Project No:** 1671484-002-R-Rev2

**Figure No:** Figure 16
10.3 Groundwater discharge

Given the groundwater sub catchments appear to be largely closed, the only form of natural groundwater loss is through evapotranspiration of groundwater through the action of phreatopytes (trees that access the watertable). From the discussion in Section 5, there were four areas mapped by Fortescue as potential GDEs. For the purpose of calculating estimates of loss from the watertable via evapotranspiration a depth of 15 mbgl was used as an “extinction depth” for groundwater dependence. Given this assumption, groundwater loss via evapotranspiration is considered unlikely to occur over the entire mapped potential GDE areas.

Losses to evapotranspiration were calculated given the area of GDE mapped that contained the groundwater level within 15 mbgl, an assumed stem density of water dependent trees of 10 m² per hectare and a mean individual stem water use of 68 L/day taken from a study completed by Keitel & Adams (2009) on *Eucalyptus camaldulensis* and *E. victrix* tree water use in Millstream National Park. Currently there are not any similar references known for water use by *E. xerothermica*. Given its form as a “mallee” the mean tree use from the Millstream study may be an over estimate. The estimated losses to evapotranspiration were then annualised and provided in Table 8.

<table>
<thead>
<tr>
<th>Groundwater catchment</th>
<th>~ GDE with groundwater at 15mbgl (Hectares)</th>
<th>Tree use &amp; Basal stem density (L/day &amp; m²/ha)</th>
<th>Water use (L/day/ha)</th>
<th>Water Use (ML/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>570a</td>
<td>15.9</td>
<td>68 &amp; 10</td>
<td>8228</td>
<td>3.9</td>
</tr>
<tr>
<td>Grunters (553)</td>
<td>44.5</td>
<td>68 &amp; 10</td>
<td>46,784</td>
<td>11.0</td>
</tr>
<tr>
<td>497</td>
<td>8.5</td>
<td>68 &amp; 10</td>
<td>5780</td>
<td>2.1</td>
</tr>
<tr>
<td>Broadway East (549)</td>
<td>12.2</td>
<td>68 &amp; 10</td>
<td>8296</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* No *E. victrix* recorded in riparian vegetation assemblage

10.4 Groundwater balance

The pre-mining groundwater water balances are calculated based on pre-anthropogenic influences in the area such that groundwater levels were assumed to be in a quasi-steady state. This assumes limited seasonal variations; and that change in storage from year to year is also negligible. Note from Figure 13 that the abstraction by others to the east of Flying Fish for construction supply purposes appears to have caused drawdown within the Grunters sub catchment.

The results of the pre mining water balance for catchments that receive some groundwater recharge given the 30 mbgl cut off and those four that have evidence for evaporative loss are provided in Table 9. A best fit of 0.5% of annual average rainfall at Hamersley rainfall station is required to balance estimated losses to evapotranspiration, with the exception of Grunters sub catchment, where ~1.2% of recharge would be required to balance estimated losses. However given groundwater levels have been steadily declining in Grunters catchment (Figure 13) due to abstraction by others, the assumed recharge was left at 0.5% of annual average rainfall.

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4 The calculations are not overly sensitive to the extinction depth chosen given the uncertainty in depth to water at the scale of the information provided; it is essentially a rough cut-off for calculating an area to apply the losses from.

5 A definition of basal stem density by FMG in the mapped GDE areas could be used to refine this assumption; but 10-20m² generally equates to a sparsely populated eucalyptus woodland.
Table 9 indicates discrepancies within the groundwater balance which are attributable to the coarse approach. However the discrepancies are measured in such insignificant volumes in comparison to subcatchment area and predicted storage and therefore are considered negligible. For example, groundwater sub catchment 572 and 544 where ~5 ML/a recharge is predicted, would equate to an annual increase in observed groundwater level of less than 4 cm. In reality recharge will be far more episodic and related to rainfall intensity and duration with high inter-annual variability dependent on climate.

Where the balances are negative, at Broadway East and Grunters sub catchment, this may reflect the mean water use per stem, or the assumed stem density applied, were too high. Regardless, at Grunters sub catchment the change in storage would equate to a 10 cm reduction in groundwater level per annum, whereas the groundwater level has fallen roughly 50 cm a year since 2007 in response to abstraction. At Broadway the annual change in groundwater level would equate to ~1 cm, and is unlikely to be perceived amongst the inter-annual variability in climate anticipated.

Where estimated recharge from rainfall in a groundwater sub catchment was less than 1 ML/a and evapotranspiration losses are not anticipated, groundwater balances are not presented in Table 9. In each case the water balance for these groundwater sub catchments assumes no inflow or outflow given the modern climate, depth to groundwater and aquifer boundary definitions.

11.0 CONCLUSIONS

The geology is consistent with recognised Hamersley Basin stratigraphy. The bedded geology bounds the aquifers between aquitards to the north and south and by dolerite dykes to the east and west. Given the bedded geology, groundwater occurs in isolated groundwater sub catchments with negligible hydraulic gradients across most of these sub catchments. This interpretation is well supported through analysis of mineral hole downhole resistivity data and large step changes in groundwater levels (up to 50m) either side of inferred, buried dolerite dykes.

Two main aquifers have been defined, the Wittenoom Aquifer, comprising the Wittenoom Formation and overlying detritals and Cainozoic sediments, where saturated. The second aquifer defined is the mineralised Brockman Aquifer, comprising only the Brockman Iron Formation where mineralised. From the test pumping, that there is heterogeneity in derived aquifer parameters from individual members of the Wittenoom Aquifer. For the most part the aquifers appear to be unconfined, and bounded by lower and upper, parallel bedded, stratigraphy and inferred impermeable dolerite dykes.

Where saturated and mineralised, the upper Newman Member of the Marra Mamba Iron Formation is considered to be an aquifer and has been acknowledged in the current conceptualisation as the mineralised Marra Mamba aquifer. However it is noted that due to its position adjacent to the West Angelas Member of the Wittenoom Formation, it could be in direct hydrostratigraphic connection with the Wittenoom Aquifer.

There is potential for NW-SE trending “strike-slip” or horst and graben type structures to influence groundwater behaviour and connect the aquifers where these structures are present.
Depth to groundwater is significant (>30 mbgl) across most of the Project area. However groundwater recharge is evident from hydrographs where groundwater levels are relatively shallow (<30 mbgl) within the valley between the Marra Mamba Iron Formation and Brockman Iron Formation ridge lines. There is no evidence of groundwater recharge occurring where depth to groundwater is significant.

Groundwater discharge may occur in some isolated sub catchments within the valley between the Marra Mamba Iron Formation and Brockman Iron Formation ridge where groundwater levels are sufficiently shallow to support groundwater dependent vegetation. Four potential groundwater dependent vegetation areas were mapped by Fortescue. However analysis of depth to water would indicate that only a portion of each mapped area could potentially sustain groundwater dependent vegetation as the depth to groundwater is greater than 20 m.

Hydraulic parameters derived from pumping testing analysis from the Wittenoom Aquifer indicate a high transmissivity aquifer in part, particularly the Paraburdoo Member. Storage parameters derived from test pumping analysis of the Wittenoom Aquifer would indicate a maximum specific yield of 0.07 where the aquifer is weathered. High yield water supply bores will best be sited where weathered Paraburdoo Member units are present within the larger groundwater sub catchments.

Hydraulic parameters derived from pumping testing analysis from the Mineralised Brockman Aquifer indicate hydraulic conductivity in the order of 1 to 6 m/day, consistent with like ore bodies in the Hamersley Province.

Review of bottom hole mineral lithology intersected and resistivity data indicate there is some potential for elevated potentiometric heads between the upper Newman and lower Newman/MacLeod members of the Marra Mamba Iron Formation. There is little evidence to support elevated potentiometric head with depth elsewhere, however more information on vertical head distribution is required to understand depressurisation requirements and pit slope stability risks.

Groundwater chemistry indicates some difference in groundwater types between the western and eastern regions of the Project area, with the east generally being a more chloride dominant anion groundwater-type. All groundwater is dominated by alkaline earth metals (Ca, Mg). Groundwater in the east is generally brackish, with all water quality >1200 mg/L TDS. The difference in groundwater quality may be related to greater evapotranspiration occurring from a shallower water table in the east of the Project area.

While uncertain, groundwater inflow and outflow appear to be balanced relative to groundwater storage, which is potentially significant. Based on the cumulative volumes from each groundwater sub catchment in the valley and the mineralised Brockman Aquifer the total volume of groundwater stored within the Project area is estimated to vary between 67 GL up to 467 GL. This large range is a reflection of the range of specific yield values derived from test pumping (between 1% and 7%). The estimated negligible inflows and outflows are consistent with the short term observation data collected over the wet period of February 2017 and longer term groundwater monitoring.
12.0 REFERENCES

Barnett J. C., 1980; Mesozoic and Cainozoic sediments in the Western Fortescue plain; Western Australia: Western Australia Geological Survey Annual Report 34, pp 35-41.


Geological Survey of Western Australia, 1990, Geology and Mineral Resources of Western Australia: Western Australia Geological Survey Memoir 3, 827p


Keitel, C., and Adams, M. A., 2009, Climate, management and ecosystem interactions in the Pilbara: Tree water use at Millstream National Park, WA: Faculty of Agriculture, Food and Natural Resources, University of Sydney.


MacLeod, W. N., and de la Hunty, L. E., 1966; Roy Hill Western Australia: Western Australia Geological Survey 1:250,000 Geological Series Explanatory Notes


Simonson, B. M., Hassler, S. W., Schubel, K. A., 1993, Lithology and proposed revision in stratigraphic nomenclature of the Wittenoom Formation (Dolomite) and overlying formations, Hamersley Group, Western Australia: Western Australia Geological Survey Report 34, pp 65-80.

Williams, I. R., 2007, Geology of the Yilgalong 1:100,000 sheet; Western Australia Geological Survey 1:100,000 Geological Series Explanatory Notes, 45p.


13.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled – “Important Information Relating to this Report”, which is included in Appendix D of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.
APPENDIX A
Borehole Logs
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 13  
**DRILLING CO:** Foraco  
**LOGGED BY:** MJRS  
**DATE BEGUN:** 7/10/2016  
**DATE COMPLETED:** 9/10/2016  

<table>
<thead>
<tr>
<th>BOREHOLE NUMBER</th>
<th>BGMB001</th>
</tr>
</thead>
</table>

**DRILLING METHOD:** RC  
**EASTING (m):** 520013.23  
**NORTHING (m):** 7506140.57  
**ELEVATION (mAHD):** 526.61  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.68

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 1/2&quot; steel monument with cap</td>
<td>0</td>
<td>Oakover Formation (or equivalent)</td>
<td>Silcrete: Off white, cryptocrystalline grain size, concoidal fracture very hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete plinth</td>
<td>5</td>
<td>Palaeochannel Sediment</td>
<td>Pisolitic Detrital: Dark brown-reddish CID; very small chips of goethite, limonite, some magnetite/maghemite and trace of hematite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&quot; Reaming to install 150mm PVC collar casing</td>
<td>10</td>
<td></td>
<td></td>
<td>Pisolitic Detrital: Increases the % of limonite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150mm PVC collar casing</td>
<td>15</td>
<td></td>
<td></td>
<td>Pisolitic Detrital: A bit more limonite and limonitic clay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annular cement</td>
<td>20</td>
<td></td>
<td></td>
<td>Pisolitic Detrital: Hematitic (reddish)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 22m: blank 50mmCl18</td>
<td>25</td>
<td></td>
<td></td>
<td>Pisolitic Detrital: Goethite and limonite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6 - 3.2 mm graded gravel pack</td>
<td>30</td>
<td>Turee Creek Formation</td>
<td>Clayey Detrital: Clear limonitic clay (lower CID?) yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentonite seal</td>
<td>35</td>
<td>Weathered Shale and Chert: Light grey, very clay rich; very small chips of quartz, hematitic chert, shales. Annulus blocked at 44m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6 - 3.2 mm graded gravel pack</td>
<td>40</td>
<td></td>
<td></td>
<td>Weathered Shale and Chert: Grey plastic clays with trace of shales and hematitic chert chips. EOH at 58m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22-34m: slotted 50mm Cl18</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0 - 58m 140mm hole</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC Endcap</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annulus blocked at 44m. Below, it could be void or fallback</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**QUALITY - pH & EC (µS/cm):** 8.14 593

**FINAL BORE DETAILS**

- Drilled Depth (mbgl): 58
- Cased Depth (mbgl): 34
- Casing Stick Up (magl): 0.586
- Development Yield (l/s): 1.6
- Water Level (mbgl) & Date: 7.204 20/10/2016
- Water Level (mbgl) & Date: 7.204 20/10/2016

**COMMENTS:** Annulus blocked at 44m. Casing installed within RC rods and rose up whilst pulling rods to 34m. Hung the 50mm PVC to keep it in place till adding gravel to 44m
## Western Hub Feasibility Assessment

### Bore Log Details

**Borehole Number**: BGMB002

**Drilling Co.**: Foraco

**Drilling Method**: RC

**Logged By**: MJRS

**Drilled Depth (mbgl)**: 64

**Cased Depth (mbgl)**: 58.8

**Casing Stick Up (magl)**: 0.583

**Development Yield (l/s)**: 1.5

**Water Level (mbgl) & Date**: 14.467 20/10/2016

**Quality - pH & EC (µS/cm)**: 8.71 416

### Bore Construction

<table>
<thead>
<tr>
<th>Depth</th>
<th>Stratigraphy</th>
<th>Lithology</th>
<th>Description</th>
<th>Yield (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Palaeochannel Sediment</td>
<td>Cemented Detrital: CID, brown-black mostly goethite but some chips show microbands of limonite (yellow) hematite (red) and magnetite (black and magnetic); some chips are up to 0.5cm and angular</td>
<td>8.82</td>
<td>450</td>
<td>8.22</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Palaeochannel Sediment</td>
<td>Cemented Detrital: Very small chips of goethite and magnetite</td>
<td>1.84</td>
<td>414</td>
<td>8.91</td>
<td></td>
</tr>
<tr>
<td>28.8</td>
<td>Palaeochannel Sediment</td>
<td>Cemented Detrital: Same but with trace of quartz veining</td>
<td>1.8</td>
<td>465</td>
<td>8.73</td>
<td></td>
</tr>
<tr>
<td>0-28.8</td>
<td>Palaeochannel Sediment</td>
<td>Cemented Detrital: Mostly magnetite (black, strongly magnetic, some cubes)</td>
<td>2</td>
<td>450</td>
<td>8.22</td>
<td></td>
</tr>
<tr>
<td>0-62m</td>
<td>Palaeochannel Sediment</td>
<td>Clayey Detrital: Red clay with trace of very small chips</td>
<td>1.8</td>
<td>414</td>
<td>8.91</td>
<td></td>
</tr>
<tr>
<td>28.8-58.8</td>
<td>Palaeochannel Sediment</td>
<td>Clayey Detrital: Yellow clay (limonitic) with magnetite (black, magnetic) 10% limonite (yellow, soft, subrounded) 10% hematite (red subrounded). More clay rich at 22-24</td>
<td>2</td>
<td>450</td>
<td>8.22</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Boolega Iron Formation</td>
<td>Clay: Kaolin (white, plastic clay)</td>
<td>2</td>
<td>450</td>
<td>8.22</td>
<td></td>
</tr>
<tr>
<td>0-58.8</td>
<td>Boolega Iron Formation</td>
<td>Clayey Detrital: Yellowish clay with dark grey goethite with alteration to limonite and hematite</td>
<td>1.8</td>
<td>465</td>
<td>8.73</td>
<td></td>
</tr>
<tr>
<td>28.8</td>
<td>Boolega Iron Formation</td>
<td>Clayey Detrital: Limonitic clay with goethite</td>
<td>1.8</td>
<td>465</td>
<td>8.73</td>
<td></td>
</tr>
</tbody>
</table>

### Stratigraphy

- **Boolega Iron Formation**
  - Palaeochannel Sediment
  - 8 1/2" steel monument with cap
  - Concrete plinth
  - Annular cement
  - Open hole, no backfill
  - 6" Reaming to install 150mm PVC collar casing
  - 150mm PVC collar casing
  - 0 - 28.8m: blank 50mm CI18 PVC
  - 1.6 - 3.2 mm graded gravel pack: 4 tonnes of gravel only filled 3 metres (from 18m to 15.1m)

- **Annulus blocked at 18m**
- **0 - 62m 140mm hole**
- **28.8 - 58.8m: slotted 50mm CI18 PVC**
- **PVC Endcap**

**Comments**: 4 tonnes of gravel only filled from 17m (blockage) to 15.1m; top sealed by inserting an orange cone upside-down, pushing it as far as possible, and adding A+B foam and then cement.
WESTERN HUB BORE LOG

PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 03
DRILLING CO: Eastern Well
DRILLING METHOD: DR
LOGGED BY: MC
EASTING (m): 484793.43
NORTING (m): 7513226.82
ELEVATION (mAH): 512.36
DRILLING DIAMETER(S) (mm): 250
COLLAR STICKUP (m) 0.56
DATE BEGUN: 15/01/2017 DATE COMPLETED: 02/14/96

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Tertiary</td>
<td>Detrital</td>
<td>Reworked Calcrete: Brown, grey black and offwhite goethitic detrital and calcrete. Sub angular to sub rounded which indicates probably reworking. Small amounts of hert and silcrete.</td>
<td></td>
<td>1645</td>
<td>7.07</td>
</tr>
<tr>
<td></td>
<td>3.2-6.4mm graded gravel pack</td>
<td>Mt McRae Shale/Mt Sylvia Formation</td>
<td>Hardcap Detrital: Brown goethite detrital or upper bedrock - partially hardcapped with clay filled vugs. Leached white clay/shale likely interbedded or infilling. Subangular Clays Detrital: Light brown goethite - likely bedrock profile with soft ochreous clay and light grey clay. Trace calcrite may be contamination from above</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5 - 70.5m: blank 50mm CL18 PVC</td>
<td>-0.5 - 104.1m: blank 50mm CL18 PVC</td>
<td>Seal to isolate black shale</td>
<td>Shale: Pastel pink, offwhite and ochreous yellow weathered shale with sub angular dark brown goethite (likely interbedded). Shale is soft and predominantly clay like Shale: As above but less weathering. Some competent, tabular shale clasts, thinly bedded. Sub angular goethite, which appears vuggy in texture, is still present. Transitions to light grey, competent shale at base of interval</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.52 - 104.1m: blank 50mm CL18 PVC</td>
<td>0 - 122m: 9 5/8 DR</td>
<td></td>
<td>Shale: Dark grey to black slightly weathered shale interbedded with minor amounts of brown goethite and dark grey chert/iron oxide. No noticeable change with depth. Chips appear thinly bedded. Gritty and sticks to tongue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 - 122m: 9 5/8 DR</td>
<td></td>
<td></td>
<td>Shale: Khaki and pink shale interbedded with dark brown to black goethite Shale &amp; Chert: White to pink weathered shales, medium to soft, SA-SR, minor cherts, A, 2-10mm</td>
<td>1 to 2</td>
<td>1127</td>
<td>7.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shale: Moderately weathered shale (soft and claylike) interbedded with dark brown to black goethite ironstone</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Comments: Similar lithology to adjacent production bore. Drilled to 122 to support observation for test pumping and also to test connection through lower black shale unit. Future consideration should be given to deeper investigation via RC rig of total depth of dolomite aquifer. Possible this hole drilled through low angle fault as Dolomite is close in depth to black shale interpreted to be form the McRae Shale (32 - 58m). During construction, clay band at 92 m swelled into hole immediately after pulling casing, preventing gravel pack.
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

EWMB001

**PROJECT NAME:** Western Hub Feasibility Assessment

**LOCATION:** Site 03

**DRILLING CO:** Eastern Well

**DRILLING METHOD:** DR

**LOGGED BY:** MC

**EASTING (m):** 484793.43

**NORTHING (m):** 7513226.82

**ELEVATION (mAH):** 512.36

**DRILLING DIAMETER(S) (mm):** 250

**COLLAR STICKUP (m):** 0.56

**DATE BEGUN:** 15/01/2017  

**DATE COMPLETED:** 02/14/96

---

### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Description</th>
<th>Drilled Depth (mbgl)</th>
<th>Cased Depth (mbgl)</th>
<th>Casing Stick Up (magl)</th>
<th>Development Yield (l/s)</th>
<th>Water Level (mbgl) &amp; Date</th>
<th>Quality - pH &amp; EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>122.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cased Depth (mbgl):</td>
<td></td>
<td>122.1 (D) &amp; 88.5 (S)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Casing Stick Up (magl):</td>
<td></td>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Development Yield (l/s):</td>
<td></td>
<td></td>
<td></td>
<td>2 (D) &amp; 2 (S)</td>
<td></td>
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<tr>
<td>Water Level (mbgl) &amp; Date:</td>
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<td></td>
<td></td>
<td>47.33(D) &amp; 47.33 (S)</td>
<td>29/01/2017</td>
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<td></td>
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<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td></td>
<td>8.00 (D) &amp; 8.58 (S)</td>
<td></td>
<td>993 (D) &amp; 955 (S)</td>
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<td></td>
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</tbody>
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### STRATIGRAPHY

<table>
<thead>
<tr>
<th>Depth</th>
<th>Stratigraphy</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td></td>
</tr>
<tr>
<td>75.5</td>
<td></td>
</tr>
<tr>
<td>75.5</td>
<td></td>
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</tbody>
</table>

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### LITHOLOGY

<table>
<thead>
<tr>
<th>Depth</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>Slightly weathered pink and white shale with chert and goethite</td>
</tr>
<tr>
<td>75.5</td>
<td>Red-brown and light to dark grey (appearing black) shale - similar to 32 - 58. Highly weathered, presents as plastic clay from 92-94, but with bedding texture still visible.</td>
</tr>
<tr>
<td>75.5</td>
<td>Light grey goethite and shale. Moderately to highly weathered</td>
</tr>
<tr>
<td>75.5</td>
<td>Weathered Dolomite: Khaki shale and brown highly weathered dolomite with angular dark blue chert (or highly silicified dolomite). Tabular chips, thinly bedded, harder ground</td>
</tr>
<tr>
<td>75.5</td>
<td>Weathered Dolomite: Orange brown, friable highly weathered dolomite with blue grey, less weathered dolomite (likely interbedded).</td>
</tr>
<tr>
<td>75.5</td>
<td>Weathered Dolomite: Light grey/blue grey to light khaki crystalline moderately weathered dolomite. Harder drilling but some blocky chips and degree of weatheringindicate rock is fractured. Browner weathered bands at 120 - 122.</td>
</tr>
</tbody>
</table>

---

### Comments

Similar lithology to adjacent production bore, Drilled to 122 to support observation for test pumping and also to test connection through lower black shale unit. Future consideration should be given to deeper investigation via RC rig of total depth of dolomite aquifer. Possible this hole drilled through low angle fault as Dolomite is close in depth to black shale interpreted to be form the McRae Shale (32 - 58m). During construction, clay band at 92 m swelled into hole immediately after pulling casing, preventing gravel pack.
PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 07
DRILLING CO: Foraco
DRILLING METHOD: RC
LOGGED BY: MJRS
EASTING (m): 493169.05
NORTHING (m): 7512935.35
ELEVATION (mAHD): 565.88
DRILLING DIAMETER(S) (mm): 140
COLLAR STICKUP (m): 0.777
DATE BEGUN: 7/12/2016 DATE COMPLETED: 9/12/2016

Drilled Depth (mbgl): 130
Cased Depth (mbgl): 128
Casing Stick Up (magl): 0.636
Development Yield (l/s): 3
Water Level (mbgl) & Date: 56.28 11/12/2016
Quality - pH & EC (µS/cm): 8.19 1257

Drilling of this bore went without incident

Tertiary Detrital
- Clayey Detrital: Red/brown clay-rich matrix supported unit with small chips, fine grained, subrounded, pitted ironstones
- Cemented Detrital: Brown/grey clay with some very fine grained big eroded and pitted BIF chips
- Cemented Detrital: Brown/grey moderately weathered Bif and shale
- Clay: Off-white and dark red/brown clay with highly weathered BIF and shale
- Shale: Highly weathered shales

Bee Gorge
- 0 - 110m: blank 50mm Cl18 PVC
- 1.6 - 3.2 mm graded gravel pack
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

<table>
<thead>
<tr>
<th>WESTERN HUB BORE LOG</th>
<th>BOREHOLE NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWMB002</td>
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**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 07  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** MJRS  
**EASTING (m):** 493169.05  
**NORTHING (m):** 7512935.35  
**ELEVATION (mAH):** 565.88  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.777  
**DATE BEGUN:** 7/12/2016  
**DATE COMPLETED:** 9/12/2016

**FINAL BORE DETAILS**

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>130</td>
</tr>
<tr>
<td>Cased Depth (mbgl):</td>
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</tr>
<tr>
<td>Casing Stick Up (magl):</td>
<td>0.636</td>
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<tr>
<td>Development Yield (l/s):</td>
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<td>Water Level (mbgl) &amp; Date:</td>
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<td>Quality - pH &amp; EC (µS/cm):</td>
<td>8.19 1257</td>
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**BORE CONSTRUCTION**

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<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
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</thead>
<tbody>
<tr>
<td>0 - 130m 140mm hole</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>97 - 100m: Bentonite seal</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.6 - 3.2 mm graded gravel pack</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>110 - 128m: Slotted 50mm Cl18</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>PVC Endcap</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Comments:**

Drilling of this bore went without incident
Clayey Silt: Alluvial red/brown Clayey Silt with some rounded gravel and some sand. Gravel is predominantly shale. Small amount of pisoliths and some magnetic minerals (black, hard).

Clayey Ironstone: Red/Brown CID. Slightly vitreous goethite. Vuggy, some cemented pisoliths. Clayey CID at base of interval, with ocreous goethite and limonite.


Shale: Black greasy weathered Shale. Some off white/pink clay.

Shale: Dark brown weathered Shale. Several interbeds of clayey shale ranging from tan colour to black. Some small magnetic (maghemite) spheres (Minor). Minor amounts of chert. Clayey bands at 48 - 52 mbgl, 96 - 100 mbgl and 106 to 108mbgl. Last band is directly

Comments: The PVC casing hit refusal at 33m. Likely a clay band that plugged the hole. Were unable to confirm that any gravel made it past 33m. Screened interval is likely open or filled with fallback.
**WESTERN HUB BORE LOG**

**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 01  
**DRILLING CO:** Foraco  
**LOGGED BY:** JB  
**EASTING (m):** 485149.55  
**NORTHING (m):** 7513791.33  
**ELEVATION (mAHD):** 503.42  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.66  
**DATE BEGUN:** 16/10/2016  
**DATE COMPLETED:** 19/10/2016

<table>
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<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
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<tbody>
<tr>
<td>PVC Endcap</td>
<td>130</td>
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<tr>
<td>111 - 129m: slotted 50mm Cl18</td>
<td>125</td>
<td>Newman</td>
<td>Ironstone &amp; BIF: Tan to reddish brown. Marra mamba fm. Some fines, but appears to be somewhat fresh.</td>
<td>3.5</td>
<td>1080</td>
<td>7.5</td>
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<tr>
<td>0 - 130m 140mm hole</td>
<td>120</td>
<td></td>
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<tr>
<td>Annulus blocked at 33.5m</td>
<td>80</td>
<td></td>
<td></td>
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**FINAL BORE DETAILS**

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<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>130</td>
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<tr>
<td>Cased Depth (mbgl):</td>
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<tr>
<td>Casing Stick Up (magl):</td>
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<td>Development Yield (l/s):</td>
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<td>Water Level (mbgl) &amp; Date:</td>
<td>29.556 20/10/2016</td>
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<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.85 1640</td>
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Comments: The PVC casing hit refusal at 33m. Likely a clay band that plugged the hole. Were unable to confirm that any gravel made it past 33m. Screened interval is likely open or filled with fallback.
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

EWMB004

**PROJECT NAME:** Western Hub Feasibility Assessment

**LOCATION:** Site 02

**DRILLING CO:** Foraco

**LOGGED BY:** MC/MJRS

**EASTING (m):** 485016.77

**NORTHING (m):** 7513674.29

**ELEVATION (mAHD):** 503.45

**DRILLING DIAMETER(S) (mm):** 140

**COLLAR STICKUP (m):** 0.805

**DATE BEGUN:** 19/10/2016

**DATE COMPLETED:** 23/10/2016

---

**FINAL BORE DETAILS**

- **Drilled Depth (mbgl):** 166
- **Cased Depth (mbgl):** 166
- **Casing Stick Up (magl):** 0.713
- **Development Yield (l/s):** 2.5
- **Water Level (mbgl) & Date:** 29.93 27/10/2016
- **Quality - pH & EC (µS/cm):** 7.75 993

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**BORE CONSTRUCTION**

- 8 1/2” steel monument with cap
- Concrete plinth
- Annular cement

- 150mm PVC collar casing
- 6” Reaming to install 150mm PVC collar casing

- 3 - 51m: open hole

- 0 - 74m: blank 50mm CI18 PVC

- 1.6 - 3.2 mm graded gravel pack

---

**DEPTH**

**STRATIGRAPHY**

**LITHOLOGY**

**DESCRIPTION**

**YIELD (l/s)**

**EC (µS/cm)**

**pH**

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**Tertiary Detrital**

- Silty Gravel: Red brown, silty gravel comprising maghemite pisolite and subangular clasts of blue grey dolomite, chert and ironstone

- Hardcap Detrital: Brown, vitreous goethite, goethite and white clay. Likely hardcap CID

- Clayey Detrital: Clayey CID; off white clay with brown sub angular goethite. Evidence of vughs and red concretions

- Cemented Detrital: Brown to yellow brown sub angular goethite clasts with vughs and faint pisolitic texture

- Clay: White, pink and ochreous yellow clay lens/pod. Partly indurated

- Clay & Gravel: Yellow brown plastic clay with white/pink stiff clay. Minor clast component includes grey brown subangular goethite with vughs. Likely clayey CID but possibly part of bedrock

- Clay & Gravel: As above but clast component increased (~50%)

- Clay & Gravel: Similar to 12 - 16 m. Soft plastic yellow brown clay with minor CID clast component

- Ironstone & Shale: Yellow brown soft, semi-plastic clay with mixed subangular clasts. Mainly goethite and black chert. Weathering on all surfaces; evidence of vughs/pitting. Some tabular, off white chert. Increasing tabular texture to all chips; highly weathered but appearing

- Shale: Red brown, plastic clay with grey brown subangular goethite clasts. No further evidence of bedded nature but likely part of bedrock

- Ironstone & Shale: Blue grey to brown subangular moderately weathered goethite and chert with some minor yellow brown/red brown shale

- Manganese Hardcap: Blue grey mix of dull, lustrous and speckled clasts of manganese precipitate. Some surfaces pitted and vuggy. Potentially a zone of alteration or mineral precipitation of manganese above dolomite.

---

**Paraburdoo**

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**Comments:** Air loss limited water return whilst drilling. Hole blocked at 55m and 1Tn of gravel has only filled to 50m
### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Description</th>
<th>Drilled Depth (mbgl):</th>
<th>Cased Depth (mbgl):</th>
<th>Casing Stick Up (magl):</th>
<th>Development Yield (l/s):</th>
<th>Water Level (mbgl) &amp; Date:</th>
<th>Quality - pH &amp; EC (µS/cm):</th>
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<tbody>
<tr>
<td>EWMB004 Final Bore Log</td>
<td>166</td>
<td>166</td>
<td>0.713</td>
<td>2.5</td>
<td>29.93</td>
<td>27/10/2016</td>
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### BORE CONSTRUCTION

<table>
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<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
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</thead>
<tbody>
<tr>
<td>0 - 166m</td>
<td>140mm hole</td>
<td></td>
<td>Weathered Dolomite: Brown, grey brown to light grey weathered dolomite. Some pitting and quartz veins with other yellow and opaque mineral precipitates</td>
<td>1</td>
<td>946</td>
<td>7.55</td>
</tr>
<tr>
<td>Annulus blocked at 55m</td>
<td></td>
<td></td>
<td>Weathered Dolomite: Siliceous dolomite with brown weathered chips similar to above</td>
<td>1049</td>
<td>7.76</td>
<td></td>
</tr>
<tr>
<td>74 - 164m: slotted 50mm CI18</td>
<td></td>
<td></td>
<td>Weathered Dolomite: As per 52 -70. Some red/pink chips and dark brown nature of discharge suggestive of dolomitic shale influence</td>
<td>965</td>
<td>7.77</td>
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<tr>
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<td></td>
<td></td>
<td>923</td>
<td>7.73</td>
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Comments: Air loss limited water return whilst drilling. Hole blocked at 55m and 1Tn of gravel has only filled to 50m.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 02  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** MC/MjRS  
**EASTING (m):** 485016.77  
**NORTHING (m):** 7513674.29  
**ELEVATION (mAHD):** 503.45  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.805  
**DATE BEGUN:** 19/10/2016  
**DATE COMPLETED:** 23/10/2016

**WESTERN HUB BORE LOG**

**BORE NUMBER:** EWMB004

<table>
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<tr>
<th>DEPTH</th>
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<th>LITHOLOGY</th>
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<th>YIELD (l/s)</th>
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<tr>
<td>165</td>
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<td>4</td>
<td>966</td>
<td>7.69</td>
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**Comments:** Air loss limited water return whilst drilling. Hole blocked at 55m and 1Tn of gravel has only filled to 50m.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 20  
**DRILLING CO:** Eastern Well  
**EASTING (m):** 488592.65  
**NORTING (m):** 751297.89  
**ELEVATION (mAHD):** 530.68  
**DRILLING DIAMETER(S) (mm):** 250  
**COLLAR STICKUP (m):** 0.65  
**DATE BEGUN:** 25/01/2017  
**DATE COMPLETED:** 29/01/2017

### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>105</td>
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<tr>
<td>Cased Depth (mbgl):</td>
<td>104</td>
</tr>
<tr>
<td>Casing Stick Up (magl):</td>
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<tr>
<td>Development Yield (l/s):</td>
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<tr>
<td>Water Level (mbgl) &amp; Date:</td>
<td>51.48</td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.73</td>
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<tr>
<td>**</td>
<td><strong>689</strong></td>
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### BORE CONSTRUCTION

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<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
</table>
| 0     | Tertiary Detrital | Clayey Detrital: Red clay with 20% angular chips, of which 90% are up to 3mm while the rest are clast size  
Clayey Detrital: Mottle zone (50:50 red and cream clay - plastic due to water injection)  
Clayey Detrital: Brown extremely weathered mostly clay with 20% BIF and shale very small rounded (transported) chips | 5 | 683 | 7.25 |
| 0 - 104m: | Paraburdoo | Weathered Dolomite: Highly weathered dolomite (high clay content)  
Weathered Dolomite: Light brown, fractured arenite textured, angular chips; sizes ranging from small to up to 3cm. 2% manganese  
Weathered Dolomite: Light brown, moderately weathered, moderately rounded dolomite | | | |
| 0.1 - 68m: | Bee Gorge | Clay: Grey clay (possibly totally weathered grey shales)  
Clay: Red clay (plastic from injection water). Water level at around 55-56m (clays come more fluid) | | | |
| -0.1 - 68m: Blank 50mm CL18 PVC | 3.2-6.4mm graded gravel pack | | | | |
| CONSTRUCTION | | | | | | |
| CONSTRUCTION | | | | | | |
| CONSTRUCTION | | | | | | |
| CONSTRUCTION | | | | | | |
| CONSTRUCTION | | | | | | |

**Comments:** Drilling of this bore went without incident
### Western Hub Feasibility Assessment

**Project Name:** Site 20  
**Drilling Co.:** Eastern Well  
**Logged By:** MJ  
**Drilling Method:** DR  
**Easting (m):** 7512927.89  
**Nordthing (m):** 530.68  
**Elevation (mAHD):** 488592.65  
**Drilling Diameter(s) (mm):** 250  
**Collar Stickup (m):** 0.65  
**Date Begun:** 25/01/2017  
**Date Completed:** 29/01/2017

#### Western Hub Bore Log

**Bore Number:** EWMB005

**Drilled Depth (mbgl):** 105

**Cased Depth (mbgl):** 104

**Casing Stick Up (magl):** 0.32

**Development Yield (l/s):** 1

**Water Level (mbgl) & Date:** 51.48  
**Quality - pH & EC (µS/cm):** 7.73  

#### Final Bore Details

<table>
<thead>
<tr>
<th>Depth (mbgl)</th>
<th>Stratigraphy</th>
<th>Lithology</th>
<th>Description</th>
<th>Yield (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 - 6.4mm graded gravel pack around slots</td>
<td>Dolomite: Fresh, crystalline, slightly fractured dolomite; chips evenly sized</td>
<td>PVC Endcap</td>
<td>5</td>
<td>657</td>
<td>7.77</td>
<td></td>
</tr>
<tr>
<td>68 - 104m: slotted 50mm CL18 PVC</td>
<td></td>
<td></td>
<td>5</td>
<td>671</td>
<td>7.59</td>
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<tr>
<td>105</td>
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<td></td>
<td>5</td>
<td>701</td>
<td>7.88</td>
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</table>

**Comments:** Drilling of this bore went without incident
Western Hub Feasibility Assessment

PROJECT NAME: Western Hub Bore Log
LOCATION: Site 05
DRILLING CO: Foraco
DRILLING METHOD: RC
LOGGED BY: MJRS
EASTING (m): 483036.15
NORTHING (m): 7511925.35
ELEVATION (mAHD): 523.94
DRILLING DIAMETER(S) (mm): 140
COLLAR STICKUP (m): 0.776
DATE BEGUN: 30/10/2016
DATE COMPLETED: 1/11/2016

Borehole Number: EWMB006

<table>
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<tr>
<th>FINAL BORE DETAILS</th>
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<tr>
<td>Drilled Depth (m): 100</td>
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<tr>
<td>Cased Depth (m): 100</td>
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<tr>
<td>Casing Stick Up (m): 0.689</td>
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<tr>
<td>Development Yield (l/s): 0</td>
</tr>
<tr>
<td>Water Level (m) &amp; Date: 73.18 4/11/2016</td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm): N/A N/A</td>
</tr>
</tbody>
</table>

**Drill Details:**
- **100 m**: Blank 50mm CI18 PVC
- **0 - 76m**: Blank 50mm CI18 PVC
- **0 - 100m**: 140mm hole

**Drill Method:** 6" reaming to install 150mm PVC collar casing

**Lithology:**
- **Joffre:**
  - BIF & Shale: Moderately weathered purple shales
  - BIF & Shale: Highly weathered (high clay content)
  - BIF and shales
  - BIF & Shale: Mod. weathered purple shales
  - BIF & Shale: Highly weathered purple shales
  - BIF & Shale: Brown clay with some chips of BIF and shales
  - BIF & Shale: Highly weathered BIF and shales
  - BIF & Shale: Mod. Weathered BIF with 10% red (hematite-rich?) mudstone
  - BIF & Shale: Yellow/brown (limonitic) clay and grey small shale chips
  - BIF & Shale: Brown/green clay with small shale and BIF chips

- **J6 Dolerite Sill:**
  - Highly Weathered Dolerite: Brown/grey/yellow clay with grey, red and yellow and grey chips

**Comments:**
Dolerite sill intersected, but extremely weathered. Developed by water injection as there was no water in the bore. Bore was not sample for water quality.
PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 05
DRILLING CO: Foraco
DRILLING METHOD: RC
LOGGED BY: MJRS
EASTING (m): 483036.15
NORTHING (m): 7511925.35
ELEVATION (mAHD): 523.94
DRILLING DIAMETER(S) (mm): 140
COLLAR STICKUP (m): 0.776
DATE BEGUN: 30/10/2016
DATE COMPLETED: 1/11/2016

BORE CONSTRUCTION

DEPTH | STRATIGRAPHY | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH

76 - 100m: slotted 50mm CI18

Annulus blocked at 55.5m

Highly Weathered Dolerite: Light brown/pink/orange clay

Highly Weathered Dolerite: Light brown/pink/purple clay

Drilled Depth (mbgl): 100
Cased Depth (mbgl): 100
Casing Stick Up (magl): 0
Development Yield (l/s): 0
Water Level (mbgl) & Date: 73.18 4/11/2016
Quality - pH & EC (µS/cm): N/A N/A

Comments: Dolerite sill intersected, but extremely weathered. Developed by water injection as there was no water in the bore. Bore was not sample for water quality.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 06  
**DRILLING CO:** Foraco  
**LOGGED BY:** MJRS  
**EASTING (m):** 482591.00  
**NORTHING (m):** 7512496.00  
**ELEVATION (mAH):** 547.61  
**DRILLING DIAMETER(S) (mm):** 140  
**DATE BEGUN:** 26/10/2016  
**DATE COMPLETED:**

### FINAL BORE DETAILS

<table>
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<th>Description</th>
<th>Value</th>
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<td>Cased Depth (mbgl)</td>
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<td>Casing Stick Up (magl)</td>
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</tr>
<tr>
<td>Development Yield (l/s)</td>
<td></td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date</td>
<td></td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm)</td>
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</tbody>
</table>

### BORE CONSTRUCTION

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Joffre  | Clayey Ironstone: Dark grey, small angular chips; fine grained  
|         | BIF & Shale: Grey/yellow, limonite-rich clay with small amount of ironstones  
|         | Shale: Purple shales  
|         | Shale: Dark grey shales  
|         | Shale: Grey/brown shales  
|         | Shale: Brown/grey shales  
|         | BIF & Shale: Yellow, limonitic clay-rich shales  
|         | Shale: Grey/brown shales; very small chips  
|         | BIF & Shale: Brown/red semi-plastic clay with shales and unmineralised BIF  
|         | BIF & Shale: Limonitic clay with shales and BIF  
|         | BIF & Shale: Brown/orange clay with trace of chips of shale and unmineralised BIF |

**Comments:** Rods bogged at 168m due to high density of ore. 30/10/2016 driller decides to leave rods in hole temporarily and move to next site. Finally abandoned in December after drilling 3 relief holes. Rods abandoned from 24 - 76 m. Strat interp taken from nearest RC hole which was interped using gamma
### Western Hub Feasibility Assessment

#### PROJECT NAME:
Western Hub Feasibility Assessment

#### LOCATION:
Site 06

#### DRILLING CO:
Foraco

#### DRILLING METHOD:
RC

#### LOGGED BY:
MjRS

#### EASTING (m):
482591.00

#### NORTHING (m):
7512496.00

#### ELEVATION (mAHD):
547.61

#### DRILLING DIAMETER(S) (mm):
140

#### COLLAR STICKUP (m):

#### DATE BEGUN:
26/10/2016

#### DATE COMPLETED:

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### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Drilled Depth (mbgl)</th>
<th>168</th>
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</thead>
<tbody>
<tr>
<td>Cased Depth (mbgl)</td>
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<tr>
<td>Casing Stick Up (magl)</td>
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</tr>
<tr>
<td>Development Yield (l/s):</td>
<td></td>
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<tr>
<td>Water Level (mbgl) &amp; Date:</td>
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<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
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### WESTERN HUB BORE LOG

**BOREHOLE NUMBER**
EWMB007

#### BORE CONSTRUCTION

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
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<tbody>
<tr>
<td>75</td>
<td>Whaleback Shale</td>
<td>Shale: Brown/yellow, highly weathered shales</td>
<td></td>
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<tr>
<td>80</td>
<td>Whaleback Shale</td>
<td>Shale: Highly weathered mineralised purple shales</td>
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<tr>
<td>85</td>
<td>Whaleback Shale</td>
<td>Shale: Very little sample; brown shales highly weathered (mostly clay)</td>
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<tr>
<td>90</td>
<td>Whaleback Shale</td>
<td>Shale: Brown/green/grey clay after highly weathered shale</td>
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<tr>
<td>95</td>
<td>BIF &amp; Shale: Small flat chips of mineralised shales/BIF. According to driller the SWL at ~100m</td>
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<tr>
<td>100</td>
<td>BIF &amp; Shale: Brown shales with trace of hematite (very small round red clay) and limonite (very small yellow round clay)</td>
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<tr>
<td>105</td>
<td>BIF &amp; Shale: Weathered mineralised BIF</td>
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<tr>
<td>110</td>
<td>BIF &amp; Shale: Red/white clay pods with signs of bedding (fully weathered BIF)</td>
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<td>115</td>
<td>BIF &amp; Shale: Highly weathered shale/BIF</td>
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<tr>
<td>120</td>
<td>BIF &amp; Shale: Weathered mineralised shales (martite?)</td>
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<tr>
<td>125</td>
<td>BIF &amp; Shale: Limonite-rich (yellow) unmineralised BIF</td>
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<tr>
<td>130</td>
<td>Shale: Grey shales with some limonite</td>
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<tr>
<td>135</td>
<td>BIF &amp; Shale: Vivid red clays with small chips of dark grey shales</td>
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<tr>
<td>140</td>
<td>Shale: Brown shales</td>
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<tr>
<td>145</td>
<td>Shale: Brown shales</td>
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**Comments:**
Rods bogged at 168m due to high density of ore. 30/10/2016 driller decides to leave rods in hole temporarily and move to next site. Finally abandoned in December after drilling 3 relief holes. Rods abandoned from 24 - 76 m. Strat interp taken from nearest RC hole which was interped using gamma
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 06  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** MJRS  
**EASTING (m):** 482591.00  
**NORTHING (m):** 7512496.00  
**ELEVATION (mAHD):** 547.61  
**DRILLING DIAMETER(S) (mm):** 140  
**DATE BEGUN:** 26/10/2016  
**DATE COMPLETED:**

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<thead>
<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>170</td>
<td></td>
<td></td>
<td>Martite: Very dark grey martite, very small chips; drilling lost water and outside return</td>
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**FINAL BORE DETAILS**

<p>| | |</p>
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<td>Drilled Depth (mbgl):</td>
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<td>Cased Depth (mbgl):</td>
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<tr>
<td>Casing Stick Up (mgl):</td>
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<tr>
<td>Development Yield (l/s):</td>
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<tr>
<td>Water Level (mbgl) &amp; Date:</td>
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</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
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</tbody>
</table>

**COMMENTS:**

Rods bogged at 168m due to high density of ore. 30/10/2016 driller decides to leave rods in hole temporarily and move to next site. Finally abandoned in December after drilling 3 relief holes. Rods abandoned from 24 - 76 m. Strat interp taken from nearest RC hole which was interped using gamma
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 04  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** MJRS  
**EASTING (m):** 481383.91  
**NORTHING (m):** 7513588.79  
**ELEVATION (mAH):** 482.76  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.603  
**DATE BEGUN:** 5/12/2016  
**DATE COMPLETED:** 7/12/2016

### FINAL BORE DETAILS

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<td>Cased Depth (mbgl):</td>
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<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.94 995</td>
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### BORE CONSTRUCTION

- **8 1/2" steel monument with cap**
- **Concrete plinth**
- **Annular cement**
- **6" Reaming to install 150mm PVC collar casing**
- **150mm PVC collar casing**
- **0 - 32m: blank 50mm Cl18 PVC**
- **0 - 64m 140mm hole**
- **32 - 62m: slotted 50mm Cl18**
- **3.2 - 6.4 mm graded gravel pack**
- **PVC Endcap**
- **Fallback from 62 to 64m**

### STRATIGRAPHY

- **Tertiary Detrital**
  - Clayey Detrital: Light brown, clay rich detritals
  - Clay: Dark grey, semi plastic clays after shales
  - Shale: Moderately weathered dark grey shale. Cavities 15-17m

- **Paraburdoo**
  - Weathered Dolomite: Light brown, moderately weathered fractured dolomite

- **Bee Gorge**
  - Weathered Dolomite: Light brown and grey, moderately to fresh, fractured dolomite

### COMMENTS

Cavities at 15-16, 30-32 and 60.62. Fallback from 62-64m. Yield 0.25L/s from fractured dolomite - most likely a significant underestimate due to airloss.
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

**EWMB009**

**PROJECT NAME:** Western Hub Feasibility Assessment

**LOCATION:** Site 22

**DRILLING CO:** Eastern Well

**DRILLING METHOD:** DR

**LOGGED BY:** MJ

**EASTING (m):** 483469.27

**NORTHING (m):** 7513612.85

**ELEVATION (mAHD):** 492.71

**DRILLING DIAMETER(S) (mm):** 250

**COLLAR STICKUP (m):** 0.635

**DATE BEGUN:** 22/01/2017

**DATE COMPLETED:** 25/01/2017

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**FINAL BORE DETAILS**

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<thead>
<tr>
<th>Description</th>
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<td>Drilled Depth (mbgl):</td>
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<td>Cased Depth (mbgl):</td>
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<td>Casing Stick Up (magl):</td>
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<td>Development Yield (l/s):</td>
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<td>Water Level (mbgl) &amp; Date:</td>
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</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.49 1550</td>
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</table>

**BORE CONSTRUCTION**

- **Tertiary Detrital**
  - Clayey Detrital: Red/brown clay-rich clast supported unit with fine grained, angular to subangular chips up to 1cm size

- **Paraburdoo**
  - Weathered Dolomite: Light beige, clay rich with 5% weathered dolomite (fine grained, carbonate cemented arenite) chips up to 4cm
  - Weathered Dolomite: Same with manganese
  - Weathered Dolomite: Beige (darker colour than above due to water content - injected) plastic clays with 5% weathered dolomite chips up tp 4cm
  - Weathered Dolomite: As above but with less clay (washed as we drill below the water table)
  - BIF & Shale: Mix of BIF, shale, chert, dolomite; all angular slightly weathered chips
  - Dolomite: Blue-grey, fresh, slightly fractured dolomite; all chips similar sizes between 0.5 and 1 cm. Quartz veining (sealed fractures); some

**Comments:** Drilling of this bore went without incident
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 22  
**DRILLING CO:** Eastern Well  
**DRILLING METHOD:** DR  
**LOGGED BY:** MJ  
**EASTING (m):** 483469.27  
**NORTHING (m):** 7513612.85  
**ELEVATION (mAHD):** 492.71  
**DRILLING DIAMETER(S) (mm):** 250  
**COLLAR STICKUP (m):** 0.635  
**DATE BEGUN:** 22/01/2017  
**DATE COMPLETED:** 25/01/2017  

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<td>Casing Stick Up (magl):</td>
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<td>Development Yield (l/s):</td>
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<td>Water Level (mbgl) &amp; Date:</td>
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<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.49 1550</td>
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### BORE CONSTRUCTION

- **0 - 152m**: 9 5/8 DR
- **3.2 - 6.4mm graded gravel pack around slots**
- **54 - 150m**: slotted 50mm CL18 PVC

**Description:** Indication of water flow though the ground with some surface staining. Flowrate around the 5L/s but lower salinity from 92.

**Comments:** Drilling of this bore went without incident.
PROJECT NAME: Western Hub Feasibility Assessment

LOCATION: Site 22

DRILLING CO: Eastern Well

DRILLING METHOD: DR

LOGGED BY: MJ

EASTING (m): 483469.27

NORTHING (m): 7513612.85

ELEVATION (mAHD): 492.71

DRILLING DIAMETER(S) (mm): 250

COLLAR STICKUP (m): 0.635

DATE BEGUN: 22/01/2017

DATE COMPLETED: 25/01/2017

Drilled Depth (mbgl): 152

Cased Depth (mbgl): 150

Casing Stick Up (magl): 0.63

Development Yield (l/s): 1

Water Level (mbgl) & Date: 27.69 31/01/2017

Quality - pH & EC (µS/cm): 7.49 1550

Comments: Drilling of this bore went without incident
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 08  
**DRILLING CO:** Eastern Well  
**LOGGED BY:** MJRS  
**EASTING (m):** 502608.95  
**NORTHING (m):** 7510275.88  
**ELEVATION (mAHD):** 581.44  
**DRILLING DIAMETER(S) (mm):** 304.8  
**COLLAR STICKUP (m):** 0.461  
**DATE BEGUN:** 16/11/2016  
**DATE COMPLETED:** 19/11/2016

### FINAL BORE DETAILS

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<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
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<td>Quality - pH &amp; EC (µS/cm):</td>
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### BORE CONSTRUCTION

- **16 3/8” steel monument with cap**
- **Concrete plinth**
- **Annular cement**
- **Cement bentonite mix seal**
- **0 - 52.6m: blank 200mm CI12 PVC**
- **13 3/8” DR**
- **3.2-6.4mm graded gravel pack**
- **52.6 - 82.6m: slotted 200mm CI 12**

### STRATIGRAPHY

- **Tertiary Detrital**
  - Clayey Detrital: Red/brown clast supported unit with small and big chips, fine grained, blocky, BIF
  - Clayey Detrital: Red/brown small BIF, shales and chert chips in clay matrix
  - Clayey Detrital: Red, clay-rich unit with subrounded chips of BIF and shales
  - Clayey Detrital: Red with 10% off-white clay-rich unit with small shale and mudstone chips
  - Clayey Detrital: Red clay with subrounded and pitted BIF chips
  - Weathered Dolomite: Blocky chips of beige, subangular, pitted textured weathered dolomite
  - Weathered Dolomite: Blocky chips of beige, tabular, arenite textured weathered dolomite
  - Weathered Dolomite: Black, fresh bedded, fine grained big tabular chips of tuff (?)
  - Manganese Hardcap: Dark grey subrounded chips of manganese in weathered dolomite
  - Weathered Dolomite: Brown/grey clay-rich with chips of weathered dolomite
  - Clay: White clay
  - Weathered Dolomite: Beige/grey tabular and angular, fine grained moderately weathered dolomite
  - Weathered Dolomite: Beige/grey with increased amount of chips, slightly weathered dolomite
  - Dolomite: Almost fresh dolomite, blue. Crystalline with stained surfaces (fluid path along fractures)
  - Dolomite: Fresh blue crystalline dolomite, fractured at 66-70m, but not indication of water flow (not stained faces)

### COMMENTS

Very little yield. SWL after drilling at 81m. End of casing probably acting as sump and water seeping from 56-58m. Bore developed by flushing.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 08  
**DRILLING CO:** Eastern Well  
**DRILLING METHOD:** DR  
**LOGGED BY:** MJRS  
**EASTING (m):** 502608.95  
**NORTHING (m):** 7510275.88  
**ELEVATION (mAHD):** 581.44  
**DRILLING DIAMETER(S) (mm):** 304.8  
**COLLAR STICKUP (m):** 0.461  
**DATE BEGUN:** 16/11/2016  
**DATE COMPLETED:** 19/11/2016

### FINAL BORE DETAILS

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<td>Cased Depth (mbgl):</td>
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<td>Casing Stick Up (magl):</td>
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<td>Quality - pH &amp; EC (µS/cm):</td>
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### BORE CONSTRUCTION

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<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
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**Comments:** Very little yield. SWL after drilling at 81m. End of casing probably acting as sump and water seeping from 56-58m. Bore developed by flushing.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 07  
**DRILLING CO:** Eastern Well  
**LOGGED BY:** MJRS  
**EASTING (m):** 493167.82  
**NORTHING (m):** 7512915.44  
**ELEVATION (mAHD):** 566.26  
**DRILLING DIAMETER(S) (mm):** 340.8  
**COLLAR STICKUP (m):** 0.51  
**DATE BEGUN:** 20/11/2016  
**DATE COMPLETED:** 25/11/2016

### FINAL BORE DETAILS

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### BORE CONSTRUCTION

- **16 3/8” steel monument with cap**
- **Concrete plinth**
- **Annular cement**
- **Cement bentonite mix seal**

### STRATIGRAPHY

- **0 - 110m:** blank 200mm CI12 PVC
- **3.2 - 6.4mm graded gravel pack**
- **0 - 128m:** 13 3/8” DR

### LITHOLOGY

#### Tertiary Detrital
- Clayey Detrital: Red/brown clay-rich matrix supported unit with small chips, fine grained, subrounded, pitted ironstones
- Cemented Detrital: Brown/grey clay with some very fine grained big eroded and pitted BIF chips
- Hardcap Detrital: Light beige/tan clay with some eroded looking hard cap of manganese at 36-40

#### Bee Gorge
- Clay: Grey, yellow and pink clays with some remnants of shale texture
- Shale: Highly to moderately weathered shales
- Clay: Fully weathered shales
- Clay: Red clay with little amount of pitted ironstones

### COMMENTS

Water intersected at 104m after drilling through low yielding shales.
Comment: Water intersected at 104m after drilling through low yielding shales.
Western Hub Feasibility Assessment

**PROJECT NAME:**

**LOCATION:** Site 03

**DRILLING CO:** Eastern Well

**DRILLING METHOD:** DR

**LOGGED BY:** GL

**EASTING (m):** 484771.41

**NORTING (m):** 7513230.54

**ELEVATION (mAH):** 512.03

**DRILLING DIAMETER(S) (mm):** 304.8

**COLLAR STICKUP (m):** 0.545

**DATE BEGUN:** 26/11/2016  
**DATE COMPLETED:** 7/12/2016

### FINAL BORE DETAILS

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<th>YIELD (l/s)</th>
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<th>pH</th>
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<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>122</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cased Depth (mbgl):</td>
<td>122</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casing Stick Up (magl):</td>
<td>0.327</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development Yield (l/s):</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date:</td>
<td>46.92 12/11/2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>8.33 936</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### BORE CONSTRUCTION

**16 3/8” steel monument with cap**
- Concrete plinth
- Annular cement
- Cement bentonite mix seal

**3.2- 6.4mm graded gravel pack**

**0 - 70m: blank 200mm Cl12 PVC**

**13 3/8” DR**
- Bentonite seal to isolate the oily shales

**Tertiary Detrital**
- Cemented Detrital: Detritals and goethitic hardcap, 2-20mm, vuggy, skewed to 2-3mm, red-brown silt (10%).
- Hardcap Detrital: Soft shales, goethitic hard cap and calcrete. 2-45mm, vuggy, weathered, khaki silty clay matrix.

**Mt McRae Shale/Mt Sylvia Formation**
- Shale: Soft hematised shales, crumbles by hand, clayey texture, minor white granular dolomite, R, <50mm

**Shale:**
- Soft black shale, crumbles in hand, clayey texture. No visible pyrite

**Shale: Transition to white and then hematised shales. Soft, crumbles by hand, clayey texture.**

**Shale & Chert:**
- White to pink weathered shales, medium to soft, SA-SR, minor cherts, A, 2-10mm

**1**
- Goethite & Shale: Very weathered goethite, medium hardness, 2-35mm, white shales, minor black shales (10%) and chert, SR-A, 2-35mm, poorly sorted. Trace calcrete, 2-30mm.

**1.5**
- Trace calcrete, 2-30mm.

**Comments:** Intercepted 28m of black shale above water table and another horizon of 6m below water table. 10 L/s yield from shales. During construction, a length of the outside steel casing fall, smashing the PVC; the PVC had to be drilled out and the bore re-cased and re-packed. Hole should be considered partially penetrating.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 03  
**DRILLING CO:** Eastern Well  
**DRILLING METHOD:** DR  
**LOGGED BY:** GL  
**EASTING (m):** 484771.41  
**NORTHING (m):** 751230.54  
**ELEVATION (mAHD):** 512.03  
**DRILLING DIAMETER(S) (mm):** 304.8  
**COLLAR STICKUP (m):** 0.545  
**DATE BEGUN:** 26/11/2016  
**DATE COMPLETED:** 7/12/2016  

### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH (m)</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 - 82m: slotted 200mm CI 12</td>
<td>70 - 82</td>
<td>Shale: White to red hematised shales, medium to soft, (80%), 2-30mm, minor weathered goethite, vuggy exterior, medium to hard, 2-35mm, poorly sorted.Minor black shales @78m, soft. Trace calcrete, 2-30mm.</td>
<td>Paraburdo</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82 - 92m: blank 200mm CI12 PVC</td>
<td>82 - 92</td>
<td>Shale: Black shale, soft, crumbles by hand, 2-40mm, R. Minor goethite, A, medium hardness, 2-8mm (10%)</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 - 6.4mm graded gravel pack</td>
<td>3.2 - 6.4</td>
<td>Shale: Transition zone. Black shale (50%) as above. Dolomite, highly weathered to the point of clay, soft to medium hard, 2-30mm, SR, poorly sorted.</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>92 - 122m: slotted 200mm CI 12</td>
<td>92 - 122</td>
<td>Weathered Dolomite: Weathered dolomite, light grey to grey, broken ground, 2-50mm, SR, poorly sorted, increase in flow.</td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC Endcap</td>
<td>122</td>
<td>Weathered Dolomite: Weathered dolomite as above, slightly fresher, blue-grey to grey, broken ground, 2-70mm, greater amount of larger blocky chips &gt;25mm, visible staining on exposed surfaces</td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered Dolomite: As above, grey, greater weathering with some light weight blocky dolomite.</td>
<td></td>
<td></td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:** Intercepted 28m of black shale above water table and another horizon of 6m below water table. 10 L/s yield from shales. During construction, a length of the outside steel casing fall, smashing the PVC; the PVC had to be drilled out and the bore re-cased and re-packed. Hole should be considered partially penetrating.
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

**EWPB004**

**PROJECT NAME:** Western Hub Feasibility Assessment

**LOCATION:** Site 02

**DRILLING CO:** Eastern Well

**DRILLING METHOD:** DR

**LOGGED BY:** MJRS

**EASTING (m):** 484994.99

**NORTHING (m):** 7513687.57

**ELEVATION (mAHD):** 503.19

**DRILLING DIAMETER(S) (mm):** 304.8

**COLLAR STICKUP (m):** 0.465

**DATE BEGUN:** 25/10/2016

**DATE COMPLETED:** 26/11/2016

---

**FINAL BORE DETAILS**

- **Drilled Depth (mbgl):** 158
- **Cased Depth (mbgl):** 156
- **Casing Stick Up (magl):** 0.241
- **Development Yield (l/s):** 35
- **Water Level (mbgl) & Date:** 29.87 & 11/12/2016
- **Quality - pH & EC (µS/cm):** 8.1 & 1013

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**BORE CONSTRUCTION**

- **16 3/8” steel monument with cap**
- **Concrete plinth**
- **Annular cement**

- **3.2 - 6.4 mm graded gravel pack**

- **0 - 57.5m: blank 200mm CI12 PVC**
- **Cement bentonite mix seal**

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**STRATIGRAPHY**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Tertiary Detrital</td>
<td>Clayey Ironstone: Mid red/brown clay with f.gr massive textured angular ironstones up to 1cm and 10% magnetite</td>
</tr>
<tr>
<td>5</td>
<td>Tertiary Detrital/CID</td>
<td>Clayey Ironstone: Light brown/pink clay with small chips of ironstone and trace of grey shales</td>
</tr>
<tr>
<td>15</td>
<td>Bee Gorge</td>
<td>Hardcap Detrital: Same but with very little clay</td>
</tr>
<tr>
<td>20</td>
<td>Bee Gorge</td>
<td>Clay: Mostly clay, light brown/pink colour and very small shale chips</td>
</tr>
<tr>
<td>35</td>
<td>Bee Gorge</td>
<td>Cemented Detrital: Cemented CID; mostly goethite, hematite and limonite with very little clay and 10% reddish mudstone</td>
</tr>
<tr>
<td>35</td>
<td>Bee Gorge</td>
<td>Cemented Detrital: Limonitic clay with goethite, limonite and hematite</td>
</tr>
<tr>
<td>45</td>
<td>Bee Gorge</td>
<td>Weathered Shale and Chert: Grey/green clay with 1m size carbonatic grey shale</td>
</tr>
<tr>
<td>50</td>
<td>Paraburdoo</td>
<td>Weathered Shale and Chert: Brown/grey clay with some angular very fine grained chips of chert up to 1cm size</td>
</tr>
<tr>
<td>60</td>
<td>Paraburdoo</td>
<td>Weathered Shale and Chert: Off-white plastic clay with chert</td>
</tr>
<tr>
<td>60</td>
<td>Paraburdoo</td>
<td>Weathered Shale and Chert: Highly weathered grey shales with 10% small chips of chert</td>
</tr>
<tr>
<td>70</td>
<td>Paraburdoo</td>
<td>Clay: Off-white/light pink plastic clay (highly weathered red mudstone and chert)</td>
</tr>
<tr>
<td>70</td>
<td>Paraburdoo</td>
<td>Weathered Shale and Chert: Grey/green plastic clay with chips up to 1 cm long of dark grey, subangular and pitted ironstones and beige, angular mudstone</td>
</tr>
<tr>
<td>70</td>
<td>Paraburdoo</td>
<td>Weathered Shale and Chert: Brown plastic clay with tubular, angular chips up to 1.5cm of ironstones and mudstone; some indication of harcap</td>
</tr>
<tr>
<td>70</td>
<td>Paraburdoo</td>
<td>Weathered Shale and Chert: Clay-rich (brown/grey colour) contact between ironstone/mudstone and dolomite (angular chips of both ironstones/mudstone and dolomite)</td>
</tr>
<tr>
<td>70</td>
<td>Paraburdoo</td>
<td>Weathered Dolomite: Moderately weathered, highly fractured dolomite (carbonate cemented arenite)</td>
</tr>
</tbody>
</table>

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**COMMENTS:** Cavity at 70m; bore needing more gravel than planned. End cap damaged during airdrilling. Rest of bore confirmed intact with downhole camera. 0.5m cement endcap placed after a month delay.
WESTERN HUB BORE LOG

PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 02
DRILLING CO: Eastern Well
DRILLING METHOD: DR
LOGGED BY: MJRS
EASTING (m): 484994.99
NORTHING (m): 7513687.57
ELEVATION (mAHD): 503.19
DRILLING DIAMETER(S) (mm): 304.8
COLLAR STICKUP (m): 0.465

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 158 m: 13 3/8&quot; DR</td>
<td></td>
<td></td>
<td>Weathered Dolomite: Same but with limonite alteration in fracture planes and quartz crystals in small open fractures</td>
<td>30</td>
<td>943</td>
<td>8.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Manganese Hardcap: Dark grey-blue, dull, subangular to subrounded manganese (massive, botryoidal and small fibresize crystals)</td>
<td>30</td>
<td>926</td>
<td>8.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weathered Dolomite: Light beige, carbonate cemented arenite (dolomite) with 10% manganese chips</td>
<td>30</td>
<td>918</td>
<td>8.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weathered Dolomite: 5% manganese chips</td>
<td>30</td>
<td>890</td>
<td>8.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weathered Dolomite: Light beige, carbonate cemented, sand size (arenite) with trace of manganese chips</td>
<td>&gt;30</td>
<td>932</td>
<td>7.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weathered Dolomite: Light beige, carbonate cemented, sand size (arenite) with trace of manganese chips</td>
<td>&gt;30</td>
<td>938</td>
<td>7.48</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>Weathered Dolomite: Light beige, carbonate cemented, sand size (arenite) with trace of manganese chips</td>
<td>&gt;30</td>
<td>913</td>
<td>7.48</td>
</tr>
<tr>
<td></td>
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<td>Weathered Dolomite: Light beige, carbonate cemented, sand size (arenite) with trace of manganese chips</td>
<td>&gt;30</td>
<td>1056</td>
<td>8.13</td>
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<td></td>
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<td>Weathered Dolomite: Light beige, carbonate cemented, sand size (arenite) with trace of manganese chips</td>
<td>&gt;30</td>
<td>1113</td>
<td>7.9</td>
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<td></td>
<td></td>
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<td>Weathered Dolomite: Light beige, carbonate cemented, sand size (arenite) with trace of manganese chips</td>
<td>&gt;30</td>
<td>1224</td>
<td>7.81</td>
</tr>
</tbody>
</table>

Comments: Cavity at 70m; bore needing more gravel than planned. End cap damaged during airlifting. Rest of bore confirmed intact with downhole camera. 0.5m cement endcap placed after a month delay
Comments: Cavity at 70m; bore needing more gravel than planned. End cap damaged during airlifting. Rest of bore confirmed intact with downhole camera. 0.5m cement endcap placed after a month delay.
Lost circulation from 29m, EOH 111m with several metres of fallback at base. Due to lost circ, strat interval taken from adjacent diamond hole (EWD0007)
Project Name: Western Hub Feasibility Assessment
Location: Site 12
Drilling Co: Foraco
Logged By: GL
Drilling Method: MR
Easting (m): 483000.98
Northing (m): 7511832.11
Elevation (m): 516.39
Drilling Diameter(s) (mm): 311.15
Collar Stickup (m): 0.538
Date Begun: 23/11/2016
Date Completed: 4/12/2016

**Western Hub Bore Log**

**Borehole Number:** EWPB005

**Final Bore Details**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Stratigraphy</th>
<th>Lithology</th>
<th>Description</th>
<th>Yield (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>61 - 103m: slotted 200mm Cl 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103 - 111m fallback</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC Endcap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Drilled Depth (mbgl):** 111
**Cased Depth (mbgl):** 103
**Casing Stick Up (magl):** 0.316
**Development Yield (l/s):** 4.5
**Water Level (mbgl) & Date:** 63.1 5/12/2016
**Quality - pH & EC (µS/cm):** 8.66 1171

**Comments:**
Lost circulation from 29m, EOH 111m with several metres of fallback at base. Due to lost circ, strat interval taken from adjacent diamond hole (EWD0007)
During drilling of the production bore the flow of water justified drilling deeper than planned and deeper than the monitoring bore was.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 04  
**DRILLING CO:** Eastern Well  
**DRILLING METHOD:** DR  
**LOGGED BY:** MJRS  
**EASTING (m):** 481396.35  
**NORTHING (m):** 7513603.38  
**ELEVATION (mAHD):** 482.82  
**DRILLING DIAMETER(S) (mm):** 304.8  
**COLLAR STICKUP (m):** 0.625  
**DATE BEGUN:** 7/12/2016  
**DATE COMPLETED:** 13/12/2016

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC Endcap</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td>998</td>
<td>8.05</td>
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<tr>
<td>Bottom fallback</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**FINAL BORE DETAILS**

- **Drilled Depth (mblg):** 80  
- **Cased Depth (mblg):** 78.5  
- **Casing Stick Up (magl):** 0.361  
- **Development Yield (l/s):** 20  
- **Water Level (mblg) & Date:** 24.43 16/12/2016  
- **Quality - pH & EC (µS/cm):** 8.98 1058

Comments: During drilling of the production bore the flow of water justified drilling deeper than planned and deeper than the monitoring bore was.
<table>
<thead>
<tr>
<th>BOREHOLE NUMBER</th>
<th>EWPB007</th>
</tr>
</thead>
</table>

**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 06  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** MR  
**LOGGED BY:** JB  
**EASTING (m):** 482605.49  
**NORTHING (m):** 7512507.98  
**ELEVATION (mAHD):** 547.96  
**DRILLING DIAMETER(S) (mm):** 311.15  
**COLLAR STICKUP (m):** 0.605  
**DATE BEGUN:** 9/12/2016  
**DATE COMPLETED:** 22/11/2016

### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Drilled Depth (mbgl)</td>
<td>180</td>
</tr>
<tr>
<td>Cased Depth (mbgl)</td>
<td>179.5</td>
</tr>
<tr>
<td>Casing Stick Up (magl)</td>
<td>0.455</td>
</tr>
<tr>
<td>Development Yield (l/s)</td>
<td>7.5</td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date</td>
<td>90.7 5/12/2016</td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm)</td>
<td>9.53 1221</td>
</tr>
</tbody>
</table>

### BORE CONSTRUCTION

- **16 3/8” steel monument with cap**
- **Concrete plinth**
- **Annular cement**
- **13” reaming to install steel collar casing**
- **Cement bentonite mix seal**

### DEPTH | STRATIGRAPHY | LITHOLOGY | DESCRIPTION |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td>Joffre</td>
<td>Clayey Ironstone: Reddish brown, small angular chips; fine grained</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>BIF &amp; Shale: Purple shales</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>Shale: Grey/brown shales</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>BIF &amp; Shale: Brown/grey limonitic clay-rich shales</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>Shale: Grey/brown shales; very small chips</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>BIF &amp; Shale: Brown/red semi-plastic clay with shales and unmineralised BIF</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>BIF &amp; Shale: Limonitic clay with shales and BIF</td>
<td></td>
</tr>
<tr>
<td>0 - 58.9m: blank 200mm Cl12 PVC</td>
<td></td>
<td>BIF &amp; Shale: Brown/orange clay with trace of chips of shale and unmineralised BIF</td>
<td></td>
</tr>
</tbody>
</table>

### COMMENTS

Two lengths of the Cl18 slotted PVC were damaged. Total slotted used 48.6m. Blank casing included Cl18 and Cl12. Gravel up to 3.5m because it took longer to set. Strat interp taken from nearest RC hole which was interped using gamma
Two lengths of the CI18 slotted PVC were damaged. Total slotted used 48.6m. Blank casing included CI18 and CI12. Gravel up to 3.5m because it took longer to set. Strat interp taken from nearest RC hole which was interped using gamma.
Comments: Two lengths of the CI18 slotted PVC were damaged. Total slotted used 48.6m. Blank casing included CI18 and CI12. Gravel up to 3.5m because it took longer to set. Strat interp taken from nearest RC hole which was interped using gamma.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 11  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** JB  
**EASTING (m):** 522377.46  
**NORTHING (m):** 7511010.95  
**ELEVATION (mAH):** 565.12  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.705  
**DATE BEGUN:** 14/10/2016  
**DATE COMPLETED:** 16/10/2016
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 11  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** JB  
**EASTING (m):** 522377.46  
**NORTHING (m):** 7511010.05  
**ELEVATION (mAHD):** 565.12  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.705  
**DATE BEGUN:** 14/10/2016  
**DATE COMPLETED:** 16/10/2016

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 106m 140mm hole</td>
<td>75</td>
<td></td>
<td></td>
<td>Chert &amp; Shale: Dark grey, big blocky chips, very hard, v f grained, sub-concoidal fracture, some lamination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>80</td>
<td></td>
<td></td>
<td>Shale: Grey (and trace of black - some oily shale) v. f grained well bedded clearly shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>87 - 105m: slotted 50mm Cl18</td>
<td>90</td>
<td></td>
<td></td>
<td>Dolomite: Fresh but very fractured (some very big chips, and surfaces with brown stain) Very high flows. EOH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>95</td>
<td></td>
<td></td>
<td>Annulus blocked at 88m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td>PVC Endcap</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Comments:** Annulus blocked at 88m
<table>
<thead>
<tr>
<th>BOREHOLE NUMBER</th>
<th>FFMB002</th>
</tr>
</thead>
</table>

| PROJECT NAME: | Western Hub Feasibility Assessment |
| LOCATION:     | Site 10 |
| DRILLING CO:  | Foraco |
| DRILLING METHOD: | RC |
| LOGGED BY:    | MJRS |
| EASTING (m):  | 516325.57 |
| NORTING (m):  | 7509667.85 |
| ELEVATION (mAH): | 551.72 |
| DRILLING DIAMETER(S) (mm): | 140 |
| COLLAR STICKUP (m): | 0.656 |
| DATE BEGUN:   | 23/10/2016 |
| DATE COMPLETED: | 25/10/2016 |

<table>
<thead>
<tr>
<th>FINAL BORE DETAILS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>100</td>
</tr>
<tr>
<td>Cased Depth (mbgl):</td>
<td>100</td>
</tr>
<tr>
<td>Casing Stick Up (magl):</td>
<td>0.575</td>
</tr>
<tr>
<td>Development Yield (l/s):</td>
<td>4</td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date:</td>
<td>8.545 2/11/2016</td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.69 2078</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 58m: blank 50mm CI18 PVC</td>
<td>58</td>
<td>Tertiary Detrital/CID</td>
<td>Paraburdo</td>
<td>Clayey Ironstone: Red/brownish CID. Dry clay with angular and pitted, subrounded ironstones and small vitreous goethite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&quot; Reaming to install 150mm PVC collar casing 150mm PVC collar casing 1.6 - 3.2 mm graded gravel pack mixed with cement</td>
<td>10</td>
<td>0 - 100m 140mm hole 25 - 100m fallback: annulus blocked at 25m</td>
<td>Cemented Detrital: Brown clay with very small grey and brown subangular chips</td>
<td>Cemented Detrital: Small, eroded, subangular chips of ironstones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 1/2&quot; steel monument with cap Concrete plinth Annular cement</td>
<td>18</td>
<td>Weathered Dolomite: Moderately weathered crystalline dolomite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered Dolomite: Weathered and faulted dolomite (Driller comments: very fractured)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered Dolomite: Moderately weathered crystalline dolomite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered Dolomite: Highly weathered, white, arenite texture, dolomite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered Dolomite: Highly weathered, small angular chips of dolomite</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Comments: Wall collapse blocking the annulus at 25m (collar casing to 24m)
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

| BOREHOLE NUMBER | FFMB002 |

**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 10  
**DRILLING CO:** Foraco  
**DRILLING METHOD:** RC  
**LOGGED BY:** MJRS  
**EASTING (m):** 516325.57  
**NORTHING (m):** 7509667.85  
**ELEVATION (m):** 551.72  
**DRILLING DIAMETER(S) (mm):** 140  
**COLLAR STICKUP (m):** 0.656  
**DATE BEGUN:** 23/10/2016  
**DATE COMPLETED:** 25/10/2016  

### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilled Depth (mbgl)</td>
<td>100</td>
</tr>
<tr>
<td>Cased Depth (mbgl)</td>
<td>100</td>
</tr>
<tr>
<td>Casing Stick Up (magl)</td>
<td>0.575</td>
</tr>
<tr>
<td>Development Yield (l/s)</td>
<td>4</td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date</td>
<td>8.545  2/11/2016</td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm)</td>
<td>7.69   2078</td>
</tr>
</tbody>
</table>

**BORE CONSTRUCTION**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>PVC Endcap</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td></td>
<td></td>
<td>58 - 100m: slotted 50mm CI18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td></td>
<td></td>
<td>Weathered Dolomite: Extremely weathered dolomite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>Cl18</td>
<td>Weathered Dolomite: Beige/greyish; highly weathered dolomite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>PVC Endcap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:** Wall collapse blocking the annulus at 25m (collar casing to 24m)
PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 09
DRILLING CO: Foraco
DRILLING METHOD: RC
LOGGED BY: MJRS
EASTING (m): 515798.78
NORTHING (m): 7509685.90
ELEVATION (mAH): 547.29
DRILLING DIAMETER(S) (mm): 140
COLLAR STICKUP (m): 0.68
DATE BEGUN: 13/10/2016 DATE COMPLETED: 14/10/2016

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH (m)</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td>Clayey Detrital: Tertiary detritals: brown-reddish, loose, sub-angular small chips of BIF and chert</td>
<td>0.5</td>
<td>1320</td>
<td>7.55</td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td>Clayey Detrital: Brown/red clays with very small chips of angular ironstones</td>
<td>0.5</td>
<td>1560</td>
<td>7.49</td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td>Weathered Shale and Chert: Highly weathered brown shale/chert unit with manganese at 38-40 and only clay at 40-42 (contact)</td>
<td>0.5</td>
<td>1560</td>
<td>7.49</td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td>BIF &amp; Shale: Highly weathered unmineralised BIF with clay only at 42-44 (litho contact with sequence above)</td>
<td>0.5</td>
<td>1940</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td>BIF &amp; Chert: Almost fresh unmineralised BIF</td>
<td>0.5</td>
<td>1940</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
<td>1940</td>
<td>7.6</td>
</tr>
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</table>

Comments: Drilling intersected a void at 8-9m. At 42m potential for a sheared lithological contact
### FINAL BORE DETAILS

<table>
<thead>
<tr>
<th>Description</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cased Depth (mbgl):</td>
<td>117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casing Stick Up (magl):</td>
<td>0.616</td>
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</tr>
<tr>
<td>Development Yield (l/s):</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date:</td>
<td>50.214</td>
<td>2/11/2016</td>
<td></td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>8.02</td>
<td>1630</td>
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</tr>
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</table>

### WESTERN HUB BORE LOG

#### FFMB003

**BORE CONSTRUCTION**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>52 - 118m: slotted 50mm CI18</td>
<td>1.6 - 3.2 mm graded gravel pack</td>
<td></td>
</tr>
<tr>
<td>118</td>
<td>PVC Endcap</td>
<td>BIF &amp; Chert: Moderately weathered/fratured, grey massive, v. fine gr. BIF</td>
</tr>
<tr>
<td>115</td>
<td></td>
<td>BIF &amp; Shale: Brown/grey fractured/weathered shales/chert/BIF; limonite rich at 94-96</td>
</tr>
<tr>
<td>110</td>
<td></td>
<td>BIF &amp; Shale: Slightly less weathered same shale/chert/BIF</td>
</tr>
</tbody>
</table>

#### Amazing Geyser

**LOCATION:** Site 09

**DRILLING CO:** Foraco

**DRILLING METHOD:** RC

**LOGGED BY:** MJRS

**EASTING (m):** 515798.78

**NORTHING (m):** 7509605.90

**ELEVATION (mAHD):** 547.29

**DRILLING DIAMETER(S) (mm):** 140

**COLLAR STICKUP (m):** 0.68

**DATE BEGUN:** 13/10/2016

**DATE COMPLETED:** 14/10/2016

**COMMENTS:** Drilling intersected a void at 8-9m. At 42m potential for a sheared lithological contact.
There were some small problems with the equipment, but drilling and casing went smoothly. Drilled open hole 88-94m but changed back to DR (very slow drilling open hole due to machine conditions).
PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 11
DRILLING CO: Eastern Well
LOGGED BY: MJRS
EASTING (m): 522379.66
NORTHING (m): 7511026.41
ELEVATION (mAHD): 565.39
DRILLING DIAMETER(S) (mm): 304.8
COLLAR STICKUP (m): 0.461

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.5 - 99.5m: slotted 200mm CI 12</td>
<td>75.0</td>
<td></td>
<td></td>
<td>Chert &amp; Shale: Dark grey, big blocky chips, very hard, v f grained, sub-conoidal fracture, some lamination</td>
<td>3</td>
<td>2600</td>
<td>8.12</td>
</tr>
<tr>
<td>99.5 - 100m: fallback</td>
<td>100.0</td>
<td></td>
<td></td>
<td>Shale: Grey (and trace of black - some oily shale) v. f grained well bedded clearly shale</td>
<td>3</td>
<td>2790</td>
<td>8.21</td>
</tr>
<tr>
<td>PVC Endcap</td>
<td></td>
<td></td>
<td></td>
<td>Dolomite: Fresh but very fractured (some very big chips, and surfaces with brown stain) Very high flows. EOH</td>
<td>25 - 30</td>
<td>2520</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 50</td>
<td>2420</td>
<td>8.43</td>
</tr>
</tbody>
</table>

Comments: There were some small problems with the equipment, but drilling and casing went smoothly. Drilled open hole 88-94m but changed back to DR (very slow drilling open hole due to machine
WESTERN HUB BORE LOG

PROJECT NAME: Western Hub Feasibility Assessment
LOCATION: Site 10
DRILLING CO: Eastern Well
DRILLING METHOD: DR
LOGGED BY: MJRS/JB
EASTING (m): 516323.80
NORTHING (m): 7509684.06
ELEVATION (mAHD): 551.61
DRILLING DIAMETER(S) (mm): 304.8
COLLAR STICKUP (m): 0.43

DATE BEGUN: 11/10/2016  DATE COMPLETED: 17/10/2016

<table>
<thead>
<tr>
<th>BORE CONSTRUCTION</th>
<th>DEPTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 3/8” steel monument with cap</td>
<td>0</td>
</tr>
<tr>
<td>Concrete plinth Annular cement</td>
<td></td>
</tr>
<tr>
<td>3.2-6.4mm graded gravel pack</td>
<td>5</td>
</tr>
<tr>
<td>0-56m: blank 200mm CI12 PVC Cement bentonite mix seal Annulus was blocked at 31 m. Were able to get gravel past blockage.</td>
<td>15</td>
</tr>
<tr>
<td>13 3/8” DR</td>
<td>25</td>
</tr>
<tr>
<td>3.2-6.4mm graded gravel pack</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary Alluvium</td>
<td>Clayey Detrital: Red clay with big, angular, fine grained, bedded chips of BIF</td>
<td></td>
</tr>
<tr>
<td>Palaeochannel Sediment</td>
<td>Mudstone &amp; Siltstone: Off-white big angular, very fine grained, massive texturized chips</td>
<td></td>
</tr>
<tr>
<td>Bee Gorge</td>
<td>Cemented Detrital: Brown semi-plastic clay with a mix of not equidimensional (5-50mm) grey and brown subangular chips</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cemented Detrital: One big (60mm long) chips and most others small, eroded, subangular showing signs of being fractured; cemented detritals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cemented Detrital: Moderately fresh, cemented pyroliths (subrounded, pitted with clear “onion” texture)</td>
<td></td>
</tr>
<tr>
<td>Paraburdoo</td>
<td>Fault: Fault/shear zone: mix of BIF and dolomite; chips are a mix of subrounded and angular, weathered and fresh, different sizes and rock types (chert, shale, dolomite, BIF) Cavities. Also manganese botroidal and massive (base of WestAng)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathered Dolomite: Fractured (weathered or faulted?) dolomite; small and big chips, light grey and light beige with stain in surfaces, some trace of cavity (crystal growth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathered Dolomite: Fresh grey/blue dolomite with some fractures (infilled with secondary mineralization - calcareous)</td>
<td></td>
</tr>
</tbody>
</table>

Comments: While pulling casing, EW encountered a clay at about 42 m that blocked the annular space between casing and PVC. EW was able to get gravel past the blockage and filled to about 32 m. They were unable to dip the hole to confirm gravel placement. The entire screen was covered with gravel.
While pulling casing, EW encountered a clay at about 42 m that blocked the annular space between casing and PVC. EW was able to get gravel past the blockage and filled to about 32 m. They were unable to dip the hole to confirm gravel placement. The entire screen was covered with gravel.
**PROJECT NAME:** Western Hub Feasibility Assessment  
**LOCATION:** Site 09  
**DRILLING CO:** Eastern Well  
**DRILLING METHOD:** DR  
**LOGGED BY:** JB  
**EASTING (m):** 515779.08  
**NORTHING (m):** 7509605.80  
**ELEVATION (mAHD):** 546.92  
**DRILLING DIAMETER(S) (mm):** 304.8  
**COLLAR STICKUP (m):** 0.505  
**DATE BEGUN:** 18/10/2016  
**DATE COMPLETED:** 23/10/2016

---

**FINAL BORE DETAILS**

<table>
<thead>
<tr>
<th>FINAL BORE DETAILS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilled Depth (mbgl):</td>
<td>98</td>
</tr>
<tr>
<td>Cased Depth (mbgl):</td>
<td>98</td>
</tr>
<tr>
<td>Casing Stick Up (magl):</td>
<td>0.451</td>
</tr>
<tr>
<td>Development Yield (l/s):</td>
<td>8</td>
</tr>
<tr>
<td>Water Level (mbgl) &amp; Date:</td>
<td>49.819 2/11/2016</td>
</tr>
<tr>
<td>Quality - pH &amp; EC (µS/cm):</td>
<td>7.7 1320</td>
</tr>
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**BORE CONSTRUCTION**

**DEPTH** | **STRATIGRAPHY** | **LITHOLOGY** | **DESCRIPTION** | **YIELD (l/s)** | **EC (µS/cm)** | **pH**
---|---|---|---|---|---|---

| Tertiary Detrital | Clayey Detrital: Tertiary detritals: brown-reddish, loose, sub-angular small chips of BIF and chert |
| West Angelas | Weathered Shale and Chert: Highly weathered brown shale/chert unit with manganese at 38-40 and only lay at 40-42 (contact) |
| Newman | BIF & Shale: Highly weathered unmineralised BIF with clay only at 42-44 (litho contact with sequence above) |

---

**Comments:** Diffuser blocked up with clay at 32m. Sample piles at 32m, 34m, and 36m is a mix of the blocked material in the diffuser.
**WESTERN HUB BORE LOG**

**BOREHOLE NUMBER**

**FFPB003**

**PROJECT NAME:** Western Hub Feasibility Assessment

**LOCATION:** Site 09

**DRILLING CO:** Eastern Well

**DRILLING METHOD:** DR

**LOGGED BY:** JB

**EASTING (m):** 515779.08

**NORTHING (m):** 7509685.80

**ELEVATION (mAHG):** 546.92

**DRILLING DIAMETER(S) (mm):** 304.8

**COLLAR STICKUP (m):** 0.505

**DATE BEGUN:** 18/10/2016  
**DATE COMPLETED:** 23/10/2016

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DESCRIPTION</th>
<th>YIELD (l/s)</th>
<th>EC (µS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 - 6.4mm graded gravel pack</td>
<td>75</td>
<td>BIF &amp; Chert: Moderately weathered/fratured, grey massive, v. fine gr. BIF</td>
<td>4</td>
<td>2400</td>
<td>7.52</td>
<td></td>
</tr>
<tr>
<td>62 - 98m: 13 3/8&quot; Convential</td>
<td>75-90</td>
<td></td>
<td>5</td>
<td>1773</td>
<td>7.67</td>
<td></td>
</tr>
<tr>
<td>68 - 98m: slotted 200mm Cl 12</td>
<td>90-95</td>
<td>BIF &amp; Shale: Brown/grey fractured/weathered shales/chert/BIF</td>
<td>6</td>
<td>1450</td>
<td>7.66</td>
<td></td>
</tr>
<tr>
<td>PVC Endcap</td>
<td>95-100</td>
<td></td>
<td>7-8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMMENTS:** Diffuser blocked up with clay at 32m. Sample piles at 32m, 34m, and 36m is a mix of the blocked material in the diffuser.
APPENDIX B
Summary of Test Pumping Analysis
APPENDIX B
Test Pumping Analysis

TEST PUMPING OVERVIEW

All test pumping analysis was undertaken using the AQTESOLV software package (HydroSOLV Inc.) unless otherwise stated. All discussion of intersected geological stratigraphy, bore completions and confined/unconfined aquifer conditions is based on review of bore logs unless otherwise stated.

EWPB002 TEST PUMPING AND ANALYSIS

A six day constant rate pumping test (CRT) was conducted at EWPB002 commencing on 31/01/2017 at an average pumping rate of 12 litres per second (L/s). Three surrounding bores were monitored throughout the test and are summarised in Table B1. The pumped bore and most monitoring bores were completed in the Wittenoom Aquifer, screened in the Paraburdoo Member of the Wittenoom Formation. The exception was monitoring bore “Talisman” for which no stratigraphy or bore completion data was supplied.

Based on initial heads, aquifer conditions at the pumped bore and two of three monitoring bores (EWMB002 and EWMB005) were considered likely to be confined. In each case the confining bed was considered to be weathered Bee Gorge Member that overlies the Paraburdoo Member (Wittenoom Formation). Confined or unconfined conditions at Talisman bore were unknown due to the lack of data.

One of the three observation bores monitored responded to pumping (Figure B1 and Table B2). Pumping rate, pumped bore drawdown and drawdown from responding observation bores is presented in Figure B2. Key observations from EWPB002 CRT results include:

- Initial standing water levels (as m AHD) were similar between the pumped bore and the nearest observation well but different to observation bores to the east and west. To the east of the production bore initial heads were around 7.7 m higher (Talisman bore) while to the west they were around 30 m lower (EWMB005). It is noted that these monitoring bores are located at substantial distances from the pumped bore: Talisman (2,432 m) and EWMB005 (4,320 m). These differences in initial heads are consistent with the compartmentalised nature of the conceptual hydrogeological model. The pumped bore and nearest monitoring bore are interpreted to be installed in a relatively narrow compartment, bounded to the east and west by interpreted dolerite dykes (Figure B1).

- Average flow rate from EWPB003 was 12 L/s but short term variations between 7.8 and 13.5 L/s were observed (Figure B2).

- The two monitoring bores that did not respond to pumping were EWMB005 and Talisman (Figure B1 and Table B2). This is considered consistent with the conceptual hydrogeological model of the region as these non-responding monitoring bores and the pumped bore are separated by inferred dolerite dykes (Figure B1). The inferred dolerite dyke is considered to act as a “no flow” boundary due to the lack of drawdown to the west of the dyke and the difference in pre-pumping initial heads.

- Final drawdown in the pumped bore was 21.9 m after six days pumping at ~12 L/s indicating that bore EWPB002 is relatively low yielding (specific capacity of approximately 0.5 L/s/m after six days pumping).

- Recovery monitoring was conducted for a relatively short period compared to the duration of pumping. The pumped bore and nearest observation bore recovery were monitored for 40 minutes while the outer monitoring bores recovery was monitored for 180 minutes. In this time the pumped bore recovered approximately 98% of observed drawdown and the monitoring bore EWMB002 recovered 96% (Table B2).
LEGEND
- Pumped Bore and Final Drawdown
- Observation Bore and Final Drawdown
- Jeerinnah Formation
- Mount MaCrae Shale
- Dolerite
- Yandicoogina Shale

NOTES
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

PROJECT:
WESTERN HUB - HYDROGEOLOGICAL CONCEPTUAL MODEL

CONSULTANT:
FORTESCUE METALS GROUP

PRODUCT:
EWPB002 CRT - FINAL DRAWDOWN (6 DAYS @ 12 L/S)

PRODUCT NO.:
147641484

CONTROL:
002 R

REV.:
2

PATH:
J:\Hydro\2016\1671484 - FMG - Western Hub - Dewatering and Water Supply Assessment\Analysis\GIS analysis\Test Pumping MXD\Sketch_TestPumping_EWPB002CRT .mxd
Figure B2: Pumping rate and selected drawdown results from EWPB002 CRT (commenced 31/01/2007 10:00)
## APPENDIX B
### Test Pumping Analysis

### Table B1: Summary of EWPB002 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB002</td>
<td>Pumped Bore</td>
<td>493168</td>
<td>7512915</td>
<td>31/01/17</td>
<td>128.0</td>
<td>110 - 128</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>56.9</td>
<td>509.3</td>
<td>Confined</td>
</tr>
<tr>
<td>EWMB002</td>
<td>Observation Bore</td>
<td>493169</td>
<td>7512935</td>
<td>10:00</td>
<td>128.0</td>
<td>110 - 128</td>
<td>Wittenoom Aquifer</td>
<td>56.4</td>
<td>509.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talisman</td>
<td>Observation Bore</td>
<td>495600</td>
<td>7512900</td>
<td>102.4</td>
<td>No stratigraphy or completion data</td>
<td>66.8</td>
<td>517.1</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EWMB005</td>
<td>Observation Bore</td>
<td>488598</td>
<td>7512901</td>
<td>104.5</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>51.6</td>
<td>479.1</td>
<td>Confined</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

### Table B2: Summary of EWPB002 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>12</td>
<td>EWPB002</td>
<td>0</td>
<td>21.9</td>
<td>40</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB002</td>
<td>20</td>
<td>15.7</td>
<td>40</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Talisman</td>
<td>2432</td>
<td>-0.1 (NR)</td>
<td>180</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB005</td>
<td>4570</td>
<td>0.0 (NR)</td>
<td>180</td>
<td>-0.07</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the observation bore that responded to pumping (EWMB002), presented in Figure B3. A review of bore logs for the pumped bore and EWMB002 identified fractured dolomite in the screened interval for each respective bore. Bearing this in mind and observing a non-radial flow response in both the pumped bore and EWMB002 the Moench solution for dual porosity, fractured rock aquifers was selected (Figure B3).

Estimates of aquifer hydraulic properties from the EWPB002 CRT are summarised in Table B3. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B3). This said, only an approximate fit was possible for data from observation well EWMB002. Some caution is considered reasonable with respect to estimated hydraulic properties from EWPB002 CRT results due to the limited number of responding monitoring wells and the inherent complexity of fractured rock aquifer systems.

Table B3: Summary of Aquifer Hydraulic Property Estimates - EWPB002 CRT

<table>
<thead>
<tr>
<th>Hydraulic Conductivity (m/day)</th>
<th>Specific Storage (1/m)</th>
<th>Matrix Hydraulic Conductivity (m/day)</th>
<th>Matrix Specific Storage (1/m)</th>
<th>Aquifer Thickness – b (m)</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.45</td>
<td>8.4e-11</td>
<td>4.5e-15</td>
<td>3.8e-6</td>
<td>24</td>
<td>Moench (slab blocks)</td>
</tr>
</tbody>
</table>
APPENDIX B
Test Pumping Analysis

Figure B3: Hydraulic Analysis Results – EWPB002 CRT
EWPB003 TEST PUMPING AND ANALYSIS

A three day CRT was conducted at EWPB003 commencing on 8/02/2017 at an average pumping rate of 28.2 L/s. Five surrounding bores were monitored throughout the test and are summarised in Table B4. Both the pumped bore and all monitoring bores were completed in the Wittenoom Aquifer, with the majority screened in the Paraburadoo Member of the Wittenoom Formation. The pumped bore is completed in both the Paraburadoo Member and the overlying Bee Gorge Member (Wittenoom Formation). Monitor bore EWMB001S is completed shallower than the other monitored bores, in the Bee Gorge Member (Wittenoom Formation).

Based on initial heads, aquifer conditions at EWPB003 and the nearest observation bores were likely confined due to the presence of the Mount McRae Shale and Mount Sylvia Formation overlying the intersected Wittenoom Formation strata (Table B4). Unconfined aquifer conditions were considered likely at observation bores to the east of EWPB003 (EWPB004 and EWMB004). Observation bore EWMB005 was also considered likely to have confined conditions due to the Bee Gorge Member (Wittenoom Formation) being described as clay rich in this location.

Two of the six observation bores monitored responded to pumping (Table B5 and Figure B4). Pumping rate, pumped bore drawdown and drawdown from responding observation bores is presented in Figure B5. Key observations from EWPB003 CRT results include:

- Initial standing water levels (as m AHD) were different between the pumped bore and the nearest observation wells EWMB001S/D by approximately 2.7 m over a distance of 16 m radially. The initial heads at the nested monitoring well site (EWMB001S/D) were essentially the same, confirming the equilibrated head across the different units of the Wittenoom Formation. The reason for the difference in head between the pumped bore and the nearby monitoring wells is currently unclear.

- There were observed differences in initial heads either side of the inferred dolerite dyke to the east of EWPB003. Bores to the west of the dyke, including the pumped bore and nearby observations bores, had initial heads between 8.7 m and 11.4 m lower than those immediately to the east of the dyke (EWPB004 and EWMB004). This strong “stepped” change in head over a short distance indicates geological structural control over the local hydrogeological system, consistent with the compartmentalised system proposed in the conceptual hydrogeological model.

- Average flow rate from EWPB003 was 28.2 L/s but short term variations between 27.5 and 28.3 L/s were observed (Figure B5).

- A number of monitoring bores completed in the Wittenoom aquifer did not respond to pumping from EWPB003 (Figure B4 and Table B5). This is considered consistent with the conceptual hydrogeological model of the region as bores EWMB001S/D and the pumped bore are separated from the observation bores to the east and north-east by an inferred dolerite dyke (Figure B4). The inferred dolerite dyke is considered to act as a “no flow” boundary due to the lack of drawdown to the east of the dyke and the difference in pre-pumping initial heads.

- Final drawdown in the pumped bore was 6.6 m after three days pumping at ~28.2 L/s indicating that bore EWPB004 is relatively moderate yielding (specific capacity of approximately 4.3 L/s/m after three days pumping).

- Recovery monitoring was conducted for 21 hours follow three days pumping. In this time the pumped bore recovered approximately 87% of observed drawdown and the monitoring bores that responded to pumping recovered between 70% and 75% (EWMB001D and EWMB001S, Table B5).
Figure B5: Pumping rate and selected drawdown results from EWPB003 CRT (commenced 8/2/2017 10:00)
## Table B4: Summary of EWPB003 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB003</td>
<td>Pumped Bore</td>
<td>484771</td>
<td>7513231</td>
<td>8/02/17 10:00</td>
<td>122.0</td>
<td>70 - 82 and 92 - 122</td>
<td>Bee Gorge Mbr and Paraburdo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>47.3</td>
<td>464.8</td>
<td>Confined</td>
</tr>
<tr>
<td>EWMB001D</td>
<td>Observation Bore</td>
<td>484784</td>
<td>7513240</td>
<td>8/02/17 10:00</td>
<td>122.2</td>
<td>104.1 - 122.2</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td></td>
<td>47.3</td>
<td>462.1</td>
<td></td>
</tr>
<tr>
<td>EWMB001S</td>
<td>Observation Bore</td>
<td>484784</td>
<td>7513240</td>
<td>8/02/17 10:00</td>
<td>88.5</td>
<td>70.5 - 88.5</td>
<td>Bee Gorge Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>47.3</td>
<td>462.2</td>
<td></td>
</tr>
<tr>
<td>EWMB004</td>
<td>Pumped Bore</td>
<td>485017</td>
<td>7513674</td>
<td>8/02/17 10:00</td>
<td>166.0</td>
<td>74 - 164</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td></td>
<td>30.0</td>
<td>473.5</td>
<td>Unconfined</td>
</tr>
<tr>
<td>EWPB004</td>
<td>Pumped Bore</td>
<td>484995</td>
<td>7513688</td>
<td>8/02/17 10:00</td>
<td>156.0</td>
<td>72 - 156</td>
<td>Bee Gorge Mbr (Wittenoom Fm)</td>
<td></td>
<td>29.7</td>
<td>473.5</td>
<td></td>
</tr>
<tr>
<td>EWMB005</td>
<td>Observation Bore</td>
<td>488598</td>
<td>7512901</td>
<td>8/02/17 10:00</td>
<td>104.5</td>
<td>68.5 - 104.5</td>
<td>Bee Gorge Mbr (Wittenoom Fm)</td>
<td></td>
<td>51.4</td>
<td>479.3</td>
<td>Confined</td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

## Table B5: Summary of EWPB003 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>28.2</td>
<td>EWPB003</td>
<td>0</td>
<td>6.6</td>
<td>1260</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB001D</td>
<td>16</td>
<td>3.46</td>
<td>1260</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB001S</td>
<td>16</td>
<td>2.83</td>
<td>1260</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB004</td>
<td>507</td>
<td>-0.05 (NR)</td>
<td>1260</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWPB004</td>
<td>509</td>
<td>-0.045 (NR)</td>
<td>1260</td>
<td>-0.065</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB005</td>
<td>3841</td>
<td>0.08 (NR)</td>
<td>1260</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
APPENDIX B
Test Pumping Analysis

Hydraulic analysis was conducted of data from the pumped bore and the two observation bores that responded to pumping (EWMB001 S/D), presented in Figure B6. A bounded aquifer response with delayed yield was observed in results. The bounded response can be seen as a late time increase of drawdown slope post 1000 minutes pumping. Delayed yield was observed as change in drawdown slope after approximately 100 minutes pumping (Figure B6).

The observed bounded aquifer response is consistent with the compartmentalised nature of the proposed conceptual hydrogeological model. Aquifer boundaries were incorporated into the solution settings and were kept consistent with surface mapping of strata that were likely to represent aquifer boundaries, particularly the inferred dolerite dyke. The delayed yield response observed in drawdown data is consistent with a thick unconfined aquifer rather than a confined aquifer as indicated by initial heads. It is possible that the dipping nature of the intersected Wittenoom Formation strata and overlying units result in an unconfined or perhaps semi-confined aquifer system. The Neuman solution for unconfined aquifers was selected for analysis as it is compatible with applied aquifer boundary settings and incorporates delayed yield in its underlying mathematical basis.

Estimates of aquifer hydraulic properties from the EWPB003 CRT are summarised in Table B6. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B6). This said, final drawdown for the pumped bore is under-predicted by approximately 1.6 m which is attributed to well loss. Relatively good fit was achieved between the analysis solution and drawdown in the shallow and deep monitoring wells (EWMB001 S/D) with the shallow well drawing down less than the deep well. The selected analysis settings indicate that across bedding anisotropy is present in the Wittenoom Aquifer surrounding EWPB003.

Table B6: Summary of Aquifer Hydraulic Property Estimates - EWPB003 CRT

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Specific Yield</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – K₂/K₁</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,180</td>
<td>0.000015</td>
<td>0.0013</td>
<td>60</td>
<td>0.003</td>
<td>Neuman (bounded aquifer)</td>
</tr>
</tbody>
</table>

Note: $K_2$ – vertical hydraulic conductivity, $K_R$ – radial hydraulic conductivity
**ALTERNATIVE LOG DATA**

Company: Golder Associates  
Client: FMG  
Project: 1671484  
Location: Western Hub - Elwana  
Test Well: EWPB003  
Test Date: 8/2/2017

**AQUIFER DATA**

Saturated Thickness: 60. m

**WELL DATA**

<table>
<thead>
<tr>
<th>Pumping Wells</th>
<th>X (m)</th>
<th>Y (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB003</td>
<td>484771</td>
<td>7513231</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observation Wells</th>
<th>X (m)</th>
<th>Y (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB003</td>
<td>484771</td>
<td>7513231</td>
</tr>
<tr>
<td>EWPB003D</td>
<td>484784</td>
<td>7513240</td>
</tr>
<tr>
<td>EWPB001S</td>
<td>484784</td>
<td>7513240</td>
</tr>
</tbody>
</table>

**SOLUTION**

Aquifer Model: Unconfined  
Solution Method: Neuman

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>1180. m²/day</td>
</tr>
<tr>
<td>S</td>
<td>1.5E-5</td>
</tr>
<tr>
<td>Kz/Kr</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Figure B6: Hydraulic Analysis Results – EWPB003 CRT
EWPB004 TEST PUMPING AND ANALYSIS

A five day CRT was conducted at EWPB004 commencing on 18/02/2017 at an average pumping rate of 31.9 L/s. Six surrounding bores were monitored throughout the test and are summarised in Table B7. Both the pumped bore and all monitoring bores were completed in the Wittenoom Aquifer, with the majority screened in the Paraburdoo Member of the Wittenoom Formation. Two monitoring wells were not screened in the Paraburdoo Member: EWMB003 (Mount Newman Member, Marra Mamba Iron Formation) and EWMW001S (Bee Gorge Member, Wittenoom Formation).

Based on initial heads, aquifer conditions at EWPB004 and the nearest observation bores were likely unconfined (Table B7). Confined aquifer conditions were considered likely at monitoring bores to the west of EWPB004 (EWMB001S/D) due to the presence of the Mount McRae Shale and Mount Sylvia Formation overlying the intersected Wittenoom Formation strata. Observation bore EWMW005 was also considered likely to have confined conditions due to the Bee Gorge Member (overlying the screened Paraburdoo Member) being described as clay rich in this location.

Two of the six observation bores monitored responded to pumping (Table B8 and Figure B7). Pumping rate, pumped bore drawdown and drawdown from responding observation bores is presented in Figure B8. Key observations from EWPB004 CRT results include:

- As with the EWPB003 CRT, initial standing water levels (as m AHD) illustrated differences in hydraulic head either side of an inferred north west to south east trending dolerite dyke. Bores to the east of the dyke, including the pumped bore and nearby observations bores, had initial heads approximately 12 m higher than those immediately to the west of the dyke (EWMB001S/D). This strong "stepped" change in head over a short distance indicates geological structural control over the local hydrogeological system, consistent with the compartmentalised system proposed in the conceptual hydrogeological model.

- Average flow rate from EWPB004 was 31.9 L/s but short term variations between 28.8 and 35.1 L/s were observed (Figure B11).

- A number of monitoring bores completed in the Wittenoom aquifer did not respond to pumping from EWPB004 (Table B8). This is considered consistent with the conceptual hydrogeological model of the region as bores EWMB001S/D and EWMB009 are separated from the pumped bore by an inferred dolerite dyke (Figure B7). The inferred dolerite dyke is considered to act as a "no flow" boundary due to the lack of drawdown to the west of the dyke and the difference in pre-pumping initial heads. Monitoring bore EWPB005 did not respond to pumping, perhaps due to the distance from the pumped bore (> 3.6 km; Table B8).

- A monitoring bore screened in the Mount Newman Member (Marra Mamba Iron Formation) did respond to pumping (EWMB003; Table B8), validating the inclusion of this stratum in the broader Wittenoom Aquifer.

- Final drawdown in the pumped bore was 1.2 m after five days pumping at ~32 L/s indicating that bore EWPB004 is relatively high yielding (specific capacity of approximately 26.6 L/s/m after five days pumping).

- Recovery monitoring was relatively short (six hours) compared to the duration of pumping (five days). Accordingly monitored bores that did respond to pumping had not fully recovered at the end of monitoring (Table B8).
Figure B8: Pumping rate and selected drawdown results from EWPB004 CRT (commenced 18/2/2017 8:00)
### Table B7: Summary of EWPB004 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting1</th>
<th>Northing1</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB004</td>
<td>Pumped Bore</td>
<td>484995</td>
<td>7513688</td>
<td>18/02/17</td>
<td>156</td>
<td>72 - 156</td>
<td>Paraburdoo Mbr (Wittenoom Fm)</td>
<td></td>
<td>29.6</td>
<td>473.6</td>
<td>Unconfined</td>
</tr>
<tr>
<td>EWMB004</td>
<td></td>
<td>485017</td>
<td>7513674</td>
<td>18/02/17</td>
<td>166</td>
<td>74 - 164</td>
<td>Mt Newman Mbr (Marra Mamba Iron Fm)</td>
<td>Wittenoom Aquifer</td>
<td>29.7</td>
<td>473.7</td>
<td></td>
</tr>
<tr>
<td>EWMB003</td>
<td></td>
<td>485150</td>
<td>7513791</td>
<td>18/02/17</td>
<td>129</td>
<td>112 - 130</td>
<td>Paraburdoo Mbr (Wittenoom Fm)</td>
<td></td>
<td>29.6</td>
<td>473.8</td>
<td></td>
</tr>
<tr>
<td>EWMB001D</td>
<td>Observation Bore</td>
<td>484784</td>
<td>7513240</td>
<td>18/02/17</td>
<td>122.2</td>
<td>104.1 - 122.2</td>
<td>Paraburdoo Mbr (Wittenoom Fm)</td>
<td></td>
<td>47.5</td>
<td>461.9</td>
<td>Confined</td>
</tr>
<tr>
<td>EWMB001S</td>
<td></td>
<td>484784</td>
<td>7513240</td>
<td>18/02/17</td>
<td>88.5</td>
<td>70.5 - 88.5</td>
<td>Bee Gorge Mbr (Wittenoom Fm)</td>
<td></td>
<td>47.6</td>
<td>461.9</td>
<td></td>
</tr>
<tr>
<td>EWMB009</td>
<td></td>
<td>483486</td>
<td>7513615</td>
<td>18/02/17</td>
<td>150</td>
<td>54 - 150</td>
<td>Paraburdoo Mbr (Wittenoom Fm)</td>
<td></td>
<td>27.8</td>
<td>466.2</td>
<td>Unconfined</td>
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<tr>
<td>EWMB005</td>
<td></td>
<td>488598</td>
<td>7512901</td>
<td>18/02/17</td>
<td>104.5</td>
<td>68.5 - 104.5</td>
<td></td>
<td></td>
<td>51.5</td>
<td>479.2</td>
<td>Confined</td>
</tr>
</tbody>
</table>

Note: 1Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

### Table B8: Summary of EWPB004 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>31.9</td>
<td>EWPB004</td>
<td>0</td>
<td>1.2</td>
<td>360</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB004</td>
<td>25.5</td>
<td>0.605</td>
<td>360</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB003</td>
<td>186.2</td>
<td>0.21</td>
<td>360</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB001D</td>
<td>494.8</td>
<td>-0.01 (NR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB001S</td>
<td>494.8</td>
<td>-0.01 (NR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB009</td>
<td>1510.7</td>
<td>-0.09 (NR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB005</td>
<td>3687.9</td>
<td>-0.115 (NR)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the two observation bores that responded to pumping (EWMB003 and EWMB004), presented in Figure B9. A bounded aquifer response was observed in results as a late time change in drawdown slope post 1000 minutes pumping. This observed bounded aquifer response is consistent with the compartmentalised nature of the proposed conceptual hydrogeological model. Aquifer boundaries were incorporated into the solution settings and were kept consistent with surface mapping of strata that were likely to represent aquifer boundaries (MacLeod Member of the Marra Mamba Iron Formation and the Mount McRae Shale). The Theis solution for unconfined aquifers was selected for analysis as it is compatible with applied aquifer boundary settings and is relatively simple compared to other unconfined aquifer models.

Estimates of aquifer hydraulic properties from the EWPB004 CRT are summarised in Table B9. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B9). This said, final drawdown for observation well EWMB003 is over-predicted by approximately 30 cm. Observed drawdown at EWMB003 being lower than predicted by the analysis solution is considered reasonable given that this well is completed with a shorter screen and in a different geological unit to the other two wells that responded to pumping (EWPB004 and EWMB004; Table B7). The lesser fit of EWMB003 may also reflect anisotropic conditions across strike from the Wittenoom Formation to the Marra Mamba Iron Formation in comparison to along strike.

Table B9: Summary of Aquifer Hydraulic Property Estimates - EWPB004 CRT

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – Kz/Kr</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,500</td>
<td>0.04</td>
<td>134</td>
<td>0.1</td>
<td>Theis (bounded aquifer)</td>
</tr>
</tbody>
</table>

Note: Kz – vertical hydraulic conductivity, K_r – radial hydraulic conductivity
Figure B9: Hydraulic Analysis Results – EWPB004 CRT
**EWPB005 TEST PUMPING AND ANALYSIS**

A two day CRT was conducted at EWPB005 commencing on 20/01/2017 at an average pumping rate of 5.9 L/s. Three surrounding bores were monitored throughout the test and are summarised in Table B10. The pumped bore and one of three monitoring bores were completed in the upper Brockman Iron Formation, above the dolerite sill. Lost circulation was experienced during drilling of EWPB005 and no stratigraphic detail about the intersected geology is available. It is inferred that monitoring bore EWD007 is screened in the upper Brockman Iron Formation based on the limited information supplied but this is considered reasonable given that groundwater level response to pumping was observed. Golder considers it likely that monitoring bore EWD019 is screened in the Mineralised Brockman Aquifer although this is based on limited supplied information. Monitoring bore EWD019 is located to the north of the dolerite sill outcrop while the pumped bore and remaining two monitoring bores are to the south of the outcrop. Monitoring bore EWMB006 is screened in the dolerite sill.

Monitoring bores EWD007 and EWD019 are converted diamond core bore holes. Bore EWD007 is completed with blank and slotted (50 mm PVC) but the respective intervals are not known. Bore EWD019 is completed with slotted 50 mm PVC casing from surface but the stratigraphy of the borehole was not supplied. However, commentary was supplied that bore EWD019 was saturated in the Mount Whaleback Shale and Dales Gorge Members (Brockman Iron Formation) suggesting that groundwater levels are likely to be representative of the Mineralised Brockman Aquifer.

Initial depth to water measurements prior to pumping were supplied for the pumped bore and monitoring bore EWD007 only. Based on these initial heads, aquifer conditions at EWPB005 and EWD007 were likely unconfined (Table B10). Aquifer conditions at the remaining observation bores (EWMB006 and EWD019) are unclear due to lack of depth to groundwater data but are considered likely to be unconfined, particularly at EWMB006 (based on the bore log).

One of the three observation bores monitored responded to pumping (Table B11 and Figure B10). Pumping rate, pumped bore drawdown and drawdown from responding observation bores is presented in Figure B11. Key observations from EWPB005 CRT results include:

- Initial heads between the production bore and EWD007 were similar suggesting that EWD007 is screened in the upper Brockman Iron Formation.
- Average flow rate from EWPB005 was 5.9 L/s but short term variations between 5.6 and 6.4 L/s were observed (Figure B11).
- Two of three monitoring bores did not respond to pumping from EWPB005 (Table B11). This is considered consistent with the conceptual hydrogeological model of the region with respect to the Joffre Member dolerite sill acting as an aquitard. Monitoring bore EWMB006 is completed in the Joffre Member dolerite sill and is not expected to respond to pumping. Bore EWD019 is to the north of the dolerite sill with respect to the other monitored bores and would be expected to be hydraulically isolated from them for this reason (Figure B10).
- Final drawdown in the pumped bore was 12.34 m after two days pumping at ~5.9 L/s indicating that bore EWPB005 is relatively low yielding (specific capacity of approximately 0.5 L/s/m after two days pumping).
- Recovery monitoring was relatively short (five hours) compared to the duration of pumping (two days). At the end of recovery monitoring the pumped bore had essentially fully recovered and EWD007 had recovered 88% of the observed final drawdown (Table B11).

---

1 It is noted in Western Hub Basis of Study Report (Golder Report 1671484-001-R-Rev0) that a dolerite sill is known to occur in the J3 band of the Joffre Member (Brockman Iron Formation). Where present this dolerite sill is responsible for significant head differences between upper and lower Brockman Iron Formation members on either side (north or south) of the sill.
LEGEND
- Pumped Bore and Final Drawdown
- Observation Bore and Final Drawdown
- Dolerite

NOTES
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

PROJECT
FORTESCUE METALS GROUP

SUBJECT
WESTERN HUB - HYDROGEOLOGICAL CONCEPTUAL MODEL

PARAMETERS
EWPB005 CRT FINAL DRAWDOWN (2 DAYS AT 5.9 L/S)

CONSULTANT

OUTPUT

PROOFREAD

APPROVED

PROJECT NO.
147641484

CONTROL
002 R

REV
2

FILE
B10
Figure B11: Pumping rate and selected drawdown results from EWPB005 CRT (commenced 20/1/2017 11:00)
### APPENDIX B
Test Pumping Analysis

#### Table B10: Summary of EWPB005 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB005</td>
<td>Pumped Bore</td>
<td>483001</td>
<td>7511832</td>
<td>103.0</td>
<td>61 - 103</td>
<td>Joffre Mbr (Brockman Iron Fm)</td>
<td>Upper Brockman Iron Fm</td>
<td>63.3</td>
<td>453.1</td>
<td>Unconfined</td>
<td></td>
</tr>
<tr>
<td>EWD007</td>
<td>Observation Bore</td>
<td>482998</td>
<td>7511821</td>
<td>116.0</td>
<td>No Information</td>
<td>Joffre Mbr – <em>above sill</em> (Brockman Iron Fm)</td>
<td>Upper Brockman Iron Fm*</td>
<td>63.9</td>
<td>452.7</td>
<td>Unconfined</td>
<td></td>
</tr>
<tr>
<td>EWMB006</td>
<td>Observation Bore</td>
<td>483036</td>
<td>7511925</td>
<td>100.0</td>
<td>76 - 100</td>
<td>J6 Dolerite Sill (Joffre Mbr, Brockman Iron Fm)</td>
<td>J6 dolerite sill</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EWD019</td>
<td></td>
<td>482998</td>
<td>7512200</td>
<td>165.4</td>
<td>0 - 165.4</td>
<td>Unclear - supplied information states &quot;saturated in Whaleback and Dales&quot;</td>
<td>Mineralised Brockman Aquifer*</td>
<td></td>
<td></td>
<td>Unclear but likely unconfined</td>
<td></td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum, *inferred from limited supplied information

#### Table B11: Summary of EWPB005 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>5.9</td>
<td>EWPB005</td>
<td>0</td>
<td>12.34</td>
<td>300</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWD007</td>
<td>12</td>
<td>0.72</td>
<td>300</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB006</td>
<td>100</td>
<td>-0.038 (NR)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWD019</td>
<td>368</td>
<td>-0.01 (NR)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the observation bore that responded to pumping (EWD007), presented in Figure B12. A delayed yield response was evident in EWD007 drawdown results as a reduction in drawdown slope post 100 minutes pumping (Figure B12). A “no flow” aquifer boundary was incorporated into analysis settings in the location of the Joffre Member dolerite sill outcrop due to the proximity of the pumped bore to the sill (Figure B10). The Neuman solution for unconfined aquifers was selected for analysis as this solution is compatible with bounded aquifers and allows for delayed yield.

Estimates of aquifer hydraulic properties from the EWPB005 CRT are summarised in Table B12. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B12). This said, drawdown for the pumped bore is substantially under-predicted (Figure B12). This under-prediction of production bore drawdown is considered likely due to additional well losses experienced at the production bore. Caution is considered reasonable with respect to hydraulic analysis of EWPB005 CRT results due to the uncertainties around test bore completions and stratigraphy described above.

**Table B12: Summary of Aquifer Hydraulic Property Estimates - EWPB005 CRT**

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Specific Yield</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – K₂/Kₚ</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>0.005</td>
<td>0.07</td>
<td>52</td>
<td>0.1</td>
<td>Neuman (bounded aquifer)</td>
</tr>
</tbody>
</table>

Note: K₂ – vertical hydraulic conductivity, Kₚ – radial hydraulic conductivity
WELL TEST ANALYSIS

Data Set: J:\\..\EWPB005_CRT_Neuman.aqt
Date: 03/10/17
Time: 08:18:45

PROJECT INFORMATION

Company: Golder Associates
Client: FMG
Project: 1671484
Location: Western Hub - Eliwana
Test Well: EWPB005
Test Date: 20/1/2017

AQUIFER DATA

Saturated Thickness: 52. m

WELL DATA

<table>
<thead>
<tr>
<th>Pumping Wells</th>
<th>Observation Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Name</td>
<td>X (m)</td>
</tr>
<tr>
<td>EWPB005</td>
<td>483001</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SOLUTION

Aquifer Model: Unconfined
Solution Method: Neuman
T = 300. m²/day
S = 0.005
Sy = 0.07
Kz/Kr = 0.1

Figure B12: Hydraulic Analysis Results – EWPB005 CRT
EWPB006 TEST PUMPING AND ANALYSIS

A three day CRT was conducted at EWPB006 commencing on 13/02/2017 at an average pumping rate of 31 L/s. Five surrounding bores were monitored throughout the test and are summarised in Table B13. The pumped bore and all monitoring bores were completed in the Wittenoom Aquifer. It is noted that limited stratigraphic detail was provided for two RC drillholes monitored during the test (EW1870 and EW1871). The majority of bores were completed in the Paraburdoo Member (Wittenoom Formation) but the two RC drillholes were completed in strata underlying the Paraburdoo Member: EW1870 (Mt Newman Member, Marra Mamba Iron Formation) and EW1871 (West Angela Member, Wittenoom Formation). It is noted that while EW1870 is completed in the Mt Newman Member it is substantially shallower than nearby bores completed in the stratigraphically overlying Paraburdoo Member (Wittenoom Formation). This is due to the southward dipping nature of the Hammersley Group in the vicinity of EWPB006 and monitoring bore EW1870 located to the north of the pumped bore (across strike), thus in a different and older stratum while having a shallower completion.

As outlined above, monitoring bores EW1870 and EW1871 are converted RC bore holes. Bore EW1870 is completed with nominal 50 mm PVC blank and slotted casing, summarised in Table B13, but the completion of EW1871 is unclear. It is anticipated that EW1871 has the same nominal 50 mm PVC blank and slotted casing completion but the respective intervals were not supplied. It is Golders understanding that as converted open RC drillholes there is no gravel pack or seal of the bore annulus.

Aquifer conditions at the pumped bore and monitoring bores are considered to be likely unconfined although this is based on limited information at sites EW1870 and EW1871 (Table B13).

Two of five observation bores monitored responded to pumping (Table B14 and Figure B13). Pumping rate, pumped bore drawdown and drawdown from responding observation bores is presented in Figure B14. Key observations from EWPB006 CRT results include:

- Initial heads at the production bore and nearby monitoring bores were similar although monitoring bore EWMB008 was slightly higher and may have been influenced by rainfall recharge prior to testing as groundwater levels were recovering prior to commencing test. It is noted that the two converted RC drillholes had similar initial heads to the pumped bore.

- To the east of the pumped bore two monitoring wells had higher initial heads than the pumped bore: EWMB009 was around 8 m higher (2090 m from the pumped bore) and EWMB004 was around 15 m higher (3621 m from the pumped bore). For monitoring bore EWMB004 (located furthest to the east of the pumped bore) the difference in initial heads is interpreted as confirmation of an inferred dolerite dyke acting as a “no flow” boundary (Figure B13). For monitoring bore EWMB009 the observed difference in initial heads with the pumping bore is considered likely due to another subsurface geological structure acting as a “no flow” boundary, the location and nature of which is currently undescribed.

- Average flow rate from EWPB006 was 31 L/s but short term variations between 30.5 and 31 L/s were observed but were generally between 30.9 and 31 L/s (Figure B11).

- A number of monitoring bores completed in the Wittenoom Aquifer did not respond to pumping from EWPB006 (Table B14). For the two monitoring bores at a relatively far distance to the east of the pumping bore (EWMB004 and EWMB009) the lack of response could be due to distance but is also consistent with the observed difference in initial heads indicating the possible presence geological structures acting as “no flow” aquifer boundaries between these bores and the pumped bore (consistent with the compartmentalised nature of the conceptual hydrogeological model).

- Monitoring bore EW1870 is located 129 m to the north of the pumped bore and did not respond to pumping. The lack of drawdown response in this monitoring bore is considered likely due to it being completed in the Mt Newman Member (Marra Mamba Iron Formation) and across-strike anisotropy between Wittenoom Formation strata and the Mt Newman Member likely restricting drawdown. The conceptual hydrogeological model includes the Mt Newman Member in the Wittenoom Aquifer,
supported by EWPB004 test pumping results and Golders understanding of the regional hydrogeological setting. It is possible with longer pumping time or increased drawdown stress (higher pumping rate at the pumped bore) that EW1870 would respond to pumping from EWPB006.

- Final drawdown in the pumped bore was 5.33 m after three days pumping at 31 L/s indicating that bore EWPB006 is relatively moderately yielding (specific capacity of approximately 5.8 L/s/m after three days pumping).

- Recovery monitoring was relatively short (three hours) compared to the duration of pumping (three days). At the end of recovery monitoring the pumped bore had 94% recovered, EWMB008 had 77% recovered and EW1871 had recovered only 12% of the observed final drawdown (Table B14).
Figure B14: Pumping rate and selected drawdown results from EWPB006 CRT (commenced 13/2/17 10:00)
## APPENDIX B
### Test Pumping Analysis

### Table B13: Summary of EWPB006 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB006</td>
<td>Pumped Bore</td>
<td>481396</td>
<td>7513603</td>
<td>13/02/17 10:00</td>
<td>78.5</td>
<td>30.5 - 78.5</td>
<td>Paraburdoo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>24.5</td>
<td>458.3</td>
<td>Unconfined</td>
</tr>
<tr>
<td>EWMB008</td>
<td>Observation Bore</td>
<td>481384</td>
<td>7513589</td>
<td></td>
<td>62.0</td>
<td>32 - 62</td>
<td>Wittenoom Aquifer</td>
<td></td>
<td>24.0</td>
<td>458.8</td>
<td></td>
</tr>
<tr>
<td>EW1871</td>
<td>Observation Bore</td>
<td>481304</td>
<td>7513589</td>
<td></td>
<td>114.0</td>
<td>Unclear</td>
<td>West Angela Mbr (Wittenoom Fm)*</td>
<td></td>
<td>22.0</td>
<td>458.4*</td>
<td>Unclear but likely unconfined</td>
</tr>
<tr>
<td>EW1870</td>
<td>Observation Bore</td>
<td>481438</td>
<td>7513726</td>
<td></td>
<td>36.0</td>
<td>30 - 36</td>
<td>Mt Newman Mbr (Marra Mamba Iron Fm)*</td>
<td></td>
<td>23.4</td>
<td>458.2*</td>
<td></td>
</tr>
<tr>
<td>EWMB009</td>
<td>Observation Bore</td>
<td>483486</td>
<td>7513615</td>
<td></td>
<td>150.0</td>
<td>54 - 150</td>
<td>Paraburdoo Mbr (Wittenoom Fm)</td>
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<td>27.9</td>
<td>466.1</td>
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</tr>
<tr>
<td>EWMB004</td>
<td>Observation Bore</td>
<td>485017</td>
<td>7513674</td>
<td></td>
<td>166.0</td>
<td>74 - 164</td>
<td></td>
<td></td>
<td>29.9</td>
<td>473.6</td>
<td></td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum, *Inferred from limited supplied information

### Table B14: Summary of EWPB006 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>31</td>
<td>EWPB006</td>
<td>0</td>
<td>5.33</td>
<td>180</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB008</td>
<td>19</td>
<td>1.46</td>
<td>180</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EW1871</td>
<td>93</td>
<td>0.57</td>
<td>180</td>
<td>0.5</td>
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<tr>
<td></td>
<td></td>
<td>EW1870</td>
<td>129</td>
<td>-0.06 (NR)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB009</td>
<td>2090</td>
<td>-0.04 (NR)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB004</td>
<td>3621</td>
<td>-0.11 (NR)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the two observation bores that responded to pumping (EWD008 and EW1871), presented in Figure B15. Some complexity was observed in EWPB006 CRT results with late time drawdown slope decreasing in both the pumped bore and EWMB008 post 1000 minutes pumping. It is also noted that monitoring bore EW1871 did not appreciably draw down until after 100 minutes pumping (a longer time than may be anticipated based on the early time data from monitoring bore EWMB008). It is considered that the observed data is generally consistent with an unconfined aquifer response showing delayed yield. Drawdown results suggest that the lower monitored unit of the Wittenoom Aquifer (West Angela Member; EW1871) took longer to respond. Early time drawdown in the pumped bore and EWMB008 was consistent with delayed yield while drawdown in EW1871 was more consistent with unconfined aquifer storage. The Neuman solution for unconfined aquifers was selected for analysis as this solution allows for delayed yield.

Estimates of aquifer hydraulic properties from the EWPB006 CRT are summarised in Table B15. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data given the complexity in drawdown data outlined above (Figure B15). The general under-prediction of pumped bore drawdown in the solution is attributed to well losses. A number of alternative analysis solutions were investigated but they did not accommodate the complexity of observed drawdown as well as the Neuman solution. Given the complexity of drawdown results and the limited number of responding monitoring bores to test pumping it is possible that improved understanding of hydraulic response and hydraulic properties in the vicinity of EWPB006 may be achieved through future pumping at higher rates or more extended periods than currently undertaken.

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Specific Yield</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – $K_z/K_R$</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>850</td>
<td>0.0025</td>
<td>0.07</td>
<td>54</td>
<td>0.1</td>
<td>Neuman</td>
</tr>
</tbody>
</table>

Note: $K_z$ – vertical hydraulic conductivity, $K_R$ – radial hydraulic conductivity
## WELL TEST ANALYSIS

Data Set: J:\..\EWPB006_CRT_Neuman.aqt
Date: 03/10/17
Time: 12:01:45

## PROJECT INFORMATION

Company: Golder Associates
Client: FM3
Project: 1671484
Location: Western Hub - Eliwana
Test Well: EWPB006
Test Date: 13/2/2017

## AQUIFER DATA

Saturated Thickness: 54. m

## WELL DATA

<table>
<thead>
<tr>
<th>Pumping Wells</th>
<th>Observation Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Name</td>
<td>X (m)</td>
</tr>
<tr>
<td>EWPB006</td>
<td>481396</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## SOLUTION

Aquifer Model: Unconfined
T = 850. m²/day
Sy = 0.07

Solution Method: Neuman
S = 0.0025
Kz/Kr = 0.1

---

Figure B15: Hydraulic Analysis Results – EWPB006 CRT
EWPB007 TEST PUMPING AND ANALYSIS

A five day CRT was conducted at EWPB007 commencing on 6/02/2017 at an average pumping rate of 6.1 L/s. Five surrounding bores were monitored throughout the test and are summarised in Table B16. The pumped bore and one monitoring bore (EWD019) were completed in the Mineralised Brockman Aquifer. Two monitoring bores (EWPB005 and EWD007) were completed above the dolerite sill in the Joffre Member (Brockman Iron Formation) which partitions the upper Mineralised Brockman Aquifer. One monitoring bore was completed in the dolerite sill within the Joffre Member (EWMB006) and one bore did not have stratigraphy data supplied (Dirty Nick).

Monitoring bores EWD007 and EWD019 are converted diamond core bore holes. Bore EWD007 is completed with blank and slotted (50 mm PVC) casing but the respective intervals are not known. Bore EWD019 is completed with slotted 50 mm PVC casing from surface but the stratigraphy of the borehole was not supplied. However, commentary was supplied that bore EWD019 was saturated in the Mount Whaleback Shale and Dales Gorge Members (Brockman Iron Formation) suggesting that groundwater levels are likely to be representative of the Mineralised Brockman Aquifer.

Initial depth to water measurements prior to pumping were supplied for all test bores aside from EWD019. Aquifer conditions were considered likely unconfined for all bores although this is based on limited information at bores EWD007, EWD019 and Dirty Nick (Table B16).

None of the five observation bores monitored responded to pumping (Table B17 and Figure B16). Pumping rate and pumped bore drawdown are presented in Figure B17. Key observations from EWPB007 CRT results include:

- Initial head at monitoring bore Dirty Nick was similar to that of the production bore, suggesting that this monitoring bore is completed in the Mineralised Brockman Aquifer. The other bore completed in the Mineralised Brockman Aquifer (EWD019) did not have an initial head measurement supplied. Initial heads in bores completed in the Mineralised Brockman Aquifer were between 3.6 m to 4.4 m higher than those to the south completed above the dolerite sill (EWPB005 and EWD007). The difference in heads either side of the dolerite sill (north/south) is consistent with the conceptual hydrogeological model in which this sill is an aquitard. The monitoring bore completed in the dolerite sill (EWMB006) had an initial head in between those bores completed either side of the sill.

- Average flow rate from EWPB007 was 6.1 L/s but short term variations between 5.95 and 6.1 L/s were observed (Figure B17).

- All monitoring bores did not respond to pumping. This is to be expected for those bores to the south of the pumping bore, completed above or in the dolerite sill (EWPB005, EWMB006 and EWD007). For the remaining observation bores it is considered possible that the lack of response to pumping was due to relatively low aquifer transmissivity as indicated by pumped bore data (discussed further below).

- Final drawdown in the pumped bore was 14.7 m after five days pumping at 6.1 L/s indicating that bore EWPB007 is relatively low yielding (specific capacity of approximately 0.4 L/s/m after five days pumping).

- Drawdown in the pumped bore was erratic during different stages of the test suggesting poor control of pumping rate (recharge or recirculation effects are considered unlikely due to the depth to water at the pumped bore). This said, variations in flow rate that could have resulted in the observed erratic drawdown were not captured in the supplied pumping rate data.

- Recovery monitoring was relatively short (four hours at the pumped bore) compared to the duration of pumping (five days). At the end of recovery monitoring the pumped bore had recovered about 91% of final drawdown (Table B17).
Figure B17: Pumping rate and selected drawdown results from EWPB007 CRT (commenced 6/02/17 10:00)
## Table B16: Summary of EWPB007 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting 1</th>
<th>Northing 1</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPB007</td>
<td>Pumped Bore</td>
<td>482605</td>
<td>7512508</td>
<td>6/02/17 10:00</td>
<td>179.5</td>
<td>131.5 - 179.5</td>
<td>Whaleback Shale Mbr and and Dales Gorge Mbr (Brockman Iron Fm)</td>
<td>Mineralised Brockman Aquifer</td>
<td>90.8</td>
<td>457.1</td>
<td>Unconfined</td>
</tr>
<tr>
<td>Dirty Nick</td>
<td>Observation Bore</td>
<td>482555</td>
<td>7512310</td>
<td>150.0</td>
<td>150</td>
<td>72 - 150</td>
<td>No Data</td>
<td>No Data</td>
<td>72.8</td>
<td>456.9</td>
<td>Likely unconfined*</td>
</tr>
<tr>
<td>EWD019</td>
<td>Observation Bore</td>
<td>482998</td>
<td>7512200</td>
<td>6/02/17 10:00</td>
<td>165.4</td>
<td>0 - 165.4</td>
<td>Unclear - supplied information states &quot;saturated in Whaleback and Dales&quot;</td>
<td>Mineralised Brockman Aquifer*</td>
<td>No Data</td>
<td>No Data</td>
<td>Likely unconfined*</td>
</tr>
<tr>
<td>EWM006</td>
<td>Observation Bore</td>
<td>483036</td>
<td>7511925</td>
<td>100.0</td>
<td>100</td>
<td>76 - 100</td>
<td>J6 Dolerite Sill</td>
<td>Above Mineralised Brockman Aquifer</td>
<td>69.4</td>
<td>454.6</td>
<td>Unconfined</td>
</tr>
<tr>
<td>EWPB005</td>
<td>Observation Bore</td>
<td>483001</td>
<td>7511832</td>
<td>103.0</td>
<td>103</td>
<td>61 - 103</td>
<td>Joffre Mbr (Brockman Iron Fm)</td>
<td>Upper Brockman Iron Formation (EWD007*)</td>
<td>63.1</td>
<td>453.3</td>
<td>Unconfined</td>
</tr>
<tr>
<td>EWD007</td>
<td>Observation Bore</td>
<td>482998</td>
<td>7511821</td>
<td>116.0</td>
<td>116</td>
<td>0.0</td>
<td>Joffre Mbr – &quot;above sill&quot; (Brockman Iron Fm)</td>
<td>63.9</td>
<td>452.7</td>
<td>Likely unconfined*</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum, *inferred from limited supplied information.
## Table B17: Summary of EWPB007 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>6.1</td>
<td>EWPB007</td>
<td>0</td>
<td>14.7</td>
<td>240</td>
<td>1.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dirty Nick</td>
<td>204</td>
<td>0.02 (NR)</td>
<td>210</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWD019</td>
<td>499</td>
<td>0.09 (NR)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWMB006</td>
<td>725</td>
<td>0 (NR)</td>
<td>1380</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWPB005</td>
<td>783</td>
<td>-0.02 (NR)</td>
<td>1380</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWD007</td>
<td>792</td>
<td>-0.02 (NR)</td>
<td>1380</td>
<td>-0.52</td>
</tr>
</tbody>
</table>

*Note: NR = No response to pumping, L/s – litres per second, min – minutes.*
Hydraulic analysis was conducted of data from the pumped bore only as this was the only bore to respond to pumping (presented in Figure B18). The Cooper-Jacob “straight-line” solution was selected due to data being from the pumped bore only. Derived aquifer hydraulic property estimates are limited to transmissivity due to the lack of monitoring bore response and are considered indicative only, given the erratic nature of the pumped bore drawdown. Estimated transmissivity is presented in Table B18.

Table B18: Summary of Aquifer Hydraulic Property Estimates - EWPB007 CRT

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity*</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – Kv/Kr</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>-</td>
<td>54</td>
<td>-</td>
<td>Cooper-Jacob</td>
</tr>
</tbody>
</table>

Note: Kv – vertical hydraulic conductivity, Kr – radial hydraulic conductivity. *Storativity estimate could not be calculated as observation bores did not respond to pumping.

It is considered likely based on pumping bore drawdown data that transmissivity is relatively low compared to other production bores tested as part of the Western Mining Hub program. Based on a transmissivity of 95 m²/day, 1 cm drawdown could be expected at radial distances of between 230 m to 680 m based on storativity of between 0.1 and 0.01 (in an infinite, radial flow, unconfined aquifer). Based on this limited analysis it is possible that observation bores Dirty Nick and EWD019 (located between 200 m and 500 m from the pumped bore) did not respond to pumping from EWPB007 due to aquifer hydraulic properties and may still be screened in the same aquifer.
Figure B18: Hydraulic Analysis Results – EWPB007 CRT

Note: Estimates of storativity from pumped bore analysis are automatically generated and are not considered reliable or valid.
FPPB001 TEST PUMPING AND ANALYSIS

A three day CRT was conducted at FPPB001 commencing on 2/03/2017 at an average pumping rate of 29.9 L/s. Three surrounding bores were monitored throughout the test and are summarised in Table B19. The pumped bore and one monitoring bore (FFMB001) were completed in the Wittenoom Aquifer. Both bores completed in the Wittenoom Aquifer were screened in the Paraburdo Member (Wittenoom Formation). Two monitoring bores (Grunters and Flying Fish) did not have stratigraphy or bore completion data.

Aquifer conditions were considered likely unconfined for the pumped bore and FFMB001. Observation bore Flying Fish was considered likely unconfined due to its proximity to FPPB001 and FFMB001 (216 m radial distance from the pumped bore). Insufficient information was available for monitoring bore Grunters to infer likely aquifer conditions (Table B19).

One of three observation bores monitored responded to pumping (Table B20 and Figure B19). Pumping rate and pumped bore drawdown are presented in Figure B20. Key observations from FPPB001 CRT results include:

- Initial heads at the pumped bore and nearby monitoring bores (FFMW001 and Flying Fish) were similar, suggesting that these bores are completed in the same formation of the Wittenoom Aquifer. Monitoring bore Grunters (to the east of the pumped bore) had initial head around 2.2 m higher than the pumped bore and is considered more likely to reflect the head of an adjacent aquifer compartment (consistent with the conceptual hydrogeological model) rather than a westward hydraulic gradient.

- Average flow rate from FPPB001 was 29.9 L/s but short term variations between 29.5 and 30 L/s were observed (Figure B20).

- One monitoring bore clearly responded to pumping (FFMB001) while the remaining two monitoring bores (Flying Fish and Grunters) did not. The final drawdowns observed from FPPB001 CRT bores are consistent with a compartmentalised aquifer (in keeping with the conceptual hydrogeological model). Golder interprets that the pumped bore and FFMB001 are likely installed in the same compartment and Grunters installed in an adjacent compartment to the east. Initial heads indicated that monitoring bore Flying Fish was likely installed in the same aquifer compartment as the pumped bore and FFMB001 but Flying Fish did not demonstrate a clear drawdown response during pumping.

- Final drawdown in the pumped bore was 11.05 m after three days pumping at 29.9 L/s indicating that bore FPPB001 is relatively moderately yielding (specific capacity of approximately 2.7 L/s/m after three days pumping).

- Recovery monitoring was conducted for 22 hours following three days pumping. At the end of recovery monitoring the pumped bore had recovered about 62% of final drawdown and FFMB001 had recovered 61% (Table B20). This level of recovery suggests a partial dewatering of the pumped aquifer compartment.
**NOTES**

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

**LEGEND**

- Pumped Bore and Final Drawdown
- Observation Bore and Final Drawdown
- Jeerinnah Formation
- Mount MaCrae Shale
- Dolerite
- Yandicoogina Shale

**PROJECT**

FORTESCUE METALS GROUP

WESTERN HUB - HYDROGEOLOGICAL MODEL

**CONSULTANT**

Golder Associates

**YEAR**

2017

**PROJECT NO.**

147041484

**CONTROL**

002 R

**REV.**

2

**FIGURE**

B19

**FILE SIZE**

J:\Hydro\2016\1671484 - FMG - Western Hub - Dewatering and Water Supply Assessment\Analysis\GIS analysis\Test Pumping MXD\Sketch_TestPumping_FFPB001CRT.mxd

**LEGEND**

- Pumped Bore and Final Drawdown
- Observation Bore and Final Drawdown
- Jeerinnah Formation
- Mount MaCrae Shale
- Dolerite
- Yandicoogina Shale

**IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:** ISO A3

**SCALE**

1:20,000
Figure B20: Pumping rate and selected drawdown results from FFPB001 CRT (commenced 2/03/17 9:00)
### Table B19: Summary of FFPB001 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFPB001</td>
<td>Pumped Bore</td>
<td>522380</td>
<td>7511026</td>
<td>2/03/17</td>
<td>99.5</td>
<td>57.5 – 99.5</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>15.7</td>
<td>549.7</td>
<td>Unconfined</td>
</tr>
<tr>
<td>FFMB001</td>
<td>Observation Bore</td>
<td>522377</td>
<td>7511010</td>
<td>2/03/17 9:00</td>
<td>105.0</td>
<td>88 – 105</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>15.3</td>
<td>549.8</td>
<td></td>
</tr>
<tr>
<td>Flying Fish</td>
<td>Observation Bore</td>
<td>522583</td>
<td>7510953</td>
<td></td>
<td>100.0</td>
<td>No stratigraphy or bore completion available supplied</td>
<td></td>
<td></td>
<td>13.3</td>
<td>549.7</td>
<td>Likely unconfined*</td>
</tr>
<tr>
<td>Grunters</td>
<td>Observation Bore</td>
<td>523400</td>
<td>7511600</td>
<td></td>
<td>48.0</td>
<td></td>
<td></td>
<td></td>
<td>12.0</td>
<td>551.9</td>
<td>No Data</td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum, *Inferred from limited supplied information

### Table B20: Summary of FFPB001 Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>29.9</td>
<td>FFPB001</td>
<td>0</td>
<td>11.05</td>
<td>1320</td>
<td>4.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFMB001</td>
<td>17</td>
<td>10.65</td>
<td></td>
<td>4.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flying Fish</td>
<td>216</td>
<td>0.05 (NR)</td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grunters</td>
<td>1171</td>
<td>0.02 (NR)</td>
<td></td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: PR = possible response to pumping, NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the monitoring bore that responded to pumping (FFMB001), presented in Figure B21. A bounded aquifer response was observed in FFPB001 CRT results, with drawdown slope increasing after around 10 minutes pumping (Figure B21). The Theis solution for unconfined aquifers was selected for analysis as it is compatible with bounded aquifer settings and is relatively simple. The FFPB001 CRT data was analysed as a strip aquifer 400 m wide based on iteration of boundary settings and is generally consistent with spacing of dolerite dyke features in the region of the CRT.

Estimates of aquifer hydraulic properties from the FFPB001 CRT are summarised in Table B21. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B21).

**Table B21: Summary of Aquifer Hydraulic Property Estimates – FFPB001 CRT**

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – Kz/Kr</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,330</td>
<td>0.001</td>
<td>89.7</td>
<td>1</td>
<td>Theis (bounded aquifer)</td>
</tr>
</tbody>
</table>

*Note: Kz – vertical hydraulic conductivity, Kr – radial hydraulic conductivity*
Figure B21: Hydraulic Analysis Results – FFPB001 CRT
FFPB002 TEST PUMPING AND ANALYSIS

A three day CRT was conducted at FFPB002 commencing on 25/02/2017 at an average pumping rate of 32 L/s. Three surrounding bores were monitored throughout the test and are summarised in Table B22. The pumped bore and all monitoring bores were completed in the Wittenoom Aquifer, although in different formations. The pumped bore and the nearest observation bore (FFMB002) were screened in the Paraburdoo Member (Wittenoom Formation) while the two remaining observation bores to the west (FFPB003 and FFMB003) were completed in the Mt Newman Member (Marra Mamba Iron Formation).

Aquifer conditions were considered likely unconfined for all monitored bores (Table B22).

One of three observation bores monitored responded to pumping (Table B23 and Figure B22). Pumping rate and pumped bore drawdown are presented in Figure B23. Key observations from FFPB002 CRT results include:

- Initial heads at the pumped bore and monitoring bore FFMB002 were similar both in terms of elevation and groundwater depth below ground. By contrast, monitoring bores to the west (FFPB003 and FFMB003) had much lower initial heads, approximately 51 m lower than the pumped bore. This strongly “stepped” change in initial heads over a relatively short distance (between 530 and 550 m radially from the pumped bore) is consistent with the compartmentalised nature of the conceptual hydrogeological model.

- Average flow rate from FFPB002 was 32 L/s but short term variations between 30.9 and 32.5 L/s were observed at the start of pumping (Figure B23).

- One monitoring bore clearly responded to pumping (FFMB002) while the other two monitoring bores (FFPB003 and FFMB003) did not. The observed final drawdown is consistent with a compartmentalised aquifer (in keeping with the conceptual hydrogeological model) with the pumped bore and FFMB002 installed in the same compartment and remaining monitoring bores (FFPB003 and FFMB003) installed in an adjacent compartment to the west. The two aquifer compartments are interpreted to be separated by dolerite dyke features based on surface geology data.

- Final drawdown in the pumped bore was 2.1 m after three days pumping at 32 L/s indicating that bore FFPB002 is relatively high yielding (specific capacity of approximately 15.2 L/s/m after three days pumping).

- Recovery monitoring was conducted for 22 hours following three days pumping. At the end of recovery monitoring the pumped bore had recovered about 63% of final drawdown and FFMB002 had recovered 56% (Table B23). This level of recovery suggests a partial dewatering of the pumped aquifer compartment.
LEGEND

- Pumped Bore and Final Drawdown
- Observation Bore and Final Drawdown
- Jeerinnah Formation

Mount MaCrae Shale
Dolerite
Yandicoogina Shale

NOTES
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

0 290 580 METRES

CONSULTANT

FOURTEEN METRES GROUP

PROJECT
WESTERN HUB - HYDROGEOLOGICAL CONCEPTUAL MODEL

ADDITIONAL INFORMATION
- PROJECT NO: FPPB002 CRT - FINAL DRAWDOWN (3 DAYS @ 32 L/S)
- FLOOR: B22

904x112 PROJECT TITLE
904x72 CONSULTANT
904x33 PROJECT NO.
646x73 LEGEND
646x51 CONTROL
646x29 REV.
646x0 FIGURE

"002 R 2"
Figure B23: Pumping rate and selected drawdown results from FFPB002 CRT (commenced 25/02/17 9:00)
### APPENDIX B
#### Test Pumping Analysis

**Table B22: Summary of FFPB002 CRT Bores**

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting1</th>
<th>Northing1</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFPB002</td>
<td>Pumped Bore</td>
<td>516324</td>
<td>7509684</td>
<td>25/02/17 9:00</td>
<td>100</td>
<td>56 - 100</td>
<td>Paraburdo Mbr (Wittenoom Fm)</td>
<td>Wittenoom Aquifer</td>
<td>9.0</td>
<td>542.6</td>
<td>Unconfined</td>
</tr>
<tr>
<td>FFMB002</td>
<td>Observation Bore</td>
<td>516326</td>
<td>7509668</td>
<td></td>
<td>100</td>
<td>58 - 100</td>
<td>Mt Newman Fm (Marra Mamba Iron Fm)</td>
<td></td>
<td>8.5</td>
<td>543.2</td>
<td></td>
</tr>
<tr>
<td>FFMB003</td>
<td>Observation Bore</td>
<td>515799</td>
<td>7509606</td>
<td></td>
<td>117</td>
<td>51 - 117</td>
<td></td>
<td></td>
<td>55.7</td>
<td>491.6</td>
<td></td>
</tr>
<tr>
<td>FFPB003</td>
<td>Observation Bore</td>
<td>515779</td>
<td>7509606</td>
<td></td>
<td>98</td>
<td>68 - 98</td>
<td></td>
<td></td>
<td>55.3</td>
<td>491.6</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

**Table B23: Summary of FFPB002 Drawdown Results**

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>32</td>
<td>FFPB002</td>
<td>0</td>
<td>2.11</td>
<td>1320</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFMB002</td>
<td>16</td>
<td>1.71</td>
<td></td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFMB003</td>
<td>531</td>
<td>-0.31 (NR)</td>
<td></td>
<td>-0.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFPB003</td>
<td>550</td>
<td>-0.33 (NR)</td>
<td></td>
<td>-0.425</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the monitoring bore that responded to pumping (FFMB002), presented in Figure B24. A bounded aquifer response was observed in FFPB002 CRT results, with drawdown slope increasing after around 30 minutes pumping (Figure B24). The Theis solution for unconfined aquifers was selected for analysis as it is compatible with bounded aquifer settings and is relatively simple. The FFPB002 CRT data was analysed as a strip aquifer 260 m wide based on iteration of boundary settings and is generally consistent with spacing of dolerite dyke features in the region of the CRT.

Estimates of aquifer hydraulic properties from the FFPB002 CRT are summarised in Table B24. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B24).

**Table B24: Summary of Aquifer Hydraulic Property Estimates – FFPB002 CRT**

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – Kz/Kr</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,460</td>
<td>0.009</td>
<td>110</td>
<td>1</td>
<td>Theis (bounded aquifer)</td>
</tr>
</tbody>
</table>

Note: Kz – vertical hydraulic conductivity, Kr – radial hydraulic conductivity
Figure B24: Hydraulic Analysis Results – FFPB002 CRT

WELL TEST ANALYSIS
Data Set: J:\,...\FFPB002_CRT_TheisBounded.agt
Date: 03/14/17  Time: 15:02:51

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Western Hub - Flying Fish
Test Well: FFPB002
Test Date: 25/02/2017

WELL DATA

<table>
<thead>
<tr>
<th>Well Name</th>
<th>X (m)</th>
<th>Y (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFPB002</td>
<td>516323.8</td>
<td>7509684.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Well Name</th>
<th>X (m)</th>
<th>Y (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFPB002</td>
<td>516323.8</td>
<td>7509684.06</td>
</tr>
<tr>
<td>FFMB002</td>
<td>516325.57</td>
<td>7509667.86</td>
</tr>
</tbody>
</table>

SOLUTION
Aquifer Model: Unconfined
Solution Method: Theis

\[
T = 4460, \text{ m}^2/\text{day}
\]

\[
Kz/Kr = 1.
\]
APPENDIX B
Test Pumping Analysis

FFPB003 TEST PUMPING AND ANALYSIS

A three day CRT was conducted at FFPB003 commencing on 25/01/2017 at an average pumping rate of 20.1 L/s. Three surrounding bores were monitored throughout the test and are summarised in Table B25. The pumped bore and all monitoring bores were completed in the Wittenoom Aquifer, although in different formations. The pumped bore and the nearest observation bore (FFMB003) were screened in the Mt Newman Member (Marra Mamba Iron Formation) while the two remaining observation bores to the east (FFPB002 and FFMB002) were completed in the Paraburdoo Member (Wittenoom Formation).

Aquifer conditions were considered likely unconfined for all monitored bores (Table B25).

One of three observation bores monitored responded to pumping (Table B26 and Figure B25). Pumping rate and pumped bore drawdown are presented in Figure B23. Key observations from FFPB002 CRT results include:

- Initial heads at the pumped bore and monitoring bore FFMW002 were similar both in terms of elevation and groundwater depth below ground. By contrast, monitoring bores to the east (FFPB002 and FFMB002) had much higher initial heads, approximately 51 m higher than the pumped bore. This strongly "stepped" change in initial heads over a relatively short distance (around 550 m radially from the pumped bore) is consistent with the compartmentalised nature of the conceptual hydrogeological model.

- Average flow rate from FFPB002 was 20.1 L/s but short term variations between 19.6 and 20.2 L/s were observed at the start of pumping (Figure B23).

- One monitoring bore clearly responded to pumping (FFMB003) while the other two monitoring bores (FFPB002 and FFMB002) did not. The observed final drawdown is consistent with a compartmentalised aquifer (consistent with the conceptual hydrogeological model) with the pumped bore and FFMB003 installed in the same compartment and remaining monitoring bores (FFPB002 and FFMB002) installed in an adjacent compartment to the east. The two aquifer compartments are interpreted to be separated by dolerite dyke features based on surface geology data and airborne geophysics of total magnetic intensity.

- Final drawdown in the pumped bore was 19.2 m after three days pumping at 20.1 L/s indicating that bore FFPB003 is relatively low yielding (specific capacity of approximately 1 L/s/m after three days pumping).

- Recovery monitoring was conducted for 22 hours following three days pumping. At the end of recovery monitoring the pumped bore had recovered about 53% of final drawdown and FFMB003 had recovered 33% (Table B23). This level of recovery suggests a partial dewatering of the pumped aquifer compartment.
LEGEND
- Pumped Bore and Final Drawdown
- Observation Bore and Final Drawdown
- Jeerinnah Formation

NOTES
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

1:15,000

PROJECT
WESTERN HUB - HYDROGEOLOGICAL CONCEPTUAL MODEL

CONSULTANT
FORTESCUE METALS GROUP

PATH: J:\Hydro\2016\1671484 - FMG - Western Hub - Dewatering and Water Supply Assessment\Analysis\GIS analysis\Test Pumping MXD\Sketch_TestPumping_FFPB003CRT.mxd
Figure B26: Pumping rate and selected drawdown results from FFPB003 CRT (commenced 25/01/2017 9:00)
APPENDIX B
Test Pumping Analysis

Table B25: Summary of FFPB003 CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFPB003</td>
<td>Pumped Bore</td>
<td>515779</td>
<td>7509606</td>
<td>25/01/17</td>
<td>98.0</td>
<td>68 - 98</td>
<td>Mt Newman Mbr</td>
<td>Wittenoom Fm</td>
<td>54.4</td>
<td>492.5</td>
<td>Unconfined</td>
</tr>
<tr>
<td>FFMB003</td>
<td>Observation Bore</td>
<td>515799</td>
<td>7509606</td>
<td>25/01/17</td>
<td>117.0</td>
<td>51 - 117</td>
<td>Mt Newman Mbr (Wittenoom Fm)</td>
<td>Wittenoom Fm</td>
<td>54.4</td>
<td>492.9</td>
<td>Unconfined</td>
</tr>
<tr>
<td>FFPB002</td>
<td>Observation Bore</td>
<td>516324</td>
<td>7509684</td>
<td>25/01/17</td>
<td>100.0</td>
<td>56 - 100</td>
<td>Paraburadoo Mbr (Wittenoom Fm)</td>
<td>Paraburadoo Mbr (Wittenoom Fm)</td>
<td>8.5</td>
<td>543.2</td>
<td></td>
</tr>
<tr>
<td>FFMB002</td>
<td>Observation Bore</td>
<td>516326</td>
<td>7509668</td>
<td>25/01/17</td>
<td>98.0</td>
<td>58 - 100</td>
<td></td>
<td></td>
<td>8.6</td>
<td>543.2</td>
<td></td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

Table B26: Summary of FFPB003 Drawdown Results

<table>
<thead>
<tr>
<th>pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>20.1</td>
<td>FFPB003</td>
<td>0</td>
<td>19.2</td>
<td>1320</td>
<td>8.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFMB003</td>
<td>20</td>
<td>13.3</td>
<td></td>
<td>8.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFPB002</td>
<td>550</td>
<td>-0.1 (NR)</td>
<td></td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FFMB002</td>
<td>550</td>
<td>-0.1 (NR)</td>
<td></td>
<td>-0.075</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted of data from the pumped bore and the monitoring bore that responded to pumping (FFMB003), presented in Figure B27. A bounded aquifer response was observed in FFPB003 CRT results, with drawdown slope increasing after around 100 minutes pumping (Figure B27). The Theis solution for unconfined aquifers was selected for analysis as it is compatible with bounded aquifer settings and is relatively simple. The FFPB003 CRT data was analysed as a strip aquifer 300 m wide based on iteration of boundary settings and is generally consistent with spacing of dolerite dyke features in the region of the CRT.

Estimates of aquifer hydraulic properties from the FFPB003 CRT are summarised in Table B27. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed data (Figure B27).

Table B27: Summary of Aquifer Hydraulic Property Estimates – FFPB003 CRT

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity</th>
<th>Aquifer Thickness - b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio - Kz/Kr</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>0.0011</td>
<td>62.6</td>
<td>1</td>
<td>Theis (bounded aquifer)</td>
</tr>
</tbody>
</table>

Note: Kz – vertical hydraulic conductivity, Kr – radial hydraulic conductivity
Figure B27: Hydraulic Analysis Results – FFPB003 CRT
DIRTY NICK TEST PUMPING AND ANALYSIS
An eight hour CRT was conducted at Dirty Nick commencing on 7/10/2016 at an average pumping rate of 1.2 L/s, no other bores were monitored during this test. Dirty Nick was drilled within the footprint of the proposed West End Pit and completed in the Brockman Iron Formation with the majority of the bore screen located in the Joffre Member and to a minor extent the Dales Gorge Members*. Due to the absence of any obvious confining strata in the area from available stratigraphic data, it was assumed that groundwater in this area is unconfined.

A summary of the test details is provided in Table B28 and Table B29, the pumping rate and drawdown observed in the pumped bore is presented in Figure B28. No logger data was available for this test. Key observations from the Dirty Nick CRT results include:

- Final drawdown in the pumped bore was approximately 1.0 m after eight hours pumping at 1.2 L/s indicating the test did not create a significant stress on the local aquifer.
- Due to the short duration of the test, it is likely that only early time drawdown data has been obtained, possibly displaying a delayed yield response towards the end of the test 200 – 480 mins.
- No evidence of boundary conditions are indicated by the test results.
- Recovery monitoring was conducted for 60 minutes over which time the groundwater level almost completely recovered to the pre-test level (residual drawdown was 0.07 m).

*No bore log for Dirty Nick was available, intersected units have been inferred from recorded stratigraphy from resource borehole EW0040. The presence of the Whaleback Shale was not recorded during drilling.
Figure B28: Pumping rate and selected drawdown results from Dirty Nick CRT
## Table B28: Summary of Dirty Nick CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting¹</th>
<th>Northing¹</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dirty Nick</td>
<td>Pumped Bore</td>
<td>482555</td>
<td>7512310</td>
<td>7/10/2016</td>
<td>150</td>
<td>72 - 150</td>
<td>Joffre and Dales Gorge Member</td>
<td>Brockman Iron Formation</td>
<td>73.1</td>
<td>456.9</td>
<td>Unconfined</td>
</tr>
</tbody>
</table>

Note: ¹Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

## Table B29: Summary of Dirty Nick Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>1.2</td>
<td>Dirty Nick</td>
<td>0</td>
<td>1.0</td>
<td>60</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Hydraulic analysis was conducted using data from the pumped bore and is presented in Figure B29. Due to the test being a single-well test, a straight line Cooper-Jacob solution was selected and applied to the early time data. There is some evidence of a delayed yield response towards the end of the test 200 – 480 mins, however due to the test ceasing after 480 minutes, this cannot be confirmed. The early time Cooper-Jacobs solution is presented in Figure B29.

Estimates of aquifer hydraulic properties from the Dirty Nick CRT are summarised in Table B30. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed early time data.

**Table B30: Summary of Aquifer Hydraulic Property Estimates – Dirty Nick CRT**

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity*</th>
<th>Specific Yield</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – $K_Z/K_R$</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>127</td>
<td>-</td>
<td>-</td>
<td>77</td>
<td>-</td>
<td>Cooper-Jacob (unconfined)</td>
</tr>
</tbody>
</table>

Note: $K_Z$ – vertical hydraulic conductivity, $K_R$ – radial hydraulic conductivity. "Storativity estimate could not be calculated due to analysis being of pumped bore data only."
APPENDIX B
Test Pumping Analysis

Figure B29: Hydraulic Analysis Results – Dirty Nick CRT

Note: Estimates of storativity from pumped bore analysis are automatically generated and are not considered reliable or valid.
KENNY BORE TEST PUMPING AND ANALYSIS

A 48 hour CRT was conducted at Kenny Bore commencing on 2/08/2016 at an average pumping rate of 3.3 L/s, no other bores were monitored during this test. Kenny Bore was drilled in the central Eliwana area and is assumed to be completed in the Mount Newman Member of the Marra Mamba Iron Formation*. A summary of the test details is provided in Table B31 and Table B32, the pumping rate and drawdown observed in the pumped bore is presented in Figure B30. No logger data was available for this test. Key observations from the Kenny Bore CRT results include:

- Final drawdown in the pumped bore was approximately 11.4 m after 48 hours pumping at 3.3 L/s.
- The drawdown curve in the pumped bore is typical for an unconfined aquifer.
- Recovery monitoring was conducted for 19 hours over which time the groundwater level almost completely recovered to the pre-test level (residual drawdown was 0.07 m).

*No bore log for Kenny Bore was available, intersected units have been inferred from recorded stratigraphy from more recently drilled resource borehole FF0307.
Figure B30: Pumping rate and selected drawdown results from Kenny Bore CRT
## Table B31: Summary of Kenny Bore CRT Bores

<table>
<thead>
<tr>
<th>Bore ID</th>
<th>Role</th>
<th>Easting&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Northing&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Test Start</th>
<th>Bore Depth (m)</th>
<th>Screen Interval (m depth)</th>
<th>Screened Stratigraphy</th>
<th>Screened Unit</th>
<th>Initial SWL (m BGL)</th>
<th>Initial SWL (m AHD)</th>
<th>Aquifer Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenny Bore</td>
<td>Pumped Bore</td>
<td>507201</td>
<td>7510115</td>
<td>2/08/2016</td>
<td>120</td>
<td>50 - 80</td>
<td>NA</td>
<td>Wittenoom Aquifer</td>
<td>44.0</td>
<td>500.7</td>
<td>Unconfined</td>
</tr>
</tbody>
</table>

Note: <sup>1</sup>Coordinates system is GDA94 MGA Zone50, SWL – Standing Water Level, m BGL – meters below ground level, m AHD – meters Australian Height Datum

## Table B32: Summary of Kenny Bore Drawdown Results

<table>
<thead>
<tr>
<th>Pumping Duration (days)</th>
<th>Average Pumping Rate (L/s)</th>
<th>Bore ID</th>
<th>Distance From Pumped Bore (m)</th>
<th>Final Drawdown (m)</th>
<th>Recovery Monitoring Duration (min)</th>
<th>Final Residual Drawdown (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.3</td>
<td>Kenny Bore</td>
<td>0</td>
<td>11.4</td>
<td>1140 (19 h)</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Note: NR = No response to pumping, L/s – litres per second, min – minutes.
Due to the test being a single-well test, a Cooper-Jacob solution was selected, the results of the Hydraulic analysis is presented in Figure B31. Estimates of aquifer hydraulic properties from the Kenny Bore CRT are summarised in Table B33. These estimated aquifer hydraulic properties are considered to give a reasonable fit to the observed early time data.

### Table B33: Summary of Aquifer Hydraulic Property Estimates – Kenny Bore CRT

<table>
<thead>
<tr>
<th>Transmissivity (m²/day)</th>
<th>Storativity*</th>
<th>Specific Yield</th>
<th>Aquifer Thickness – b (m)</th>
<th>Vertical to radial hydraulic conductivity ratio – Kᵥ/Kᵣ</th>
<th>Analysis Method/Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>235</td>
<td>-</td>
<td>-</td>
<td>76</td>
<td>-</td>
<td>Cooper-Jacob (unconfined)</td>
</tr>
</tbody>
</table>

*Note: Kᵥ – vertical hydraulic conductivity, Kᵣ – radial hydraulic conductivity, *Storativity estimate could not be calculated due to analysis being of pumped bore data only.*
Figure B31: Hydraulic Analysis Results – Kenny Bore CRT

Note: Estimates of storativity from pumped bore analysis are automatically generated and are not considered reliable or valid.
APPENDIX C
Slug Test Analysis Results
WELL TEST ANALYSIS

Data Set: J:\...\EWMB001_D_Springer-Gelhar_20170315.aqt
Date: 03/15/17 Time: 09:42:29

PROJECT INFORMATION

Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB001_D
Test Date: 16/02/2017

AQUIFER DATA

Saturated Thickness: 74.34 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (EWMB001_D)

Initial Displacement: 3.058 m
Total Well Penetration Depth: 78.44 m
Casing Radius: 0.025 m
Static Water Column Height: 74.34 m
Screen Length: 22. m
Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 4.225 m/day
Le = 61.72 m
WELL TEST ANALYSIS

Data Set: J:\...\EWMB001_S_Bouwer-Rice_20170315.aqt
Date: 03/17/17
Time: 10:09:02

PROJECT INFORMATION

Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB001_S
Test Date: 16/02/2017

AQUIFER DATA

Saturated Thickness: 40.84 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (EWMB001_S)

Initial Displacement: 3.343 m
Total Well Penetration Depth: 41.34 m
Casing Radius: 0.025 m
Static Water Column Height: 40.84 m
Screen Length: 18.5 m
Well Radius: 0.125 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 1.187 m/day
y0 = 3.423 m
WELL TEST ANALYSIS
Data Set: J:\...\EWMB002_Hsorslev_20170315.aqt
Date: 03/15/17    Time: 11:19:32

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB002
Test Date: 16/02/2017

AQUIFER DATA
Saturated Thickness: 68.64 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (EWMB002)
Initial Displacement: 0.09996 m
Total Well Penetration Depth: 81.64 m
Casing Radius: 0.025 m
Static Water Column Height: 68.64 m
Screen Length: 28. m
Well Radius: 0.07 m

SOLUTION
Aquifer Model: Unconfined
K = 1.025 m/day
Solution Method: Hvorslev
y0 = 0.1593 m
WELL TEST ANALYSIS

Data Set: J:\...\EWMB003_Hvorslev_20170315.aqt
Date: 03/15/17  Time: 10:37:46

PROJECT INFORMATION

Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB003
Test Date: 15/02/2017

AQUIFER DATA

Saturated Thickness: 72.99 m  Anisotropy Ratio (Kz/Kr): 1

WELL DATA (EWMB003)

Initial Displacement: 3.095 m  Static Water Column Height: 72.99 m
Total Well Penetration Depth: 151.5 m  Screen Length: 96.5 m
Casing Radius: 0.025 m  Well Radius: 0.07 m

SOLUTION

Aquifer Model: Unconfined  Solution Method: Hvorslev
K = 1.043 m/day  y0 = 5.357 m
WELL TEST ANALYSIS
Data Set: J:\..\EWMB004_Springer-Gelhar_20170315.aqt
Date: 03/15/17 Time: 10:43:01

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB004
Test Date: 16/02/2017

AQUIFER DATA
Saturated Thickness: 136.3 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (EWMB004)
Initial Displacement: 4.568 m
Total Well Penetration Depth: 134.3 m
Casing Radius: 0.025 m
Static Water Column Height: 136.3 m
Screen Length: 90. m
Well Radius: 0.07 m

SOLUTION
Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 5.279 m/day
Le = 44.6 m
WELL TEST ANALYSIS
Data Set: J:\...\EWMB005_Springer-Gelhar_20170315.aqt
Date: 03/15/17 Time: 10:50:01

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB005
Test Date: 16/02/2017

AQUIFER DATA
Saturated Thickness: 53. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (EWMB005)
Initial Displacement: 2.229 m
Total Well Penetration Depth: 63.5 m
Casing Radius: 0.025 m
Static Water Column Height: 53. m
Screen Length: 46.5 m
Well Radius: 0.125 m

SOLUTION
Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 6.801 m/day
Le = 19.3 m
WELL TEST ANALYSIS
Data Set: J:\...\EWMB006_Springer-Gelhar_20170315.aqt
Date: 03/15/17  Time: 10:58:15

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB006
Test Date: 15/02/2017

AQUIFER DATA
Saturated Thickness: 30.62 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (EWMB006)
Initial Displacement: 1.085 m
Total Well Penetration Depth: 30.62 m
Casing Radius: 0.025 m
Static Water Column Height: 30.62 m
Screen Length: 24. m
Well Radius: 0.07 m

SOLUTION
Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 4.708 m/day
Le = 8.107 m
WELL TEST ANALYSIS
Data Set: J:\\..\EWMB008_Springer-Gelhar_20170315.aqt
Date: 03/15/17  Time: 11:02:00

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWMB008
Test Date: 17/02/2017

AQUIFER DATA
Saturated Thickness: 37.8 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (EWMB008)
Initial Displacement: 3.567 m
Total Well Penetration Depth: 37.8 m
Casing Radius: 0.025 m
Static Water Column Height: 37.8 m
Screen Length: 30. m
Well Radius: 0.07 m

SOLUTION
Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
\( K = 3.78 \text{ m/day} \)
\( Le = 27.89 \text{ m} \)
## WELL TEST ANALYSIS

Data Set: J:\...\EWMB009_Springer-Gelhar_20170315.aqt  
Date: 03/15/17  Time: 11:09:41

## PROJECT INFORMATION

- **Company:** Golder Associates  
- **Client:** FMG  
- **Project:** 1671484  
- **Location:** Eliwana  
- **Test Well:** EWMB009  
- **Test Date:** 16/02/2017

## AQUIFER DATA

- **Saturated Thickness:** 122.2 m  
- **Anisotropy Ratio (Kz/Kr):** 1

## WELL DATA (EWMB009)

- **Initial Displacement:** 3.591 m  
- **Total Well Penetration Depth:** 132.2 m  
- **Casing Radius:** 0.025 m

- **Static Water Column Height:** 122.2 m  
- **Screen Length:** 106. m  
- **Well Radius:** 0.125 m

## SOLUTION

- **Aquifer Model:** Unconfined  
- **Solution Method:** Springer-Gelhar  
- **K:** 4.047 m/day  
- **Le:** 31.45 m
WELL TEST ANALYSIS
Data Set: J:\...\EWPB001_Horselv_20170315.aqt
Date: 03/15/17 Time: 11:23:50

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Eliwana
Test Well: EWPB001
Test Date: 09/12/2016

AQUIFER DATA
Saturated Thickness: 65.59 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (EWPB001)
Initial Displacement: 19. m
Total Well Penetration Depth: 65.59 m
Static Water Column Height: 65.59 m
Casing Radius: 0.1524 m
Screen Length: 30. m
Well Radius: 0.1 m

SOLUTION
Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 0.2212 m/day
y0 = 6.817 m
WELL TEST ANALYSIS
Data Set: J:\..\FFMB001_Springer-Gelhar_20170315.aqt
Date: 03/15/17  Time: 10:13:19

PROJECT INFORMATION
Company: Golder Associates
Client: FMG
Project: 1671484
Location: Flying Fish
Test Well: FFMB001
Test Date: 14/02/2017

AQUIFER DATA
Saturated Thickness: 89.86 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (FFMB001)
Initial Displacement: 4.078 m
Total Well Penetration Depth: 136.9 m
Casing Radius: 0.025 m
Static Water Column Height: 89.86 m
Screen Length: 64. m
Well Radius: 0.07 m

SOLUTION
Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 4.778 m/day
Le = 44.18 m
WELL TEST ANALYSIS

Data Set: J:\...\FFMB002_Springer-Gelhar_20170315.aqt
Date: 03/15/17 Time: 11:13:57

PROJECT INFORMATION

Company: Golder Associates
Client: FMG
Project: 1671484
Location: Flying Fish
Test Well: FFMB002
Test Date: 15/02/2017

AQUIFER DATA

Saturated Thickness: 91.56 m  Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (FFMB002)

Initial Displacement: 2.838 m
Total Well Penetration Depth: 91.56 m
Casing Radius: 0.025 m
Static Water Column Height: 91.56 m
Screen Length: 42. m
Well Radius: 0.07 m

SOLUTION

Aquifer Model: Unconfined  Solution Method: Springer-Gelhar
K = 16.28 m/day  Le = 45.64 m
APPENDIX D

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