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Water Resource Evaluation

Plunge Pool; Mode of Occurrence

January 2022

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Executive Summary

Plunge Pool (the pool) is a permanent water body at the base of a small gorge in the Hardey River catchment. The pool has ecological importance and has high cultural significance to the Eastern Guruma Traditional Owners. Therefore, the pool is to be protected from mining-related impacts. This report outlines the pool's hydrology, hydrogeology as well as providing conclusions and recommendations regarding its ongoing protection.

The pool is fed by surface water runoff from an approximately 20 km^2 sub-catchment of the Hardey River catchment. The pool is also supported by groundwater from unmineralised Marra Mamba Iron Formation (MMIF). The maximum observed water level in the pool is 542.6 m RL. Bathymetry data suggests that the depth of the pool is up to approximately 2 m.

The pool is approximately 20 km east of the current Brockman Syncline 4 (BS4) mining operations, 3 km east of Brockman Syncline Marra Mamba – M (BSM-M) and Marra Mamba – N (BSM-N), 1 km south of Brockman Syncline 3 (BS3) and is down gradient of three deposits referred to as BS3 Extension**Error! Reference source not found.** (Marra Mamba – J (MM-J), Creekside (CRK) and Brokenwood (BKWD)) within the Greater Brockman Syncline.

Bedrock aquifers of the Hamersley Group are somewhat strata bound by alternating higher and lower permeability rock types. Pre-mining groundwater levels across the Greater Brockman syncline are observed to change suddenly within short distances along strike of bedrock aquifers. It is hypothesised that dolerite dykes that cross the bedrock at oblique angles compartmentalise groundwater flow (Golder, 2017, Dodson, 2010). There is strong evidence that dykes are impeding groundwater flow across the Hamersley Basin and the Brockman Syncline in particular. Dolerite dykes occur in close proximity to the pool and the groundwater level observations support the compartmentalisation hypothesis that lateral groundwater flow is impeded across dolerite boundaries. Where bedrock is eroded and infilled with younger sediments and these are saturated below water table (BWT), groundwater may 'overtop' a dyke at the palaeo-erosion surface (eg. top of dyke).

Local groundwater levels are 593 mRL at MM-J and CRK, which are located ~9 km northeast of the pool. The groundwater level decreases stepwise through subsequent downstream compartments to the pool compartment where the groundwater level in MMIF monitoring bores (MB's) are at 546 m RL. The groundwater levels continue to reduce past the pool to ~535 m RL in the BSM-M deposit.

The hydrochemistry of the pool and surrounding groundwater further supports that the pool is groundwater fed, which is topped up by runoff during rainfall events. The electrical conductivity (EC) within the pool immediately increases during high rainfall events as a result of runoff from the local catchment collecting salts prior to flowing into the pool. This peak in EC is then followed by a sudden decrease related to later runoff with a decreased salt load. Overtime, the EC signature of the pool gradually returns to an EC signature similar to adjacent groundwater until the next rainfall event takes place.

The chloride (Cl) concentration of groundwater adjacent to the pool is ~150 mg/L. The highest recorded Cl concentration in the pool is 194 mg/L, which was recorded after several months of a relatively dry period. The lowest Cl concentration was recorded as 32 mg/L after cyclone Damien rainfall event. The Cl concentration in the pool decreases after rainfall events following the first flush spike due to the additional rainwater being fresher than the pool water, but the Cl concentration gradually increases to resemble adjacent groundwater.

The Brockman Syncline Proposal includes deposits BSM-N, BSM-M, BS3, MM-J and CRK. BWT mining was planned to take place at each of these deposits. The conceptual model suggests that dewatering of deposits west of the pool (BSM-N and BSM-M) will not have any impact on groundwater levels in the pool due to the presence of dolerite dykes preventing drawdown within the pool compartment. Monitoring of water levels in BSM-N, BSM-M and the Plunge Pool compartment will still be tracked to monitor for any potential effect on the pool from dewatering of these deposits. Dewatering from BS3, MM-J and CRK could reduce the 'overtop' flow into the downgradient pool compartment.

In order to better understand and confirm the hydraulic connectivity between regional groundwater, the pool and the role of adjacent dykes in groundwater flow, a drilling and pumping testing programme is planned to take place in 2022, with specific emphasis on monitoring drawdown propagation during pumping testing either side of dolerite dykes to gain further confidence on the pool conceptualisation.

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1. Introduction

Plunge Pool has high cultural significance to the Eastern Guruma people and ecological importance to fauna species. Therefore, it is important that the pool is protected from mining activities. The pool is a permanent water body that occurs at the base of a small gorge (wall heights up to about 20 m), which is fed by surface water runoff from a 20 km^2 sub catchment of the Hardey River and groundwater from unmineralised MMIF. The maximum water level recorded in the pool is 542.6 m RL. Bathometry data suggest that the pool is up to approximately 2.0 m deep (Figure 1, Figure 2 and Figure 3). Regionally, the pool is located approximately 20 km east of current BS4 mining operation, 3 km east of BSM-M and 1 km south of BS3 deposits and 9 km SE of three deposits referred to as BS3 Extension**Error! Reference source not found.** namely; Marra MM-J, CRK & BKWD on the Brockman Syncline's southern limb (Figure 4). This document describes the pool's mode of occurrence and should be read in conjunction with the "Brockman Syncline Hydrogeological Assessment".

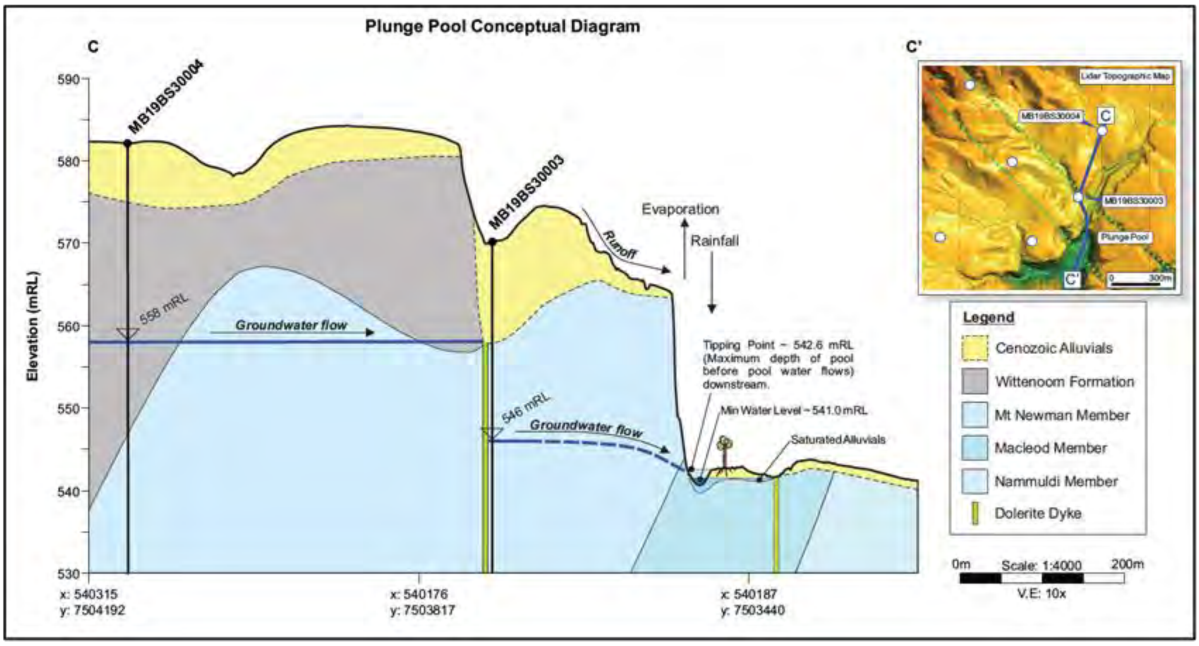

Figure 1 Plunge Pool conceptual diagram, the distance between the two MB's is approximately 1 km.

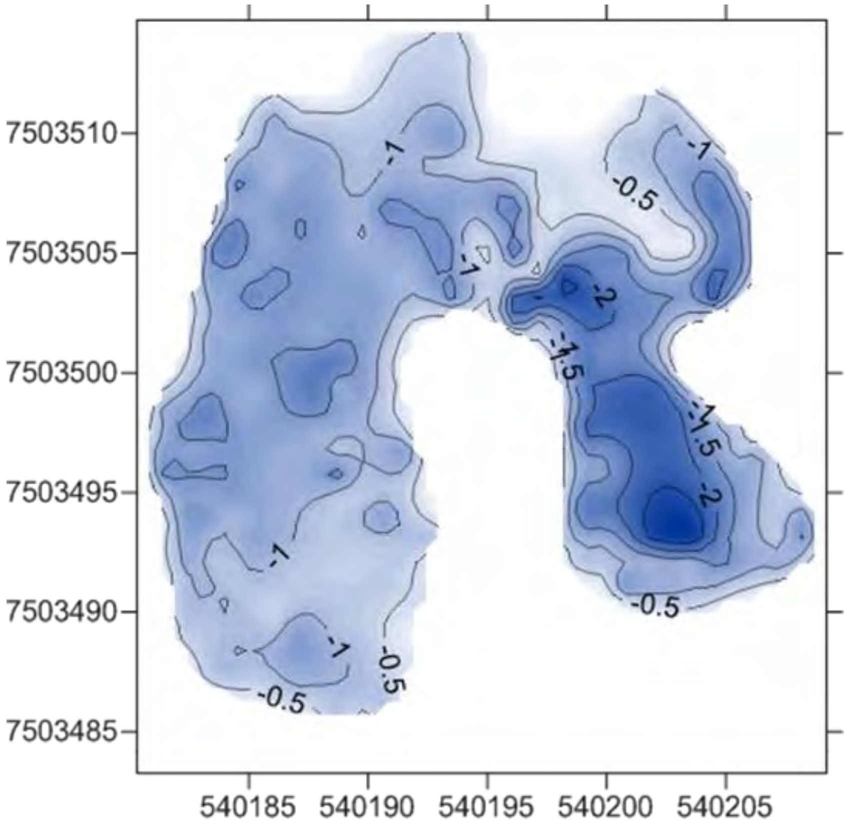

Figure 2 Bathymetry survey of Plunge Pool in November 2016.

Figure 3 Aerial photo of Plunge Pool.

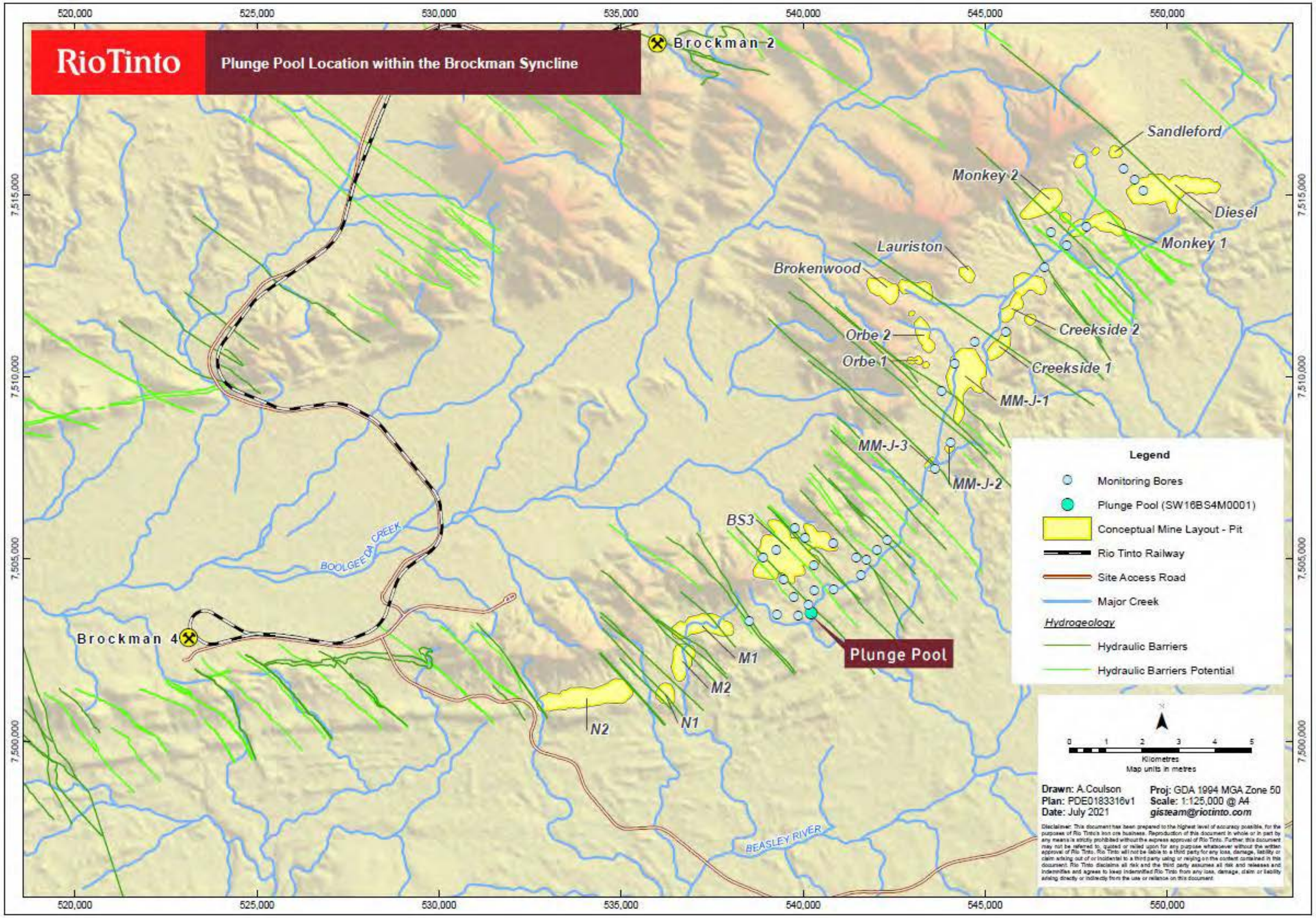

Figure 4 Plunge Pool location within the Brockman Syncline.

2. Regional Setting

2.1 Geology and Topography

The pool is located on the southern limb of the Brockman Syncline, a dominant topographic feature with its central apex trending roughly east-west for approximately 60 km. The syncline stratigraphy consists of the Hamersley Group, characterised by high ridges of Brockman Iron Formation (BIF) standing 300–400 m above the syncline valley floor with a maximum elevation of 1,132 m. The ridge formed by the Brockman Iron Formation, is separated from an outer, lower lying ridge of the older MMIF by the Mount McRae Shale, Mount Sylvia Formation and Wittenoom Formation. Recent Paleogene/Neogene detrital sediments overly the Wittenoom Formation within the intervening valleys. High grade iron mineralisation across the syncline is hosted within both the Brockman and Marra Mamba iron formations.

Dolerite dykes and sills are ubiquitous across the Pilbara. However, they are particularly abundant across the Brockman syncline and are in close proximity to the pool. The dykes have been identified from geophysics, geological mapping, encountered during resource drilling and as visible erosional features in aerial imagery (Figure 5). The dykes trend northwest-southeast, are sub vertical and cross cut the major geological formations. The dykes intrude only the Archean age bedrock and were subsequently eroded prior to deposition of younger detrital sediments. A continuous dolerite sill also wraps around the syncline along strike within the Joffre Member of the BIF. The dolerite sill intruded before the major deformation and north-west southeast dyke swarm event as it exhibits similar folding and faulting as the bedrock formations.

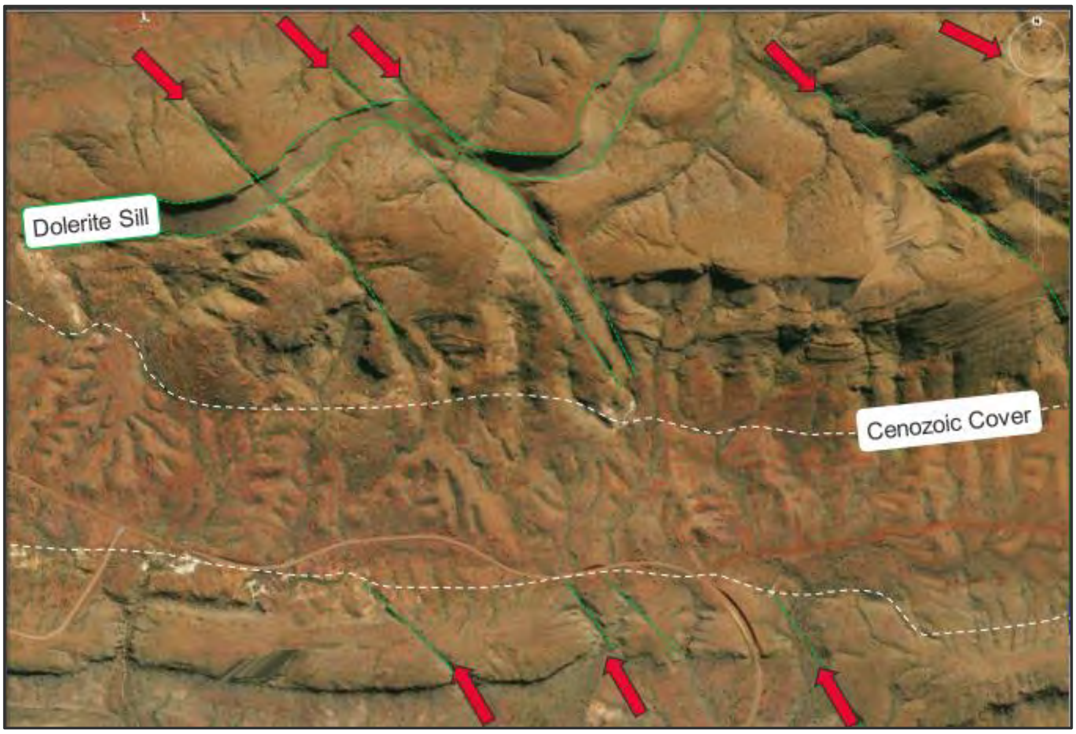

Figure 5 Aerial photo of BSM - M area showing surface features associated with dolerite dykes (red arrows).

2.2 Climate and Rainfall

The climate of the Brockman Syncline is classified as semi-arid to subtropical with hot, wet summers and cool dry winters. Weather data is collected at automatic weather stations across the syncline. The long-term mean annual rainfall across the Brockman Syncline is 385 mm with a range of 90 mm to 1,090 mm illustrating the high inter-annual variability. Rainfall is typically associated with tropical low-pressure systems and thunderstorm activity from the monsoonal trough that develops over northern Australia during summer. While winters are typically dry and mild, unseasonal rainfall can occur owing to tropical cloud bands that intermittently affect the area. The mean annual pan evaporation is 3,385 mm (BoM, 2008), greatly exceeding the mean annual rainfall.

2.3 Hydrology

The pool and adjacent ore deposits (BSM - M, BS3 and BS3 Extension) are located at the headwaters of the Hardey River regional catchment. The pool is fed by surface water flow from a 20 km^2 sub catchment of Hardey River regional catchment (Figure 6). Surface water drainage around the syncline flows before it eventually discharges away from the syncline. Plunge pool occurs at one of these locations.

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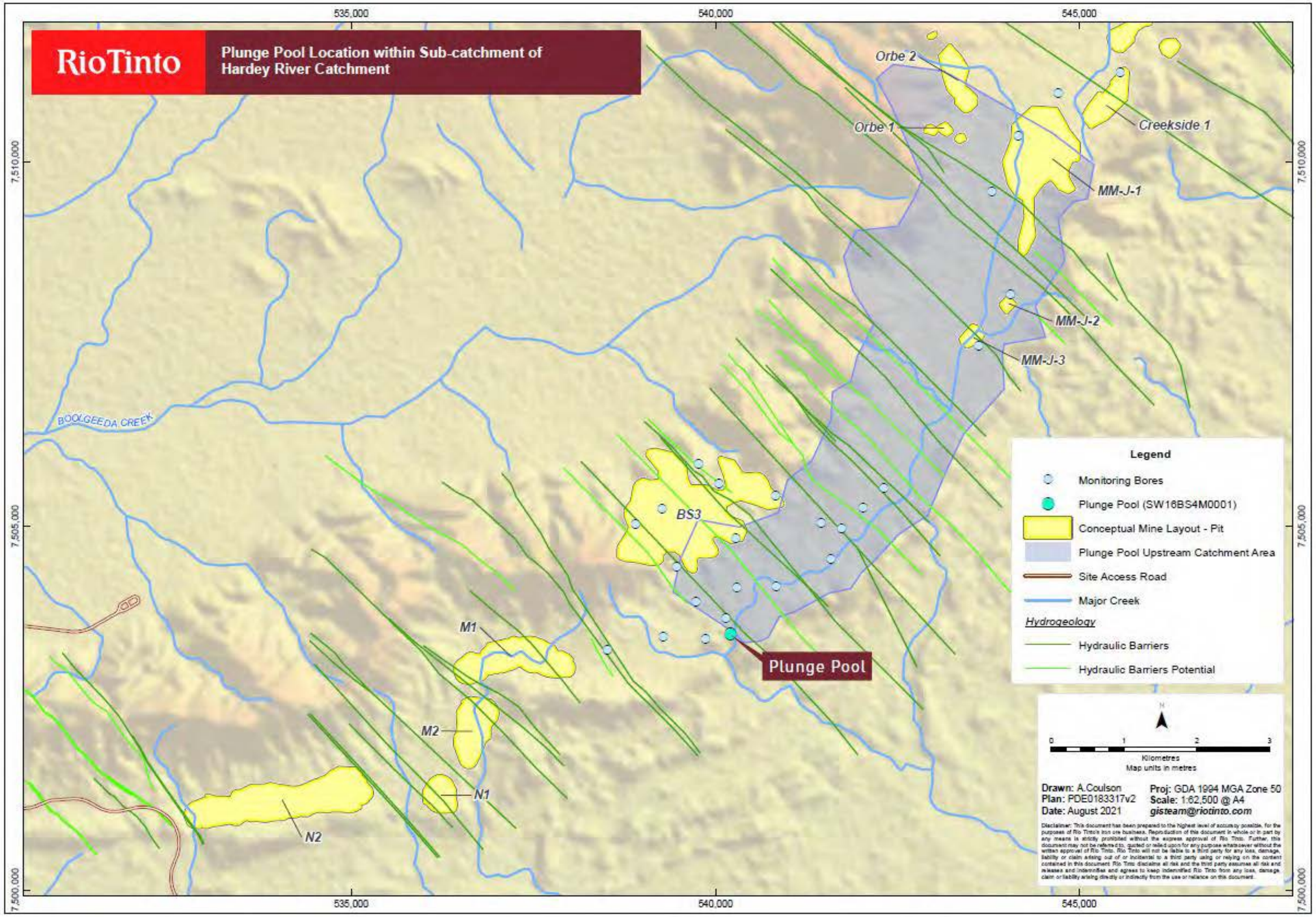

Figure 6 Plunge Pool location within sub-catchment of Hardey River regional catchment.

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2.4 Hydrogeology

Geological and hydrogeological drilling and testing programmes across Brockman Syncline deposits commenced in the 1980's and have been ongoing since. Groundwater monitoring and sampling of over 200 monitoring bores (MB's) and vibrating wire piezometers (VWP's) has been ongoing from 1990's, with regular monitoring since 2004.

Data gathered has been used to assess the extent of groundwater resources within the region and to identify and develop dewatering strategies for the BWT deposits. In addition to baseline field investigations, reconciliation of aquifer stress (drawdown response) associated with dewatering at existing BS4 and B2N BWT mines has allowed for ongoing refinement of hydrogeological conceptualisation (aquifer geometry/extents and aquifer properties) in the syncline (Figure 7).

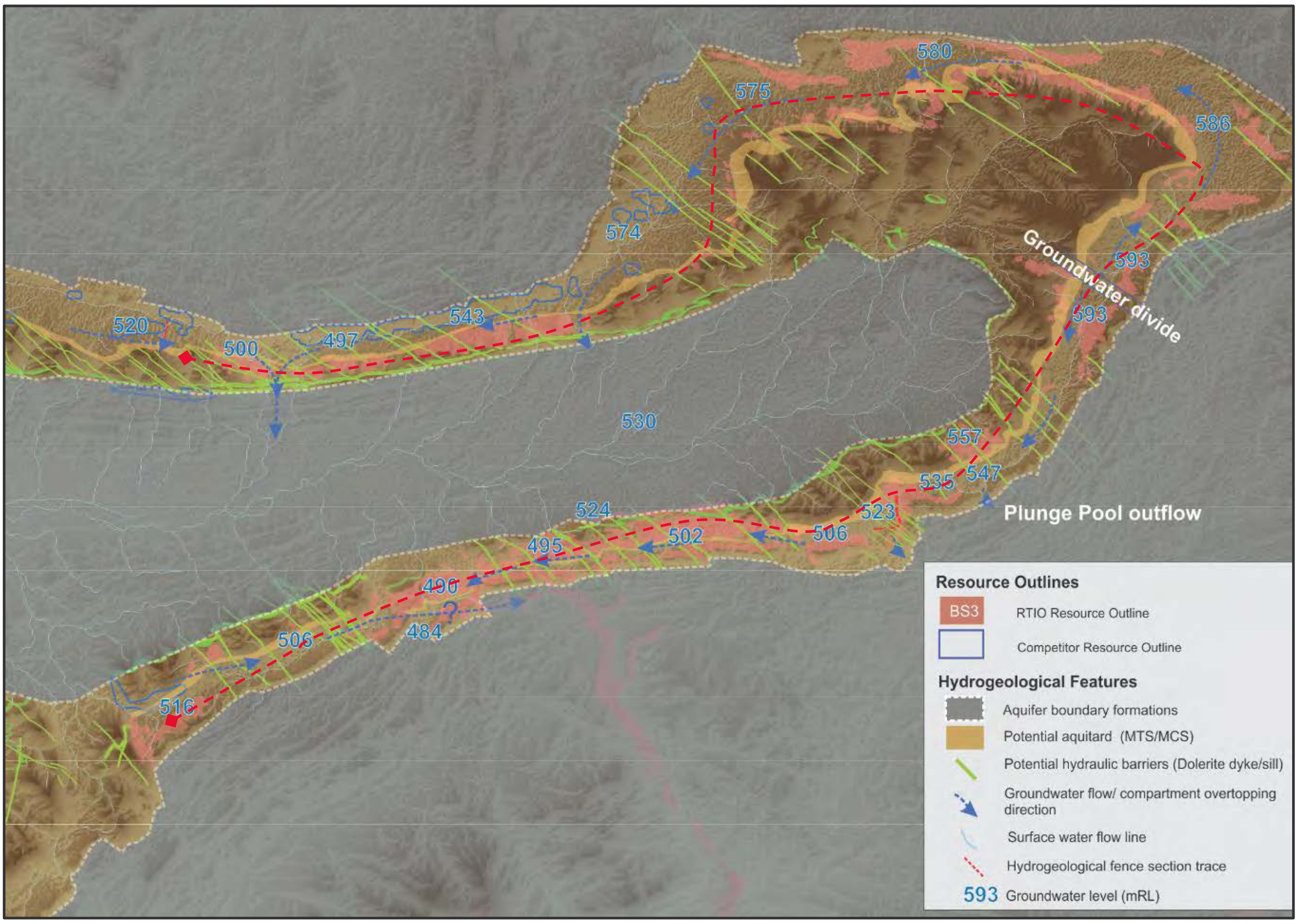

Figure 7 Overview map of extents of the Brockman Syncline, illustrating pre-mining groundwater levels, dolerite dyke locations, groundwater flow direction and Plunge Pool location.

Two key aquifers have been identified within the Brockman Syncline (Golder, 2017):

- Mineralised and fractured Brockman Iron Formation, hereby referred to as the Brockman Aquifer and
- Wittenoom Formation (where weathering and dissolution of dolomite has occurred) and the mineralised upper Newman Member of the MMIF; hereby referred to as the Wittenoom Aquifer.

The two aquifers are strata bound and separated from one another by over and underlying lower permeability aquitards. The younger sedimentary detritals can be hydraulically connected with the underlying bedrock aquifers when saturated or form an isolated aquifer. Groundwater level observations suggest that the dolerite sill acts as a no flow boundary resulting in no hydraulic connection between Brockman Aquifer and the upper Hamersley Group Weeli Wolli, Woongarra or Boolgeeda Iron formations). Discrete changes in groundwater levels across dolerite dykes infers that they compartmentalise the Brockman and Wittenoom aquifers (Figure 8). The influence of dolerite dykes on groundwater flow can be masked, where there is hydraulic connection between compartments through saturated sedimentary detritals above the elevation of the dyke (Figure 9).

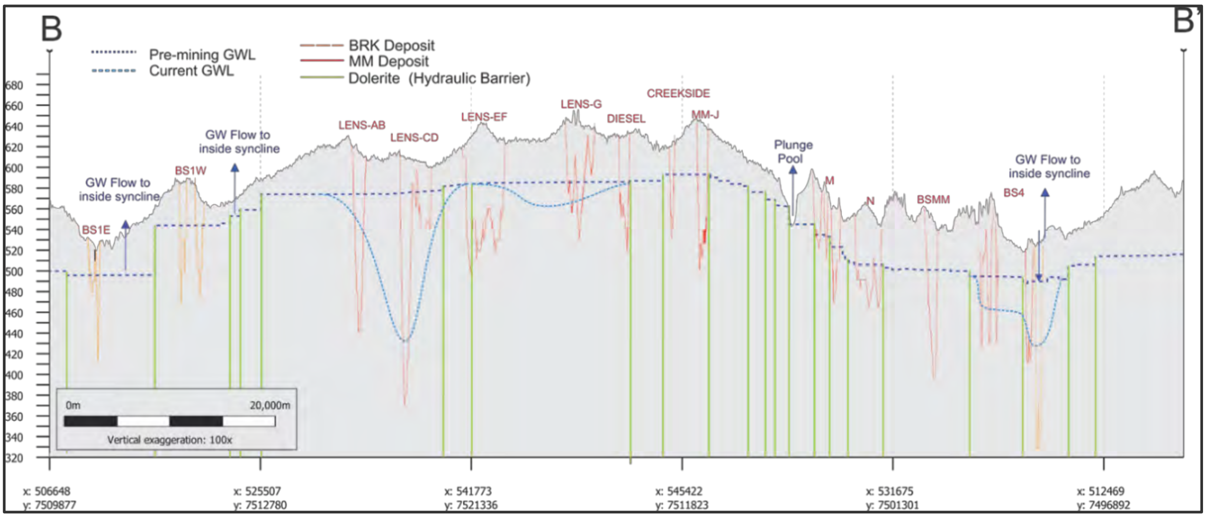

Figure 8 Brockman Syncline fence section of pre-mining and current groundwater levels, illustrating groundwater compartmentalisation and location of Plunge Pool.

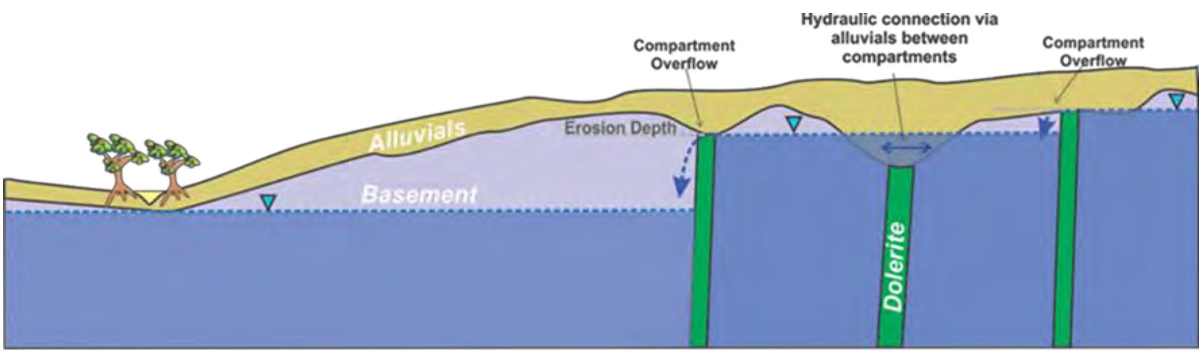

Figure 9 Schematic illustrating how groundwater is compartmentalised by dolerite dykes, hydraulic connection occurs where paleo-erosion surface is below the water table allowing flow between compartments.

The Mount McRae Shale (MCS) and Mount Sylvia Formation (MTS) are observed to be an aquitard relative to the Brockman and Wittenoom aquifers. Regional scale strike slip faulting and displacement, and local scale fracturing and faulting can result in hydraulic connection between the Brockman aquifer and Wittenoom aquifer. The unmineralised lower Mount Newman Member, MacLeod Member and Nammuldi Member of the MMIF are also assumed to be aquitards.

The contact between unmineralised Nammuldi Member and Jeerinah Formation of the Fortescue Group has been observed to act as a no flow boundary. Therefore, no hydraulic connection with the Jeerinah Formation of the Fortescue Group exists.

2.5 Evidence of Hydraulic Barriers in Brockman Syncline

Confidence that the dolerite dykes act as hydraulic barriers is critical to the hydrogeological conceptualisation. Elsewhere in the Pilbara, aquifers are generally observed to be in equilibrium, hydraulic gradients are not observed across aquitards such as the MCS until the aquifer is stressed through pumping. In the case of dolerite dykes, groundwater level variation is observed across the dykes, where the aquifer has not been stressed by pumping. Hence, dolerite dykes and the dolerite sill are considered barriers, whereas the MCS is considered an aquitard, that is it impedes, but does not prevent some flow between aquifers.

2.5.1 Dewatering at BS4

Multiple dolerite dykes have been mapped across the BS4 area, but not all dolerite dykes seem to be impeding groundwater flow as there is thick alluvial cover (likely saturated) above top of dyke depth, which allows hydraulic connection until dyke depth is intersected and then these dykes become hydraulic barriers.

Abstraction to dewater in alignment with BS4 mine plan commenced in 2008 and is planned to continue to end Life of Mine (LoM). The first area at BS4 to commence dewatering was Pit 3 in 2008, and water supply pumping began in Pit 18 in 2007. East of Pit 18 are the BSM-N and BSM-M deposits, where ground water levels have been actively monitored since 2016. Ground water levels (MB16BS4M001, MB16BS4M0002, MB16BS4M0003 and MB16BS4M0004) in this area show no evidence of draw down across the dolerite dykes due to dewatering at Pit 18 (Figure 10). MB11BSSM010 is located within the same compartment as Pit 18 and as a result the water level has been declining since commencement of abstraction in Pit 18. This long-term pumping information further supports that dolerite dykes in the area are acting as hydraulic barriers to ground water flow and are causing compartmentalisation of bedrock aquifers.

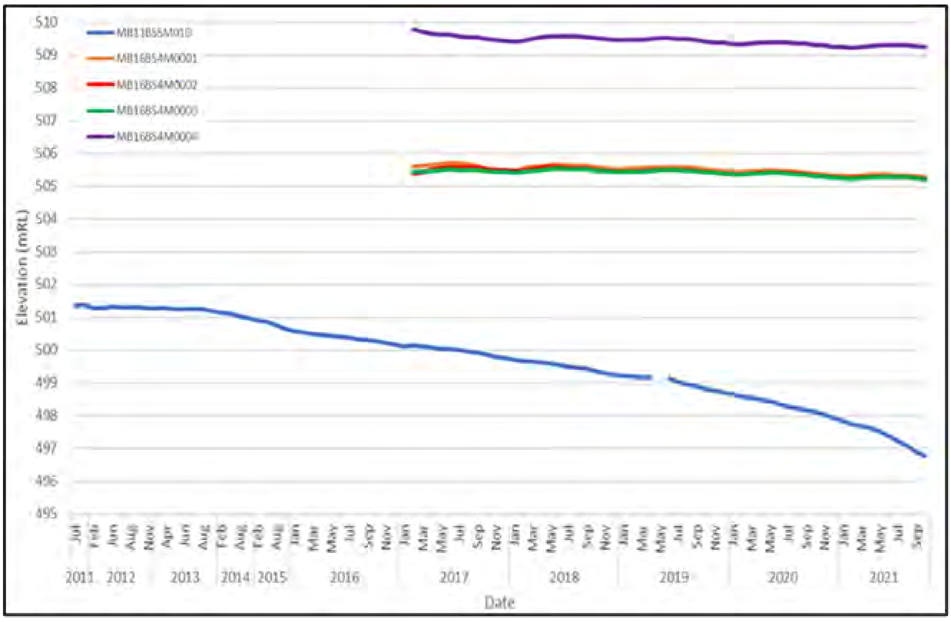

Figure 10 Monitoring bore water levels in BSM - N and BSM - M have not decreased from abstraction in Pit 18. MB11BSSM010 is located in Pit 18 and as a result the water levels in this monitoring bore have declined.

2.5.2 Groundwater Dating

A Carbon 14 (C^{14}) sampling programme took place in December 2014 at BS4, which is on the southern limb of Brockman Syncline. BS3, BSM-N, BSM-M and Plunge Pool are also on the southern side of the syncline. Therefore, similar results are expected between compartments in proximity to Plunge Pool.

At BS4, samples were collected from operating dewatering and water supply bores in Pit 18, Pit 3 and Pit 2I/Pit 5 compartments (Figure 11). The samples were analysed to calculate the relative age of the groundwater in the area. The higher the value of percent modern carbon (pMC) the younger the age of groundwater.

The pMC values ranged from 2.56 to 52.73 pMC, suggesting that the groundwater at BS4 is 15,000 – 30,000 years old. This data and other supporting data suggest that recharge occurred post-glaciation. Any recharge that causes water levels to rise above the erosion surface (ie top of the dolerite) results in overtopping into the downgradient compartment. This allows mixing of groundwater between compartments, resulting in similar pMC values. Where inter flow cannot or has not occurred, different groundwater pMC values are expected.

The pMC results obtained from DW07BS4B003 indicates that the age of groundwater north of the dolerite sill is younger in comparison to two water supply bores DW07BS4B005 and DW07BS4B007 south of the sill (Figure 11). This indicates that the dolerite sill is acting as a hydraulic barrier with no mixing taking place. DW07BS4B005 and DW07BS4B007 are located on the eastern side of a nearby dolerite dyke and DW07BS4B004 is situated on the western side of this dyke. The relative age of groundwater gathered from DW07BS4B005, DW07BS4B007 and DW07BS4B004 are similar as this dyke is not impeding groundwater flow as there is a thick alluvial deposit on top of this dyke.

Further towards the east of the current BS4 mining area, the relative age of groundwater in Pit 2 Final (Pit 2F) differs to Pit 2I and Pit 5 (see pMC values from WB13BS4B001, DW07BS4B009, WB13BS4B005 AND WB13BS4B004 in Figure 11). This is due to the dolerite dyke between the two areas acting as a hydraulic barrier preventing groundwater flow and mixing**Figure 11**. In summary, the C^{14} data is consistent with the concept of discrete groundwater compartments bounded by dolerite dykes.

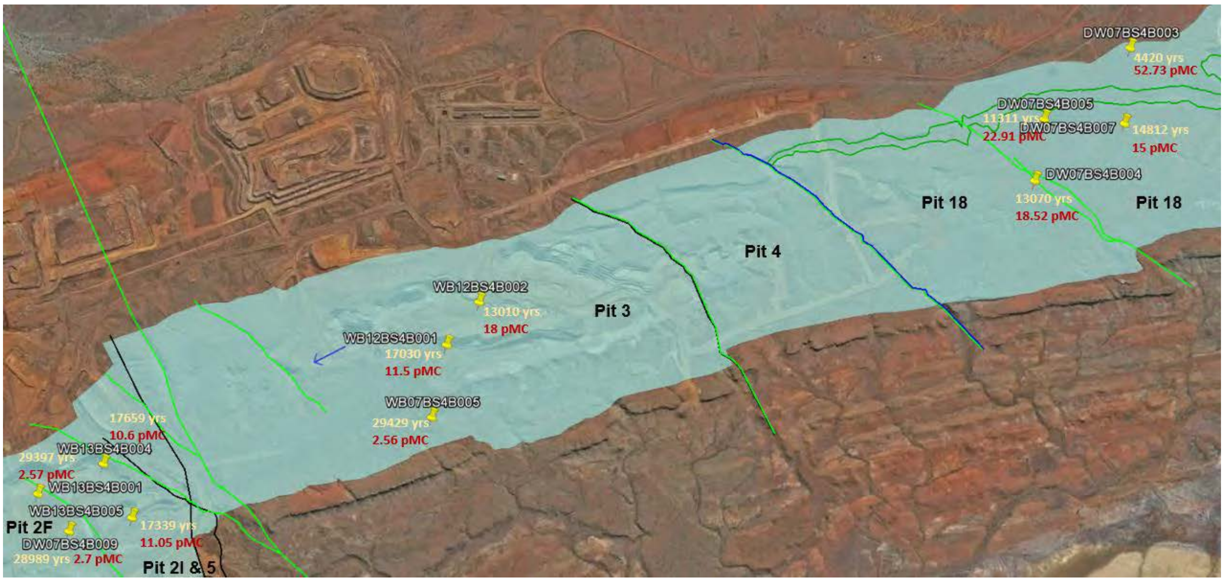

Figure 11 Groundwater dating locations and results across current BS4 mining area.

2.5.3 Pumping Testing at BS1

During 2019 and 2020, specific hydrogeological drilling and testing programmes took place in Brockman Syncline 1 (BS1) on the northern limb of the syncline. These programmes were focused on understanding the nature of hydraulic barriers (dolerite dykes and sill), assessing drawdown propagation and gaining an understanding of MCS and MTS response to pumping from the Brockman aquifer. While BS1 is located on the northern flank of the Brockman Syncline and BS3 is located on the southern flank, the geology is analogous and BS1 hydrogeological programmes aided in understanding hydrogeological conceptualisation around Plunge Pool as geological setting is similar.

Based on pre-mining groundwater level information gathered from MB's, water bores (WB's) and VWP's in BS1, the groundwater levels range between 548 to 543 mRL in the east and 497 to 496 mRL in the west (Figure 12). A north to south trending dolerite dyke has been mapped between the east and west deposits. The dyke appears to be acting as a hydraulic barrier as there is a 45 m pre-mining groundwater level difference either side of the dyke (Figure 12). The pre-mining water levels are at 497 mRL on the western side of the dyke and 543 mRL on the eastern side. Additional dolerite dykes have been mapped across the BS1 deposit, which are trending at a northwest to southeast orientation. These dykes are thought to compartmentalise the bedrock aquifers and inhibit groundwater flow unless the pre-mining groundwater level is above the eroded basement palaeo-topography.

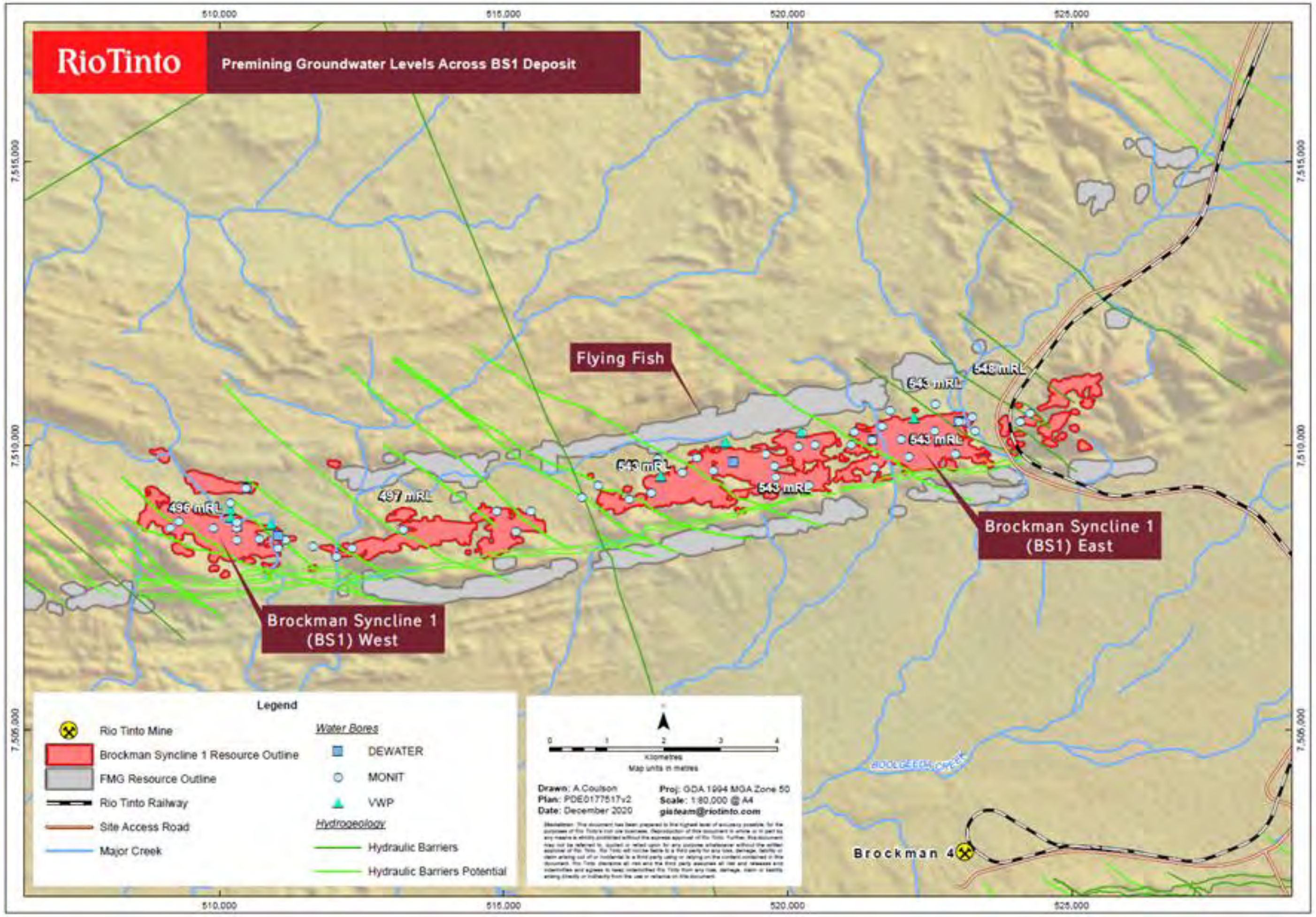

Figure 12 Pre-mining groundwater levels across BS1 deposit, which displays the effect of dolerite dykes on groundwater level.

Pumping testing was undertaken on all production bores (PB's). The drawdown contours at the end of constant rate testing (CRT) are elongated along the direction of strike within the Brockman and Wittenoom aquifers (Figure 13 to Figure 15). The elongation reflects the anisotropy imparted by the strata bound aquifers as a consequence of over and under lying aquitards to both aquifers. The dolerite dykes, which cross cut the bedrock aquifers, act as hydraulic barriers where there is no overlying saturated detrital. This was determined through monitoring the response in MB's either side and in close proximity to dolerite dykes and reviewing the thickness of detrital sediment overlying the basement palaeo-topography.

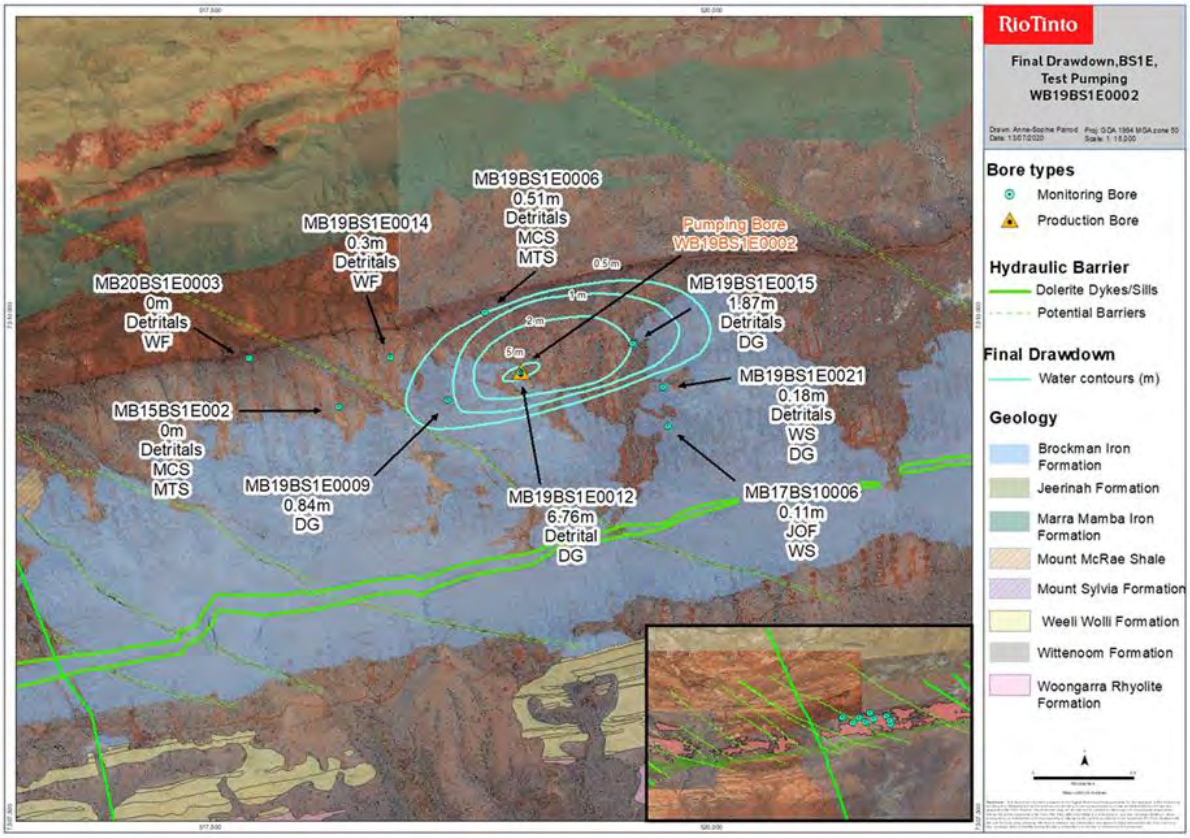

Figure 13 Final drawdown contours at end CRT for WB19BS1E0002.

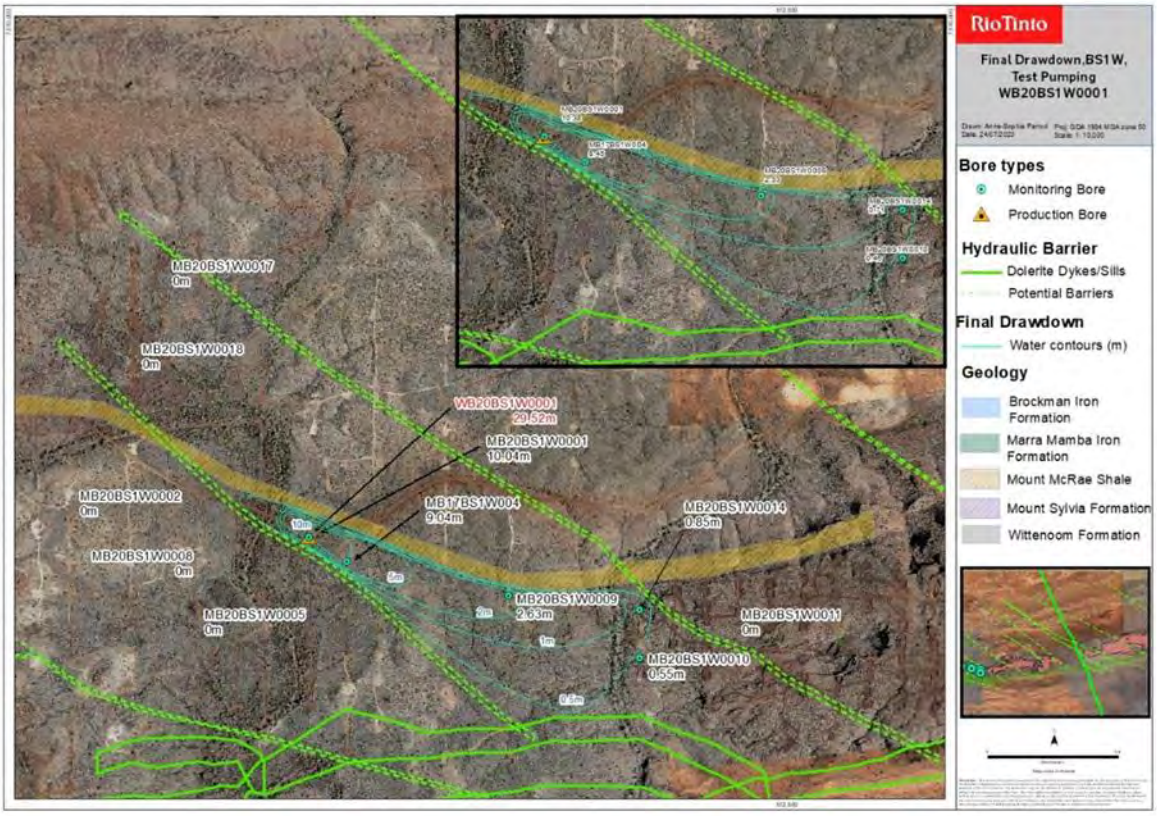

Figure 14 Final drawdown contours at end CRT for WB20BS1W0001.

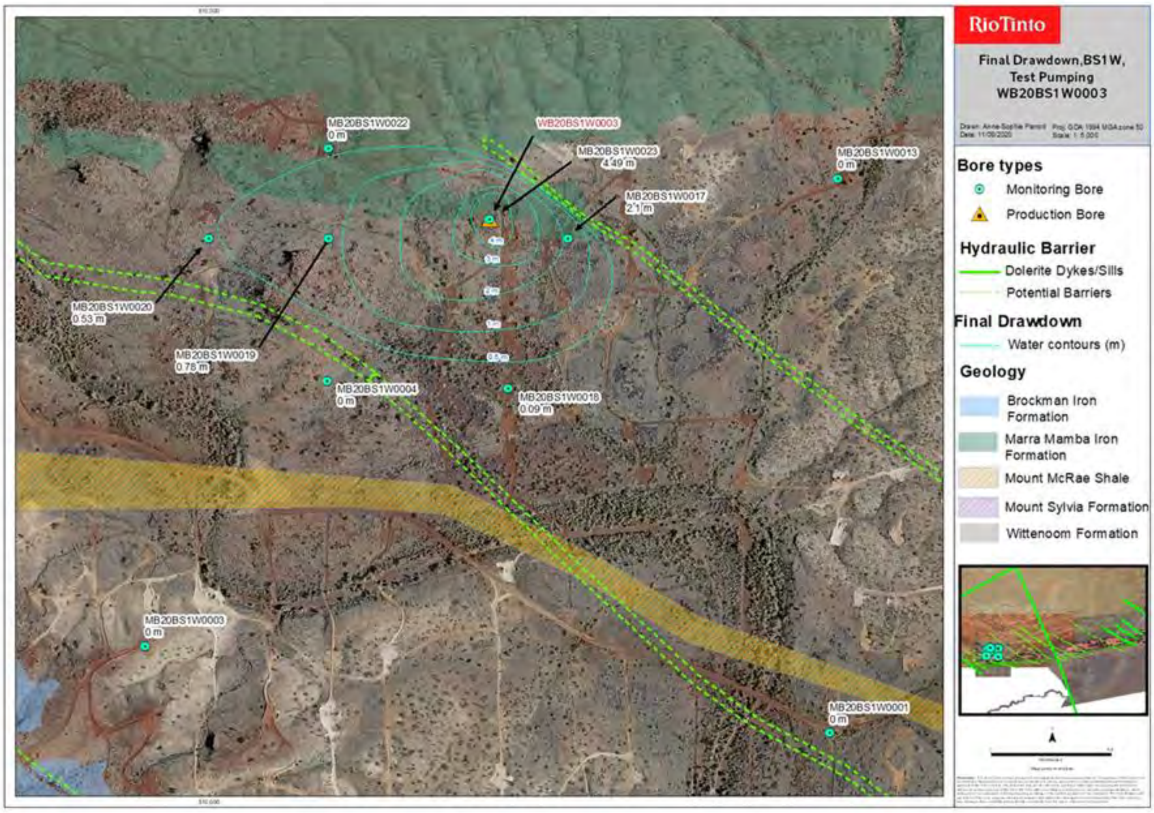

Figure 15 Final drawdown contours at end CRT for WB20BS1W0003.

3. Plunge Pool Local Hydrogeology

3.1 Hydrogeological Data Acquisition

During 2017 five MB’s were installed to obtain pre-mining groundwater levels across the BS3 and BS3 Extension region. Additional MB’s were installed in 2018. A total of 19 MB’s were installed in 2019 with specific emphasis placed on building a monitoring network around Plunge Pool, and either side of dolerite dykes in BS3 and BS3 extension (Figure 16).

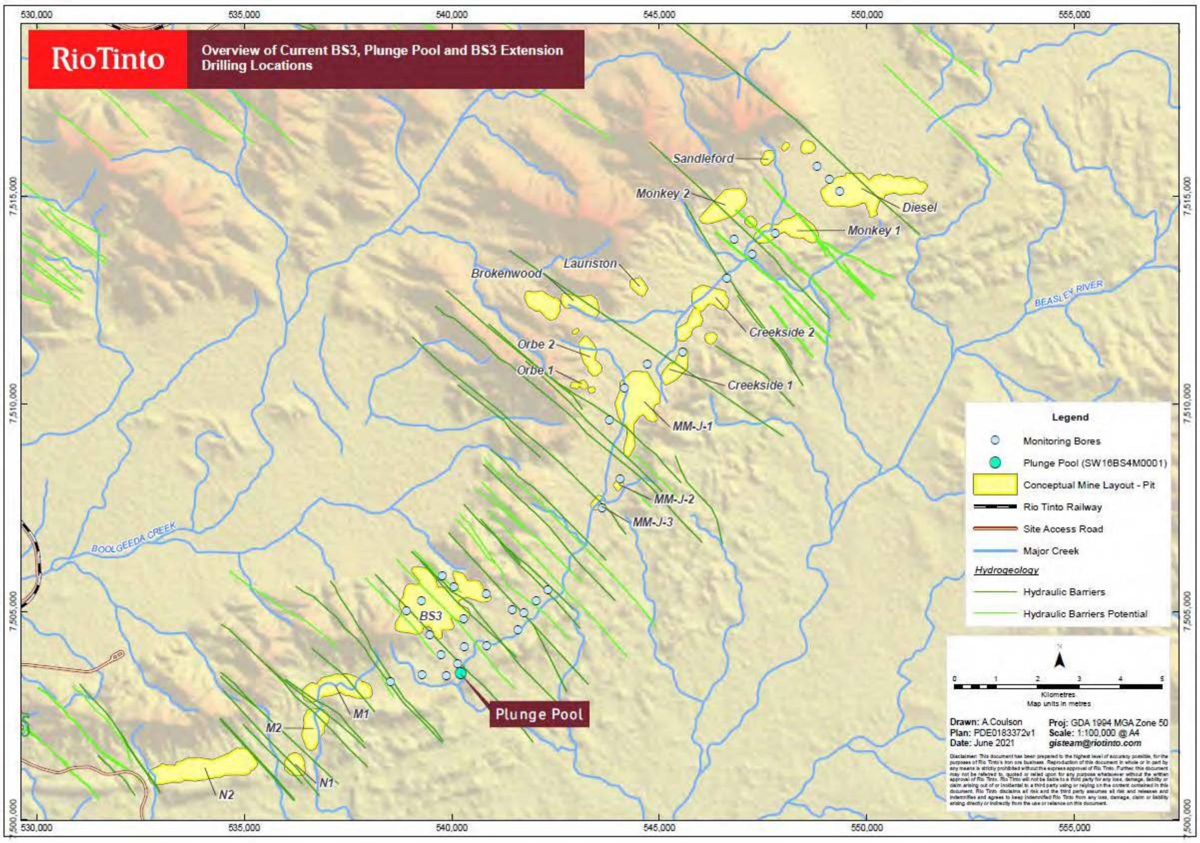

Figure 16 Overview of current BS3, Plunge Pool and BS3 Extension drilling locations.

Based on pre-mining groundwater level information gathered from this network of MB’s between 2017 and 2021, the groundwater level at MM-J and CRK is at 593 m RL and then decreases across each compartment to the Plunge Pool compartment where the groundwater level in lower MMIF MB’s are at 546 m RL (Figure 17). Dolerite dykes have been mapped across this area of the syncline, trending at a northwest to southeast orientation. This data indicates that the dykes are acting as hydraulic barriers compartmentalising the bedrock aquifers and preventing groundwater flow between compartments, unless the pre-mining groundwater level is above the bedrock erosion surface (Figure 17). The hydrogeological section (**Error! Reference source not found.**) illustrates the pre-mining groundwater level difference either side of dolerite dykes**Error! Reference source not found.**.

Along with groundwater level monitoring, MB’s have been regularly sampled for water chemistry. The Cl concentrations vary across BS3, MM-J and CRK when sampled at a similar time of the year (Figure 19). The Cl concentration trend is thought to be related to water contained in saturated alluvials overtopping dykes from one compartment into the next and mixing with groundwater within the downgradient compartment (Figure 19).

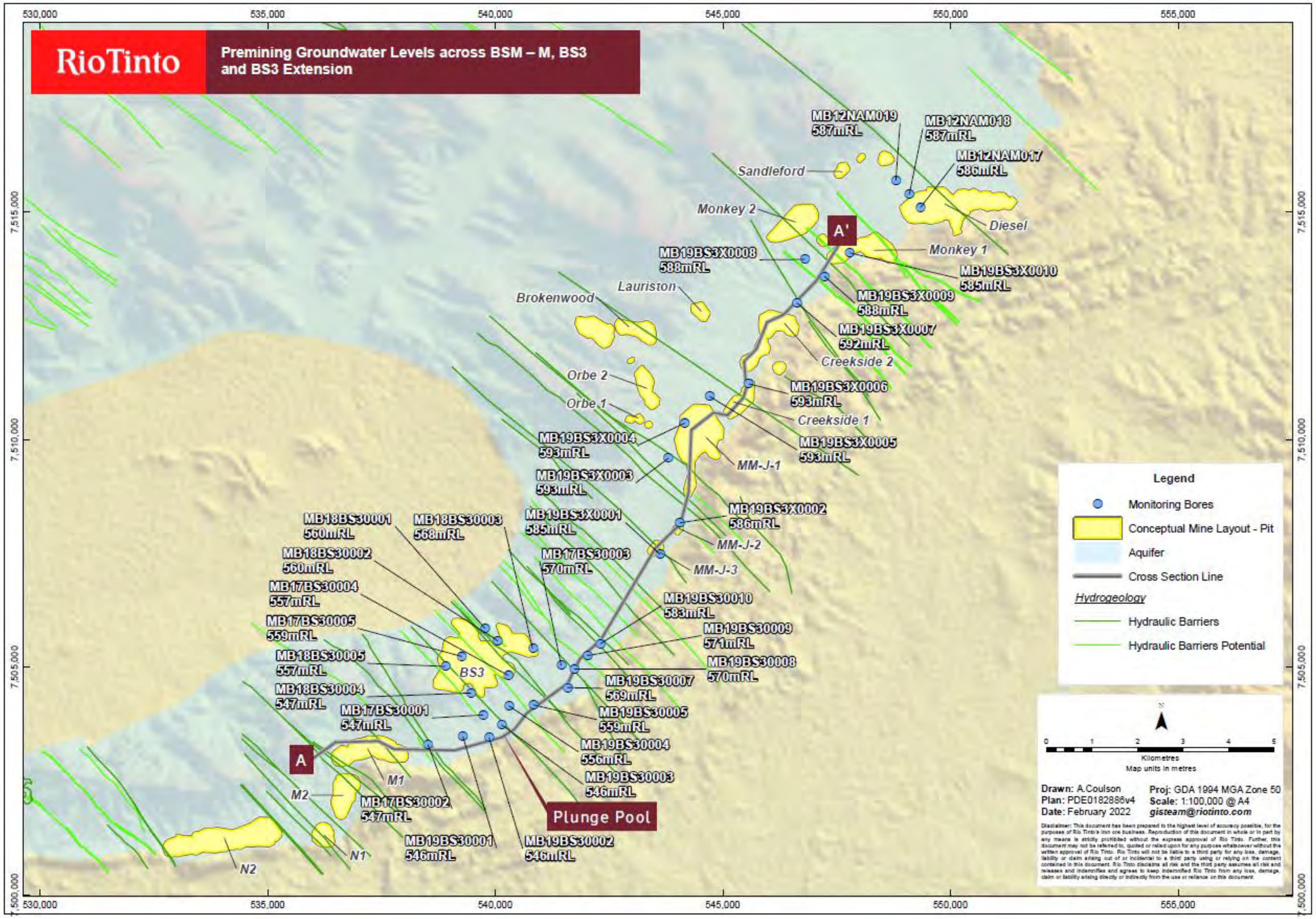

Figure 17 Pre-mining groundwater levels across BSM - M, BS3 and BS3 Extension.

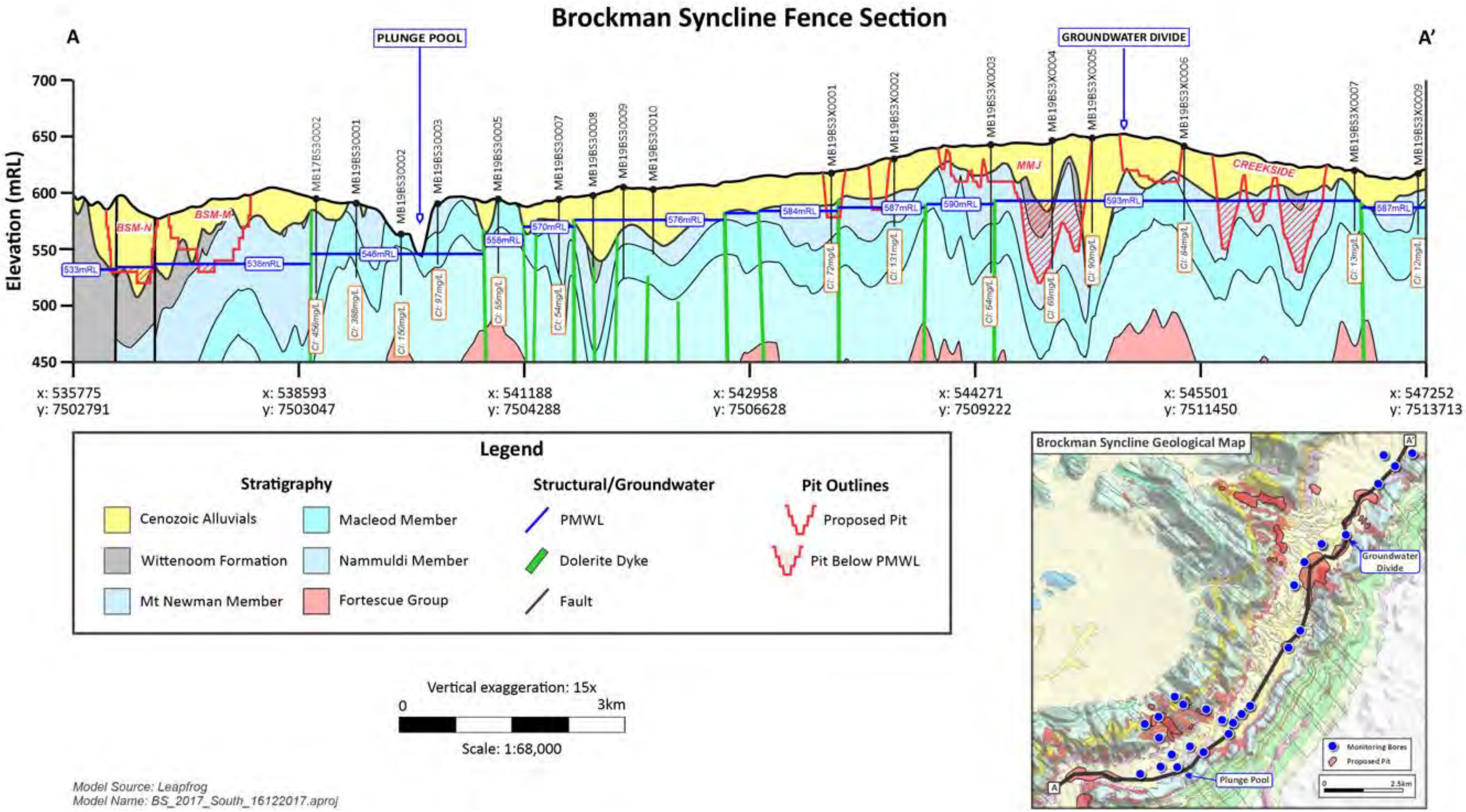

Figure 18 Fence section across BSM - M, BS3, Plunge Pool and BS3 Extension.

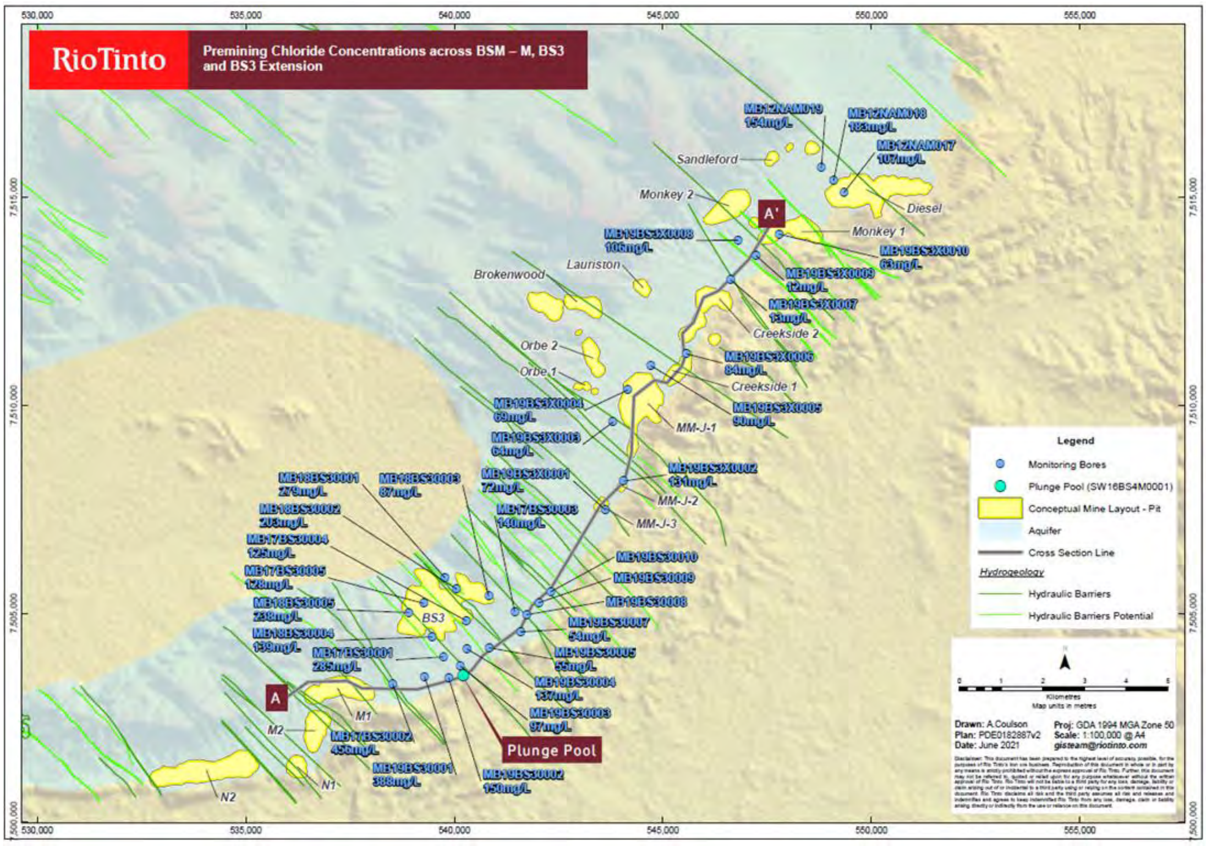

Figure 19 Pre-mining chloride concentrations across BSM - M, BS3 and BS3 Extension.

3.2 Seasonal Fluctuation In Response To Rainfall

Temporal groundwater level fluctuation is measured in MB's to understand recharge processes and baseline conditions. The MB's that contain information for an entire or multiple climatic season provide greater insight, in particular the bores located close to creek lines, which have shallow depths to groundwater. MB19BS30003 is screened in MMIF approximately 100 m from a creek line. The bore has been monitored every 24hrs hours from 29/09/2019 to current date and ongoing. (Figure 20). MB19BS30003 is installed to 54 m and has a depth to water of 24 m. There is a slight annual fluctuation of approximately 0.15 m, which may illustrate diffuse recharge during the wet season. Based on groundwater and rainfall information gathered to date, no rapid rainfall recharge response is evident across the Plunge Pool groundwater compartment.

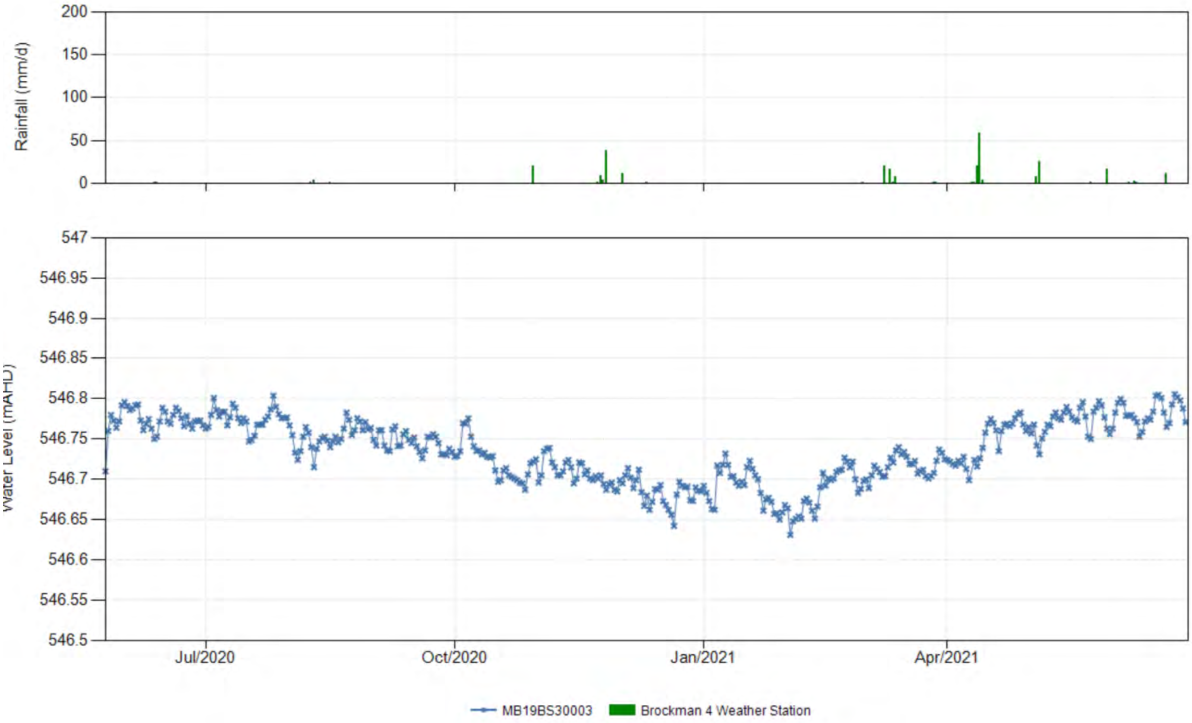

Figure 20 MB19BS30003 groundwater level vs rainfall.

4. Plunge Pool Water Balance

The pool water balance was constructed with the following objectives:

1. Determine the Plunge Pool's mode of occurrence and
2. Assess potential dewatering impacts from nearby BWT deposits on the pool.

The inputs to the pool water balance are rainfall, runoff from upstream catchment and groundwater flow through weathered unmineralised MMIF. The outputs are throughflow within the alluvium and evaporation (Figure 1). The BS4 weather station, which is located close to BS4 mine site, was used for daily rainfall and evaporation. This weather station is located outside the 20 km^2 upstream catchment but is only 10 km from Plunge Pool and is likely to be representative of weather at the pool. The daily evaporation was calculated from the weather station observations likely overestimates evaporation from Plunge Pool due to the amount of shade that is provided by gorge walls and surrounding vegetation. The daily rainfall may not be accurate given the isolated nature of rainfall events in Pilbara but should be representative of the seasonal rainfall trend.

Surface water stage heights in the upstream catchment are used to estimate flows into Plunge Pool via a surface water logger approximately 300 m upstream of the pool in the creek bed (logger installed in 2018). The graph below displays the surface water stage height from 2018 to end 2020, which ranges from 0 m to 1.8 m (Figure **21**).

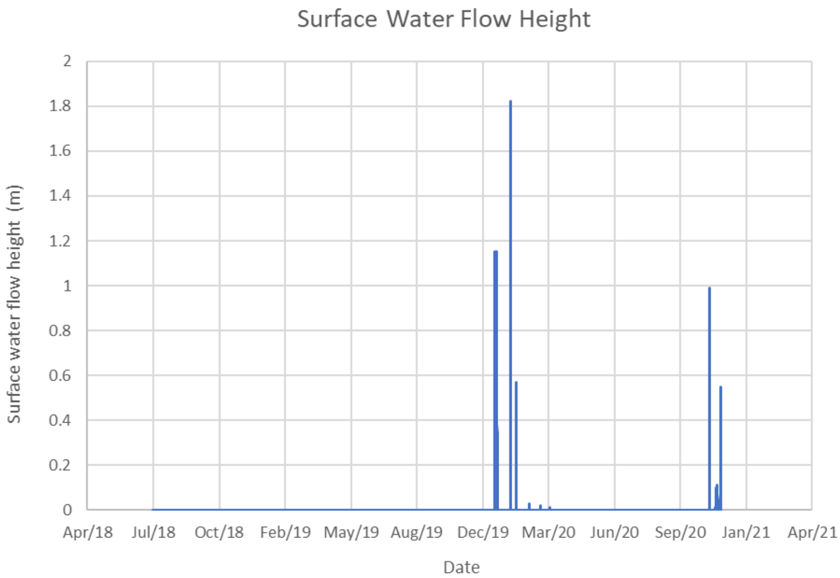

Figure 21 Surface water flow height from 2018 to end 2020 from upstream logger that is installed in creek bed

Based on a bathymetry survey that was completed in November 2016, the surface area of the pool was estimated to be 450 m^2 and the volume of water (combined groundwater and surface water) within the pool was predicted to be 585 m^3 at the time of survey (Figure 3). Please refer to Plunge Pool – Hydrological Impact Assessment (RTIO-PDE-0172037) for runoff volumes estimates for the 1 in 2 AEP design events. It is predicted that 47 ML of runoff from the pre-development catchment would flow into Plunge Pool (RTIO, 2021).

The amount of evaporation greatly exceeds rainfall and runoff, which suggests that the pool would become dry over time unless the pool receives groundwater from unmineralised MMIF. The daily water level recordings (~540.9 to 542.6 m RL) within the pool and monthly images highlight that the pool has not become dry (Figure 22).

The surrounding monitoring network suggests groundwater gradient is towards the pool. MB17BS30001 is screened in Wittenoom Formation, ~700 m northwest of pool and has a consistent water level of ~547 m RL (Figure 17). The closest monitoring bores to the pool (MB19BS30002 and MB19BS30003) are installed in MMIF have an approximate water level of 546 m RL (Figure 17). The pool water levels range between 540.9 to 542.6 m RL (Figure 22). The maximum pool water level of 542.6 m RL is understood to be the tipping point of the pool that was surveyed by flow height markings on a *Eucalyptus camaldulensis* tree within the pool (Figure 1).

Another surface water logger was installed approximately 20 m downstream of pool in the creek bed. This logger recorded flow data between March 2018 to November 2019. During this time period, no surface water flow was recorded as the tipping point of the pool was not reached (Figure 22).

Field chemistry data further supports that the pool is groundwater fed, topped up by rainfall and runoff up to the tipping point and depleted by evaporation to a level where groundwater inflow occurs from unmineralised MMIF. The electrical conductivity (EC) within the pool is observed to immediately increase during runoff events, which is assumed to be a result of rainfall runoff from the local catchment collecting salts prior to entering the pool (seen as water level rise of less than 0.5 m) (Figure 22). This peak in EC is then followed by a sudden decrease related to later rainfall runoff (without the salt load) entering the pool (Figure 23, see data approximately 22/3/2020 as example). Overtime, the EC signature of the pool gradually increases until another rainfall event takes place.

As seen in Figure 22, given the consistency of groundwater levels, this inflow rate will be relatively constant, so that (in the absence of streamflow) the variability in the salinity of the pool is driven by seasonal variation in temperature and evapotranspiration. These seasonal weather patterns drive evapo-concentration of solutes in the pool as water levels fall during the dry season and freshening of the pool as water levels rise when evapotranspiration decreases in winter (May-Sep).

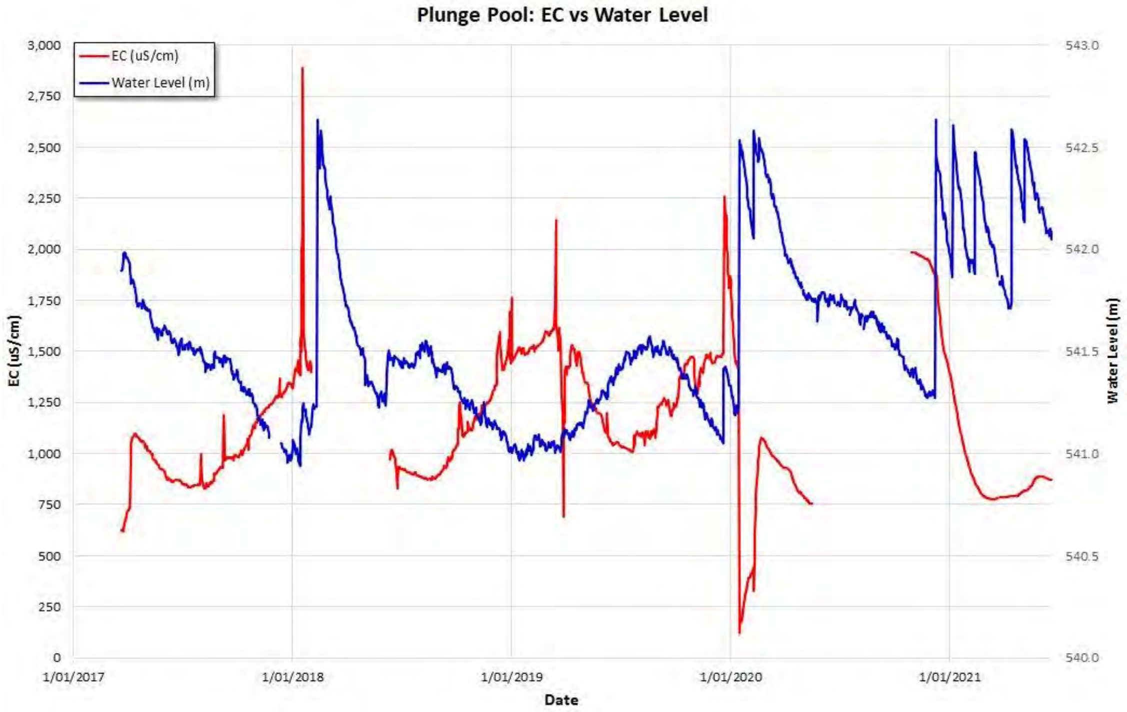

Figure 22 Plunge Pool water level vs EC during reporting period

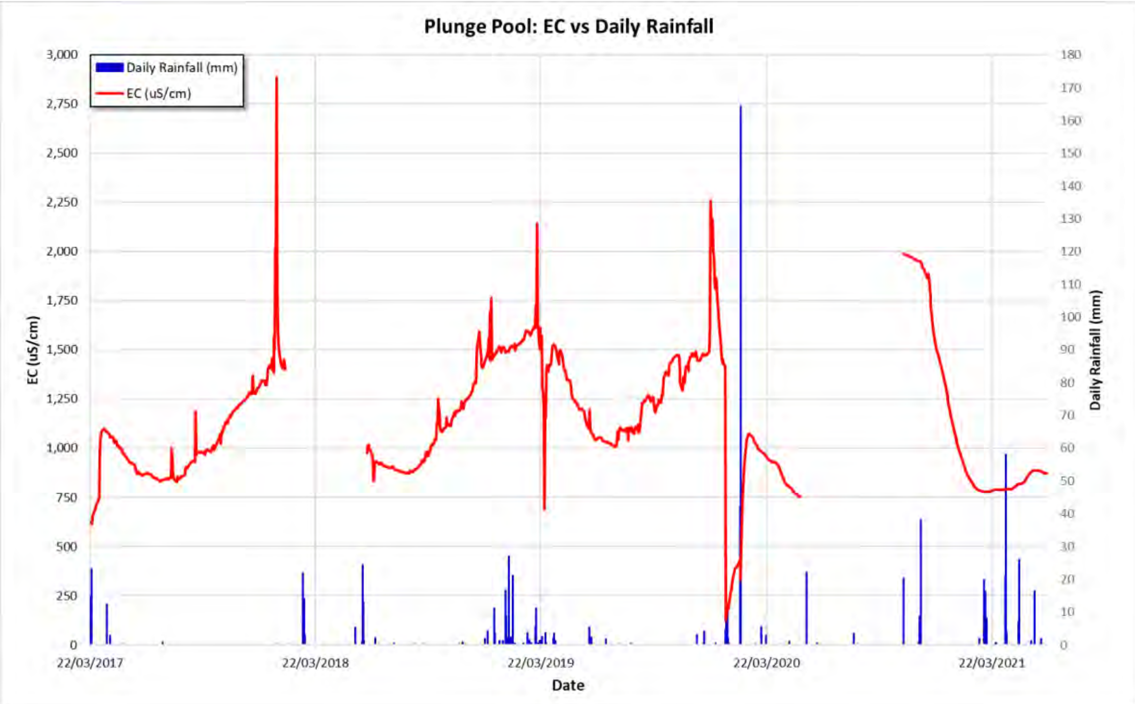

Figure 23 Plunge Pool EC vs Rainfall during monitoring period

The Cl concentrations within the recently installed MB19BS30002 in MMIF is 150 mg/L, which is assumed to be the baseline Cl concentration for the area (Figure 19). The highest recorded Cl concentration of Plunge Pool during the monitoring period is 194 mg/L, which was recorded after several months of minimal rainfall, and the lowest Cl concentration was recorded as 32 mg/L, after largest rainfall event (Figure 24). The Cl concentration in the pool decreases during and after rainfall events due to the additional water being fresher (less saline) than groundwater feeding the pool. The Cl concentration gradually equilibrates back to the groundwater concentration over time (Figure 24).

Note: Monitoring of Cl concentrations during 2020 and 2021 was irregular due to COVID related access restrictions. Prior to COVID, the Cl concentration within the pool were recorded on a monthly basis.

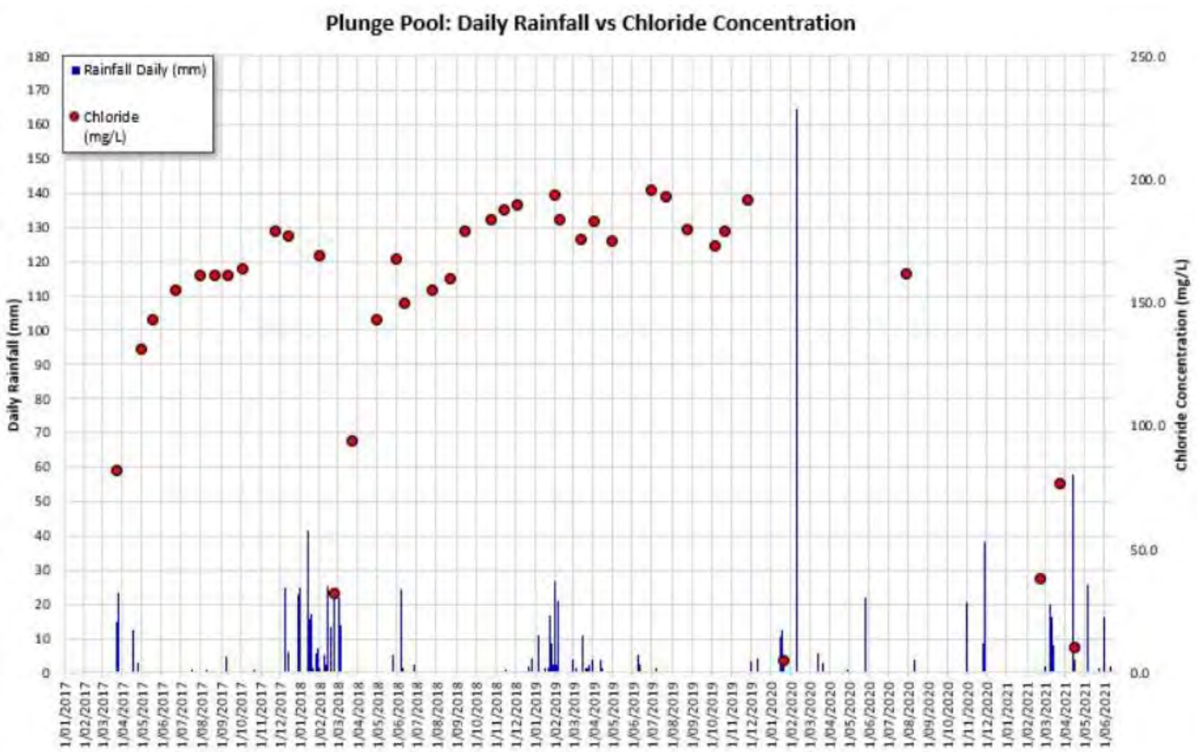

Figure 24 Plunge Pool Chloride concentration (mg/L) vs rainfall during reporting period

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5. Conclusion

Plunge Pool is a permanent water body at the base of a small gorge in the Hardey River catchment. The pool has ecological importance and has high cultural significance to the Eastern Guruma Traditional Owners. Therefore, the pool is to be protected from mining-related impacts.

The pool is fed by surface water runoff from an approximately 20 km^2 sub-catchment of the Hardey River catchment. The pool is also supported by groundwater from unmineralised MMIF. The maximum observed water level in the pool is 542.6 mRL. Bathometry data suggests that the depth of the pool is up to approximately 2 m.

The pool is approximately 20 km east of the current BS4 mining operations, 3 km east of BSM-M and BSM-N, 1 km south of BS3 and is down gradient of three deposits referred to as BS3 Extension; MM-J, CRK and BKWD within the Greater Brockman Syncline.

Bedrock aquifers of the Hamersley Group are somewhat strata bound by alternating higher and lower permeability rock types. Pre-mining groundwater levels across the Greater Brockman syncline are observed to change suddenly within short distances along strike of bedrock aquifers. It is hypothesised that dolerite dykes that cross the bedrock at oblique angles compartmentalise groundwater flow (Golder, 2017, Dodson, 2010). There is strong evidence that dykes are impeding groundwater flow across the Hamersley Basin and the Brockman Syncline in particular. Dolerite dykes occur in close proximity to the pool and the groundwater level observations support the compartmentalisation hypothesis that lateral groundwater flow is impeded across dolerite boundaries. Where bedrock is eroded and infilled with younger sediments and these are saturated BWT, groundwater may 'overtop' a dyke at the palaeo-erosion surface (eg. top of dyke).

Local groundwater levels are 593 mRL at MM-J and CRK, which are located ~9 km northeast of the pool. The groundwater level decreases stepwise through subsequent downstream compartments to the pool compartment where the groundwater level in MMIF MB's are at 546 m RL. The groundwater levels continue to reduce past the pool to ~535 m RL in the BSM-M deposit.

The hydrochemistry of the pool and surrounding groundwater further supports that the pool is groundwater fed, which is topped up by runoff during rainfall events. The EC within the pool immediately increases during high rainfall events as a result of runoff from the local catchment collecting salts prior to flowing into the pool. This peak in EC is then followed by a sudden decrease related to later runoff with a decreased salt load. Overtime, the EC signature of the pool gradually returns to an EC signature similar to adjacent groundwater until the next rainfall event takes place.

The Cl concentration of groundwater adjacent to the pool is ~150 mg/L. The highest recorded Cl concentration in the pool is 194 mg/L, which was recorded after several months of a relatively dry period. The lowest Cl concentration was recorded as 32 mg/L after cyclone Damien rainfall event. The Cl concentration in the pool decreases after rainfall events due to the additional rainwater being fresher than the pool water, but the Cl concentration gradually increases to resemble adjacent groundwater.

The Brockman Syncline Mining Proposal includes deposits BSM-N, BSM-M, BS3, MM-J and CRK. BWT mining was planned to take place at each of these deposits. The conceptual model suggests that dewatering of deposits west of the pool (BSM-N and BSM-M) will not have any impact on groundwater levels in the pool due to the presence of dolerite dykes preventing drawdown within the pool compartment. Monitoring of water levels in BSM-N, BSM-M and the Plunge Pool compartment will still be tracked to monitor for any potential effect on the pool from dewatering of these deposits. Dewatering from BS3, MM-J and CRK could reduce the ‘overtop’ flow into the downgradient pool compartment.

In order to better understand and confirm the hydraulic connectivity between regional groundwater, the pool and the role of adjacent dykes in groundwater flow, a drilling and pumping testing programme is planned to take place in 2022, with specific emphasis on monitoring drawdown propagation during pumping testing either side of dolerite dykes to gain further confidence on the pool conceptualisation.

References

Dodson 2010, Brockman Syncline 4 Life of mine water supply options. Unpublished report for Rio Tinto Iron Ore Expansion Projects, Resource Development Division, RTIO-PDE-0073403. April 2010.

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