Memorandum

Date	15 October 2019
To	Jon Hanna
CC	Suzi Wild
Authorised Sender	Tim Lawton, Russel Sanders
Our ref	RED NPH Ministers North Conceptual Hydrogeological Model Rev 3

Subject	**Ministers North Conceptual Hydrogeological Model**

Background

The Ministers North project area is situated approximately 8km south of the eastern pits of BHP Billiton's Yandi operation. The project area contains outcropping Brockman Iron Formation members which form the NW /SE trending Wirriba Anticline (BHP, 2017).

BHP Resource Engineering Water Planning is ramping up investigations as interest in using Ministers North to provide sustaining tonnes to feed Yandi infrastructure increases. Early activities included the installation of frontier piezometers in the Ministers North project area to enable monitoring of baseline groundwater conditions and potential longer term changes in groundwater levels. Changes in groundwater levels are anticipated if mining and associated dewatering proceed at Ministers North.

Monitoring data will inform BHP's adaptive management strategy for the Northern Pilbara region, which will be a key component of the upcoming Environmental Approvals for the development of Ministers North.

This memo is the third update of one initially compiled in March 2017 and includes the results of a 2019 field reconnaissance in an area of Yandicoogina Creek in the east of the tenement where groundwater is suspected to emerge in the streambed and sustain a groundwater dependent ecosystem. It also includes time series monitoring data from loggers installed in selected piezometers.

Field Programs

Rail Bore Installations

Two production bores were drilled in the Ministers North area in 2002 as part of the Mining Area C rail construction water supply (Figure 1, Table 1). Bores MN2P and MN3P (also known as M323.3 and M322.7 respectively) were cased with 195 mm ID PVC with slotted PVC installed below the water table and blank PVC comprising the rest of the casing string. Composite logs for bores MN2P and MN3P are presented in Appendix A (note that grid references in these logs are in not in MGA94 Zone 50 as they are in other parts of this report and should be ignored as a result).

Mineralised Dales Gorge Member BIF, where intersected by geologic al lineaments, was targeted for drilling. Mineralisation had previously been identified during BHP mineral exploration drilling on the northern and southern limbs of the east-west striking anticline in this area. Bores MN2P and MN3P were installed to depths of 98 and 93.5 mbgl respectively on the northern limb of the anticline.

The bores performed differently during 48 hour constant rate pumping tests, during which MN2P was pumped at 15.5 L/s and MN3P was pumped at 14 L/s (Table 2, Appendix B), with MN2P being the better of the two. The pumping rates were likely constrained by the size of pump able to be installed in the 8" casing.

An aquifer transmissivity of 420 m^2/d was derived for MN2P. In comparison the aquifer transmissivity for MN3P was estimated at 100 m^2/d. MN2P was used as an observation bore during the testing of MN3P, but no drawdown response was observed over the 495m separation distance over the 48 hours. It is possible that pumping at a higher rate and for longer duration could induce a reaction if there were hydraulic connection between the two locations (a critical factor to be determined since this will influence whether dewatering is likely to affect groundwater levels in Yandicoogina Creek). Initial water levels at the bores were recorded at 51.25 and 45.69 mbgl respectively, with field EC readings ranging from 630 to 740 µS/cm.

Subsequent analysis of the test pumping data indicated a sustainable long term abstraction at MN2P of 1700 kL/day (20 L/s) and 600 kL/day (7 L/s) at MN3P. Subsequent to rail construction MN2P has been utilised as water supply for the resource exploration drill programs (undetermined pumping rates) and is currently (October 2019) being used for rail upgrade works at rates up to 20 L/s.

Resource Exploration Drilling

Resource exploration drilling has been undertaken in recent years, ranging from extents programs in 2014/16, infill in 2016, to drillout in 2018/19. The extent of the exploration drilling over all programs is shown in Figure 2.

During these programs twenty eight frontier piezometers have been constructed using 50mm Class 18 PVC within 140mm diameter RC drill holes. Slotted casing (3mm aperture) was typically installed from around assumed water table to bottom of the hole. The 3mm slots allow the holes to be used for stygofauna traps.

Completion details are included in Table 3. Frontier piezometer locations are shown in Figure 1 including a number where water level loggers have been installed.

Several holes have recorded the intersection of black shales in the Whaleback Shale Member. These may limit discharge to land if encountered during hydro drilling.

Water Level Survey and Groundwater Flow Direction

A water level survey was undertaken on March 9 2017. The survey utilised 16 of the 19 frontier piezometers installed at that time (three in the south east of the project area were inaccessible due to washouts) and estimated water levels (based on measurements from October 2015) for the three inaccessible installations. Subsequent water level measurements were taken in August and September 2019 and are recorded in Table 3 and Figure 3. However, despite the increased number of frontier piezometers represented there was not sufficient discrepancy to update contours, based on the 2017 data, that were used to develop a pre-mining water level surface in early 2019 (Figure 4).

The 2017 survey aimed to:

- Obtain stabilised water levels for the holes completed in this programme;
- Provide a snapshot of water levels on a single day with a view to estimating groundwater flow directions.

To develop the water level surface dummy points were used along Yandicoogina Creek due to limited data coverage within this low lying topographic area. Without these dummy points water levels appeared to rise above ground in areas where this is not the case. This has been confirmed in Yandicoogina Creek (see

later section of this memo) in the eastern part of the model where phreatophytic (groundwater-dependent) vegetation and seepages/pools are present in the creek bed and adjacent banks in the vicinity of the dummy points. This can be referred to as the Yandicoogina Creek discharge zone.

- The predicted water level elevation ranges from 566 mRL in the southwest of the deposit to 553 mRL in the northeast. However, throughout the drilled orebody zones the measured water levels range between 564 mRL (over most of the deposit) and 562 mRL near to the Yandicoogina Creek discharge zone. This is very flat despite the significant topographical variability over the area.

- As a result of the topographic variability the measured depth to water level (Figure 3) ranges from 40mbgl (in the incised creeks near the centre of the deposit) to 155 mbgl (under the high country in the south of the deposit). It is near ground level in the Yandicoogina Creek discharge zone.

- Based on contouring there is a general groundwater flow from west to east through the domain with a component of northerly flow particularly in the north of the area. The northerly flow is inferred from topographic levels only and there are no groundwater levels measured between Ministers North and Marillana Creek at Yandi. This means that there is low confidence to the interpreted northerly flow component. Discharge from groundwater to Yandicoogina Creek appears to have a significant effect on groundwater flow direction in that area, but is based on limited data.

Hydrogeology

Stratigraphy

Local geology comprises Hamersley Group sediments from the Weeli Wolli Formation to the Mount McRae Shale, with the Brockman Iron Formation in between (Figure 5). Regionally Ministers North is situated in the hinge of the Wirriba Anticline. At deposit scale it is a gently dipping E-W doubly plunging anticline with shallowly dipping limbs in N-S directions (Figure 5) (BHP Billiton, 2016; BHP Billiton, 2017). The hinge of the anticline seems to be cylindrical and does not host mineralisation as the primary outcropping unit is the non-prospective Mount McRae Shale as shown in Figure 5 (BHP Billiton, 2017).

Mineralisation at Ministers North occurs within the Dales Gorge and Joffre Members of the Brockman Iron Formation, with the majority hosted by the D2/D4 units. Mineralisation occurs on both limbs of the Wirriba Anticline, with the more consistent mineralisation on the northern limb which is slightly steeper dipping than the southern limb as shown in Figures 6 to 9 (BHP Billiton, 2016; BHP Billiton 2017). The southern limb is gently dipping towards the south at approximately 15° (with some local steepening). The northern limb is gently dipping towards the north at approximately 25° (BHP Billiton, 2017).

Mineralisation on the southern limb occurs primarily in the Dales Gorge Member; within the strata-bound D4/D3 mineralisation in the west, and D2 mineralisation moving east as shown in Figure 8 (BHP Billiton, 2017) and Table 2. Similarly within the northern limb mineralisation primarily occurs within the strata-bound Dales Gorge Member and it not unusual for the entire sequence to be mineralised as shown in Figure 9 (BHP Billiton, 2017)

Sulphur-bearing Mt Whaleback Shale Member is present across the northern limb. On a number of occasions this prevented drill holes reaching target horizons in the Dales Gorge Member as shale material is not able to be discharged into receiving environment once a sump overflows (BHP Billiton, 2017).

Hydrogeological Units

Drillers' observations indicate that mineralised Dales Gorge Formation forms the dominant aquifer system beneath Ministers North. However, sections of the Whaleback Shale and Joffre Member (sometimes

mineralised) yielded some water (probably from fractures in brittle zones including chert bands). In typical fractured rock fashion the higher yielding holes are erratically distributed.

Several holes indicated ambiguity surrounding the water source as sumps overflowed across mineralised and unmineralised units. One hole, MN0637RE, indicated inflows in both the D4 and D2 ore zone, indicating increased permeability in both units.

Groundwater Levels and Flow

Sixteen loggers have been installed throughout Ministers North (Figure 1) to collect time series water level data to determine water level fluctuations. These include:

- Eight installed throughout the deposit on 16 March 2018;
- Four installed in the vicinity of the Yandicoogina Creek discharge area on 12 December 2018 (in an attempt to pick up any response to potential creek flow in the 2018/19 wet season);
- Four installed in the vicinity of bore M323.3 in September 2019 with a view to recording response to pumping from that water supply bore by rail contractors.

Data was downloaded from the first two categories in September 2019, with length of data being between 10 and 20 months. The data is plotted in Appendix C and is compared to rainfall data from the Ministers North rain gauge, WMN001 (Figure 1). General observations include:

- All loggers have been declining throughout those periods with the typical decline being about 1m over the 20 month period.
- All loggers responded to 95mm of rainfall between 23 January and 7 February 2019. It is possible that this rainfall resulted in flow in Yandicoogina Creek. However, there was little reaction to dry season rainfall of 101mm between the 6 and 8 June 2018. The latter, although large, had effectively 4 months of no preceding rainfall.
- Two types of reaction to the rainfall in early 2019 are observed:
    - A rapid rise in water level of between 0.15 and 0.25 m in 9 of the holes (Figure C1). After this rapid rise the trend returns to a similar rate of decline to that before the rainfall event. One of the affected holes, MN0068R (Figure 9a), has a water level depth of 155m and so direct recharge is unlikely. The rapid response could be interpreted as a pressure effect, potentially due to flow in Yandicoogina Creek.
    - A more subdued response to the January/February 2019 rainfall where the rate of water level decline decreases for about four months after the rainfall, and then returns to the antecendent rate of about 0.1m per month (Figure C2). The affected holes are located along the northern limb of the anticline or in the hinge.

The distribution of the loggers showing the different responses is shown in Figure 9a. In general the loggers showing a rapid “stepped” rise are closer to Yandicoogina Creek or significant tributaries, while the more subdued responses are more remote. Of interest loggers in holes adjacent to the two water supply bores MN2P/M323.3 and MN3P/M322.7 respond differently. One possible explanation could be that these holes are not hydraulically connected.

Yandicoogina Creek Reconnaissance Visits

The incised and heavily vegetated portion of Yandicoogina Creek (Photos 1 and 2) was visited by Water Planning hydrogeologists on 15 March 2018, primarily to determine whether there was any evidence of groundwater emergence in the streambed. This area, in the eastern sector of Ministers North (Figure 3), was the subject of vegetation surveys in September 2016 and May – July 2017 (Biota Environmental Sciences, 2017).

The vegetation surveys had demonstrated the presence of three vegetation associations of elevated local importance in the broader Ministers North. The area of interest in Yandicoogina Creek supported one of these associations termed "Melaleuca argentea open forest". This association includes the groundwater-dependent tree species Eucalyptus camaldulensis refulgens (River Gum) and Melaleuca argentea (silver cadjeput or silver-leafed paperbark). Scattered sedges and rushes also occur within this association; generally in areas of surface moisture.

As well as the presence of groundwater-dependent vegetation (GDV) evidence consistent with groundwater emerging in Yandicoogina Creek was collected during the March 2018 visit, including:

- Water quality from shallow water under rushes (GR MGA Zone 50: 720088 – 7473809, Photo 3) is consistent with typical groundwater in these areas (e.g. from the rail test pumping program) rather than recent rainfall. One sample from a small excavated hole under the rushes was tested using a handheld meter. The results were:
    - Electrical conductivity 696µS/cm at 31º
    - pH 6.7
- Seepage at the base of the valley wall (at and above valley floor), indicated by sedge grasses and moist soil (GR MGA Zone 50: 720125-7473915, Photo 4). This moist zone contrasted with dry soil over most of the valley with no visible surface water despite this being after recent rains. It is likely that evapotranspiration rates are lowering the water levels to below the ground surface over much of the area.
- The Melaleuca argentea trees were large and healthy (described as excellent to very good health in the BES report), which is consistent with a shallow and reliable groundwater supply.

Photo 1: View looking eastwards into incised and heavily vegetated area of Yandicoogina Creek in eastern sector of Ministers North

Photo 2: Healthy vegetation, including rushes and paperbarks in Yandicoogina Creek

Photo 3: Excavated shallow water at base of rushes (tested using handheld meter)

Photo 4: Seepage ("Sanders Seep") at the base of the valley wall indicated by healthy sedge grasses

The BES report also noted that a "Eucalyptus open woodland" vegetation association occurred in the southern section of Yandicoogina Creek (upstream of the visited zone) within the study area and supported the potentially phreatophytic tree species Eucalyptus victrix. This association is also of importance as it is considered potential GDV.

A second reconnaissance by BHP Water Planning and Biodiversity staff was undertaken on the 28 to 29 August 2019. This involved a simple survey of pools in the Yandicoogina Creek discharge zone for 3km downstream of the first GDE type vegetation (large paperbarks) (Figure 10, Table 4) and then a survey upstream of this area where pools had been observed earlier in the year.

Key observations from this field visit include:

- GDV and persistent pools occur downstream of the point where the RL of the Yandicoogina Creek bed is about 562.9mRL (similar to nearby groundwater levels as observed at MN0117R and MN1499R). This area is denoted by a large Melaleuca argentea (paperbark) (Photo 5). Details and locations of the pools downstream of this point are summarised in Figure 10 and Table 4.

- The water bodies in the discharge zone range from seepages (often under sedge) to large pools (e.g. Delaneys Pool (Photos 6 – 8). Electrical conductivities (EC) of the pools vary between 528 and 798 µS/cm, which are consistent with groundwater values in the area, although it can be expected that these values have been influenced by rain-sourced stream flow and subsequent evaporation. Measured pH values vary between 7.16 and 8.3. The vegetation (particularly large old paperbarks) and the presence of fish in some pools is indicative of permanence of water in the area.

- A walking survey of Yandicoogina Creek upstream of the discharge zone found no pools although some had been observed by the Biodiversity team on 1 May 2019. The vegetation (Camaldulensis, Glomerata, Euc. victrix) and lack of standing water were consistent with an area above groundwater levels, but with seasonal water at shallow depths in the alluvium, and pools fed by wet season rainfall but receding as a result of evaporation and infiltration. Further evidence for this area being surface water fed include:

    - A small water sample was taken at a site where a pool (Photo 9) was observed by Biodiversity on 1 May (obtained by excavating in the bottom of the dry pool). The EC (407 µS/cm) and pH (6.97) are consistent with surface water that has been subjected to evaporation and is lower than the groundwater values measured elsewhere.

    - Groundwater levels measured at MN0117R (Figure 10) are 7m below the RL of the adjacent creekbed, confirming that in this upstream area groundwater is unlikely to be sustaining pools.

Photo 5: Large paperbark at upstream end of Yandicoogina Creek discharge zone (MGA94-50

Photo 6: Standing water among sedges (EC 715 µS/cm, pH 7.16). GR 720640 – 7473900.

Photo 7: Pool with sedges and rainbow fish (indicating permanence). EC 621 µS/cm. GR 720991 – 7474102.

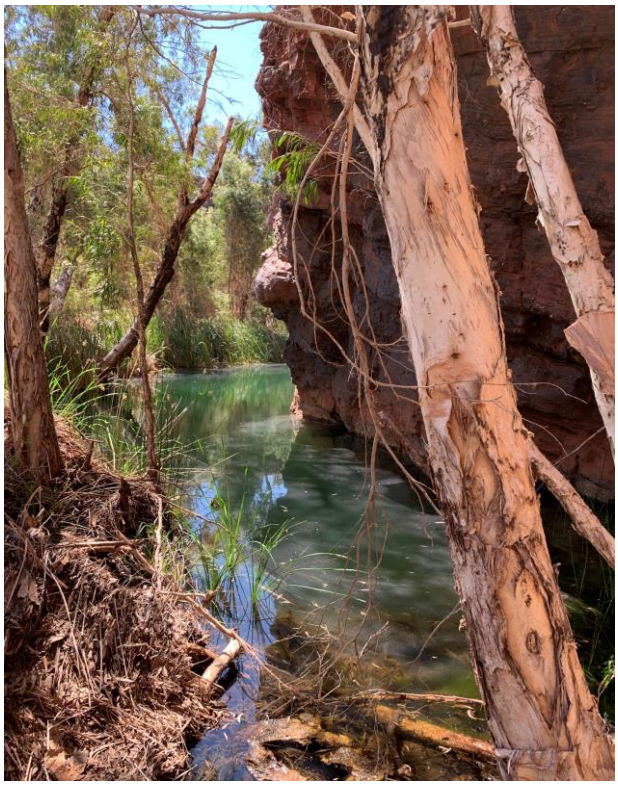

Photo 8: Delaneys Pool with fish, paperbarks and sedge. EC 655 µS/cm, pH 7.42. GR 721954 – 7474120.

Photo 9: Remnant pool site (observed as wet in May 2019) upstream of discharge zone. Readings from water in hole excavated at lowest point of pool were EC 407 µS/cm, pH 6.97. GR 718226 – 7472340.

Conceptual Hydrogeological Model Summary

- The Ministers North Project Area comprises Hamersley Group sediments from the Weeli Wolli Formation to the Mount McRae Shale, with the Brockman Iron Formation in between. It is in the hinge of the Wirriba Anticline (at deposit scale it is a gently dipping E-W doubly plunging anticline with shallowly dipping limbs). The hinge of the anticline does not host mineralisation and the primary outcropping unit is the low permeability Mount McRae Shale.

- The mineralisation occurs predominantly in the Dales Gorge and Joffre Members of the Brockman Iron Formation. Groundwater yields have been observed from both mineralised and fractured unmineralised lithologies, but aquifer extent is limited with significant groundwater intercepts not noted in most exploration holes.

- Faulting is inferred in the area and has been demonstrated to provide increased groundwater yields where present.

- Groundwater levels are generally very flat throughout the deposit suggesting only very slow groundwater movement through the area, although the incised Yandicoogina Creek in the east of the deposit seems to provide a groundwater outlet from the tenement. The groundwater emerging in this area sustains pools, groundwater dependent vegetation, and fauna, including fish.

- Seasonal variability is suggested by the limited number of water level loggers installed in the area but this appears to be small. On average a dry season recession in water levels occurs at about

0.1m/month, and levels respond to recharge which may be the result of stream flow in the wet season, but may also be a pressure response.

Further work

Unknowns

- Degree of connectivity between dewatering area and gorge
- Explanation for rapid recharge response despite water levels being deep at most locations
- Are both north and south orebodies providing flow to the gorge
- What dewatering is required to meet the mine plan
- How could the drawdown impact of potential dewatering be mitigated
- How do we re-establish the flow regime in closure (is there enough water)
- How much outflow occurs via evapotranspiration flux in the gorge
- Can we mitigate and dewater; will we run out of water for mitigation

Possible studies

- Hydrogeochemistry and isotopes (orebody water vs pools)
- Assessment of GWL data from loggers with increasing length of data (including the reasons for the rapid response of some bores, including deep ones, to prolonged rainfall)
- Test pumping to assess connectivity throughout orebody (south and north)
- Assessment of ET flux
- Stream gauges
- Mitigation options analysis
- Closure landform and management

References

BHP Billiton, 2016. Infill drilling program to improve confidence in volume and grade variability to support the Yandi Opportunity Assessment.

BHP Billiton, 2017. Ministers North FY17 Field Geology Summary.

Biota Environmental Sciences, 2017. Ministers North Detailed Flora and Vegetation Survey. Prepared for BHP, October 2017.

Table 1: Ministers North Production Bore Details and Construction Summary

Bore	Location Data[1]		Drilling Data						Construction Data			Geology
	Easting (m)	Northing (m)	Date Drilled		Drilled Depth (mbgl)	Water Level (mbgl)	Date of WL Reading	Max Airlift Yield[*2] (L/s)	Total Cased Depth[*3] (m)	Material and Slotted Interval		Screened Units
			Started	Finished						195 mm ID PVC (mbgl)	254 mm ND Steel (mbgl)	
MN2P	718517	7474596	23/01/02	25/01/02	100	51.25	26/01/02	7.5	98	50-98		Mineralised BIF
MN3P	718961	7474376	25/01/02	27/01/02	100	45.69	27/01/02	8.5	93.5	39.5-93.5		Mineralised BIF

1 – Surveyed with hand-held GPS unit

Table 2: Summary of Ministers North Production Bore Test Pumping Schedules

Test Bore	SWL (mbgl)	Obs Bore	Testing Dates		Test Duration (mins)			Constant Rate Test			Adopted Transmissivity (m^2/d)
			Start	Finish	Step Test	Constant Rate	Recovery	Discharge		Drawdown Test Bore (m)	
								KL/d	L/s		
MN2P	45.69	-	03/03/02	07/03/02	4 x 100	2880	60	1339	15.5	6.72 m	420
MN3P	51.25	MN2P	28/02/02	03/03/02	4 x 100	2900	60	1210	14	13.52 m	100

Table 3: Hydro Installations

Hole Name	Easting MGA94-50	Northing MGA94-50	Ground RL (mAHD)	RL TOC (mAHD)	Start Date	Finish Date	Drilled Depth (m)	Inclination (degrees)	Slotted Interval (m)	Screened Stratigraphy	Interpreted Inflow Stratigraphy	WL mbTOC	WL mRL	Date	Comment
MN2P/ M323.3	718517	7474596			23/01/2002	25/01/2002	100	-90	50-98	Mineralised D BIF	Mineralised D BIF	53.11		23/09/2019	Rail bore. TOC 0.33magl
MN3P/ M322.7	718961	7474376			25/01/2002	27/01/2002	100	-90	39.5-93.5	Mineralised D BIF	Mineralised D BIF				Rail bore
MN0053R	717601	7473563	634.074	634.48	5/07/2014	6/07/2014	123	-70	96-120	D2	D2	76	563.07	20/09/2019	Frontier piezometer
MN0055R	718117	7473428	660.441	661.24	7/07/2014	8/07/2014	123	-70	114-120	D1	D1	102.44	564.98	26/07/2018	Frontier piezometer
MN0057R	719450	7473970	606.646	607.66	9/07/2014	10/07/2014	93	-70	54-78	D4	D4	48.13	562.43	20/09/2019	Frontier piezometer
MN0068R	716406	7472964	717.206	718.02	30/09/2015	30/09/2015	201	-90	135-201	J1-W-D2	J1-W	155.43	562.59	20/09/2019	Frontier piezometer
MN0088R	720057	7472583	653.434	654.30	20/10/2015	20/10/2015	129	-90	42-126	D3	D2-D3	91.94	562.36	20/09/2019	Frontier piezometer
MN0117R	718860	7472766	610.335	611.18	12/10/2015	12/10/2015	111	-90	36-96	D4	D4	48.66	562.52	20/09/2019	Frontier piezometer
MN0121R	720050	7473270	606.761	607.57	15/10/2015	15/10/2015	81	-90	15-57	D1-D2	D1-D2	43.83	563.75	6/12/2018	Frontier piezometer
MN0297R	714346	7475373	656.882	657.88	17/11/2016	18/11/2016	105	-90	90-102	D1-RU D3	D1-RU	95.45	562.43	23/09/2019	Frontier piezometer
MN0315R	714651	7475496	636.255	637.24	17/11/2016	17/11/2016	87	-88	72-84	D2-D3	D3	74.68	562.59	20/09/2019	Frontier piezometer
MN0368R	715232	7475462	636.404	637.15	8/11/2016	9/11/2016	129	-90	72-126	D4	D2-D3	74.42	562.73	23/09/2019	Frontier piezometer
MN0439R	716144	7475398	668.352	669.05	5/11/2016	5/11/2016	153	-90	132-150	D3-D4	D4	106.28	562.77	23/09/2019	Frontier piezometer
MN0447R	716305	7473411	697.072	697.99	25/11/2016	25/11/2016	165	-90	102-150	D2-D3	D3-D4	135.72	562.27	23/09/2019	Frontier piezometer
MN0475R	716625	7473454	663.777	664.71	27/11/2016	27/11/2016	147	-90	102-126	D3-D4	D2-D3	102.23	562.48	20/09/2019	Frontier piezometer
MN0599R	717640	7475004	635.678	636.36	22/10/2016	23/10/2016	198	-90	72-120	D2-D3	D3-D4	73.6	562.76	23/09/2019	Frontier piezometer
MN0671R	718244	7474803	620.848	621.71	8/10/2016	9/10/2016	159	-90	60-138	D2	D2-D3	58.83	562.88	23/09/2019	Frontier piezometer
MN0707R	718553	7474521	615.335	616.06	7/10/2016	7/10/2016	99	-90	46-66	J1-W-RU	D2	53.16	562.9	23/09/2019	Frontier piezometer
MN0742RE	718988	7474385	607.956	608.86	10/12/2016	14/12/2016	129	-89	36-82	RN	J1-W	45.34	563.53	16/03/2018	Frontier piezometer
MN0786R	715848	7475179	661.362	662.30	29/10/2016	29/10/2016	123	-89	98.7-104.7	D1-D2	RU-RN	99.56	562.77	23/09/2019	Frontier piezometer
MN0848DTM	716813	7475123	603.72	604.33	31/10/2016	1/11/2016	90	-90	42-84		D1-D2	41.44	562.9	29/08/2019	Frontier piezometer
MN1018R	715754	7475459	655.67		17/12/2018	17/12/2018	138	-90	90-138	J1-W-D4-D3					Frontier piezometer
MN1119R	716396	7475308	672.701		13/12/2018	13/12/2018	135	-90	108-132	D4-D3					Frontier piezometer
MN1212R	717249	7475177	627.912		9/11/2018	9/11/2018	93	-90	60-84	W					Frontier piezometer
MN1418R	718339	7474627	623.516	624.48	2/10/2018	2/10/2018	75	-88	55-67	D1	D1	61.37	563.16	23/09/2019	Frontier piezometer
MN1465R	718598	7474414	609.473	610.23	8/10/2018	9/10/2018	72	-90	48-72	D1-R	D1	47.38	562.85	23/09/2019	Frontier piezometer
MN1474R	718647	7474603	609.475	610.10	1/11/2018	2/11/2018	143	-90	48-102	D3-D2	D3-D2	47.25	562.85	23/09/2019	Frontier piezometer
MN1499R	719755	7474166	611.597	612.37	26/09/2018	26/09/2018	93	-90	30-66	J1-W-D4	W	49.91	562.46	29/08/2019	Frontier piezometer
MN1503R	720047	7474239	633.392	634.00	25/09/2018	25/09/2018	84	-89	54-84	J2	J2	71.82	562.19	20/09/2019	Frontier piezometer
MN1643R	717051	7473601	648.097		14/02/2019	15/02/2019	117	-90	85-115	D3-D2-D1	D2-D1				Frontier piezometer

Table 4: Data from 28 – 29 August 2019 Field Visit

Site ID	Easting	Northing	EC	pH	Temp	Date	Vegetation	Comments
Groundwater Discharge Zone								
Potential gauging site	719511	7473495				28/08/2019	Melaleuca (paperbark)	Small tree upstream of first paperbark (Melaleuca quinquenervia)
	719618	7473706	528	OR	19	28/08/2019	Melaleuca, sedge	First water
	719690	7473749	569		19	28/08/2019		
	719736	7473772				28/08/2019	Sedge, Victrix?	Photos of variation of structure from south side of valley to north (folded vs flat). As if valley acting as a fault.
	719839	7473806				28/08/2019	Eucalyptus victrix	Distinct drier zone (water level deeper?), more victrix, less Melaleuca. Broader valley. Unmineralised BIF to north, Dales 3? to south perhaps.
Sanders Seep	720113	7473910				28/08/2019	Sedge	No standing water. At base of Joffre BIF (possibly some fracturing). Silty cobble colluvium damp.
Rauls Pool	720457	7473807	73	8.3	21.7	28/08/2019		Rocky (chert) gorge. Seems to be rainwater
	720171	7473910				28/08/2019		Joint on north side
	720616	7473971				28/08/2019		Raul standing in wet patch against northern wall (mainly dry in this area)
	720963	7474112	654		23.8	28/08/2019	Melaleuca roots	Site for stygofauna. Water visibly flowing through from rocky alluvium
	720757	7473966	662	7.57	19.8	28/08/2019	Sedge	Not much standing water, but some.
	720991	7474102	621		25.3	28/08/2019	Sedge	Large pool with sedges. Rainbow fish suggesting permanence.
	721707	7474191	798	7.67	20.5	28/08/2019		Hole dug in alluvium at top end of pool (EC =824 @ 21.6, pH = 7.34). Higher EC may be due to further from source rather than evaporation since excavated hole not yet subjected to evap.
Delaneys Pool	721954	7474120	655	7.42	21.1	28/08/2019	Melaleuca, sedge	Big deep pool
	720640	7473900	715	7.16	20.7	28/08/2019	Sedge	Lots of standing water in among sedges
	722056	7474266	685	7.48	23.1	28/08/2019	Sedge	
	722166	7474288	685		13.8	28/08/2019		Rocky pool with manganese staining on wall
	722269	7474252	692	7.82	16.8	28/08/2019	Melaleuca, sedge	North wall with well jointed rock. Pool in alluvium
	721524	7474170	715	7.5	22.2	28/08/2019	Melaleuca, Euc camaldulensis	Furthest downstream pool visited
Upstream of Groundwater Discharge Zone								
	717782	7471466				29/08/2019	Large Eucalyptus camaldulensis	Camaldulensis indicative of shallow water. This seems like transition zone from deeper water to shallow.
	717931	7471539				29/08/2019	Sedge	
	718244	7471659				29/08/2019	Melaleuca glomerata	Glomerata sign that may be moving towards GDE
	718512	7471900				29/08/2019	Victrix	Back into victrix with some evaporative white in alluvials
	717722	7471492				29/08/2019	Camaldulensis	Camaldulensis may be indicator of more water influence
	718503	7472043				29/08/2019	Victrix, Camals, Gloms	Deep wash out against eastern rock wall. Was wet ground when visited by Biodiversity earlier in year. Bone dry now.
	718226	7472340	407	6.97	15	29/08/2019		Deep wash out against northern rock wall. Was pool when visited by Biodiversity earlier in year. Damp silty bottom now. Generally shaded perhaps. Excavated in silt to get free water.

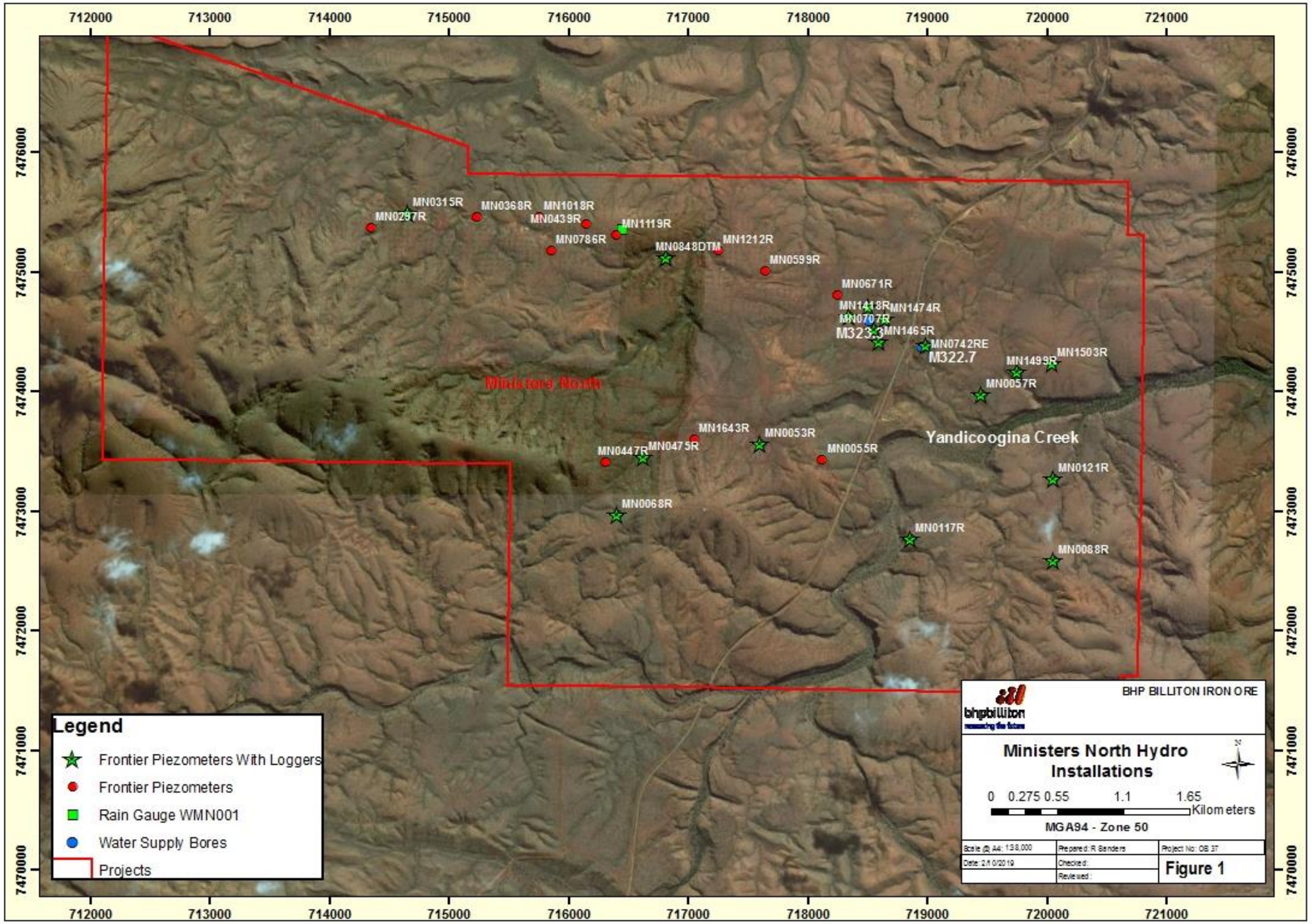

Figure 1 Ministers North location map with hydro installations.

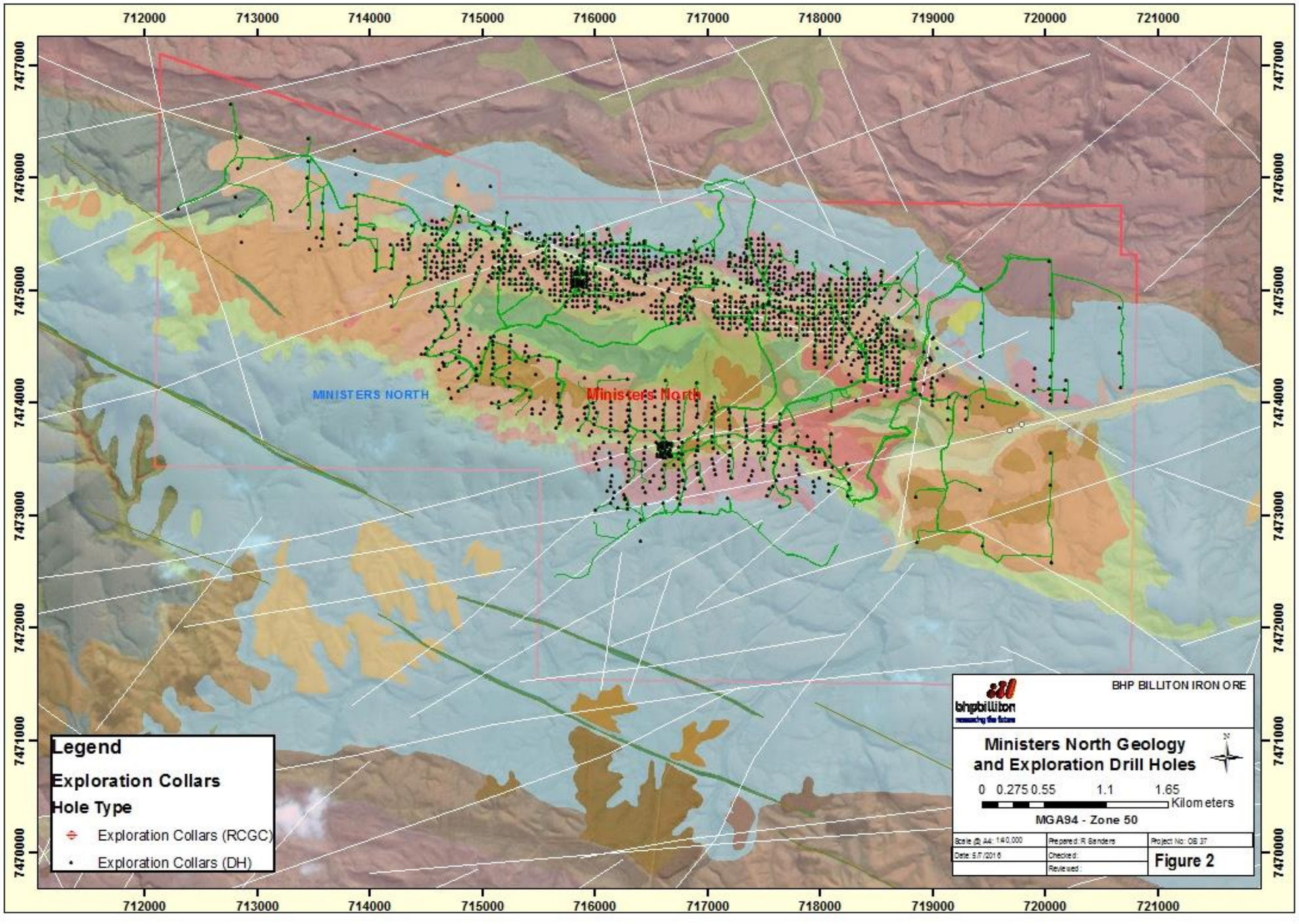

Figure 2 Exploration drill holes from all programs

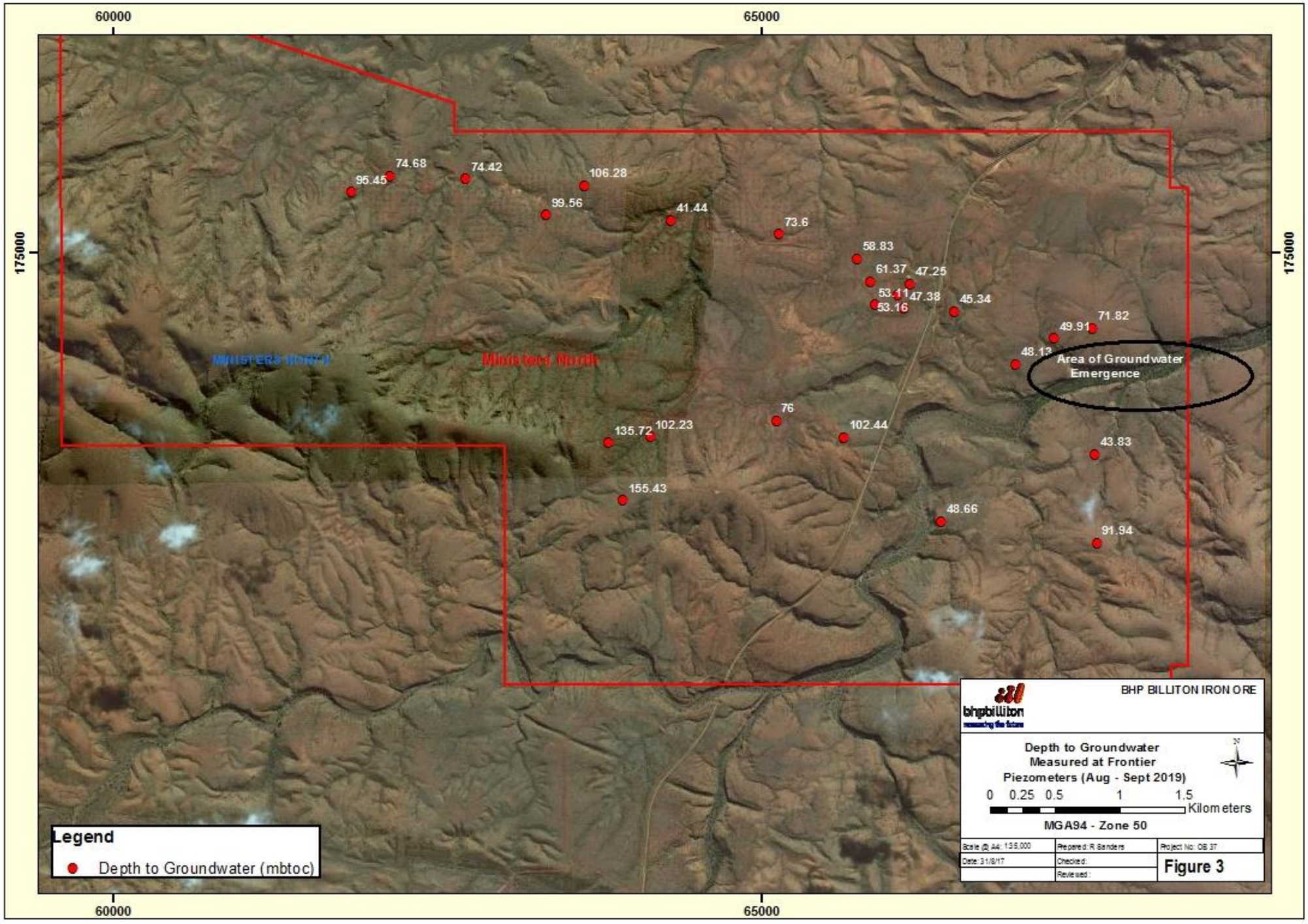

Figure 3 Depth to water (mbtoc) measured between August and September 2019

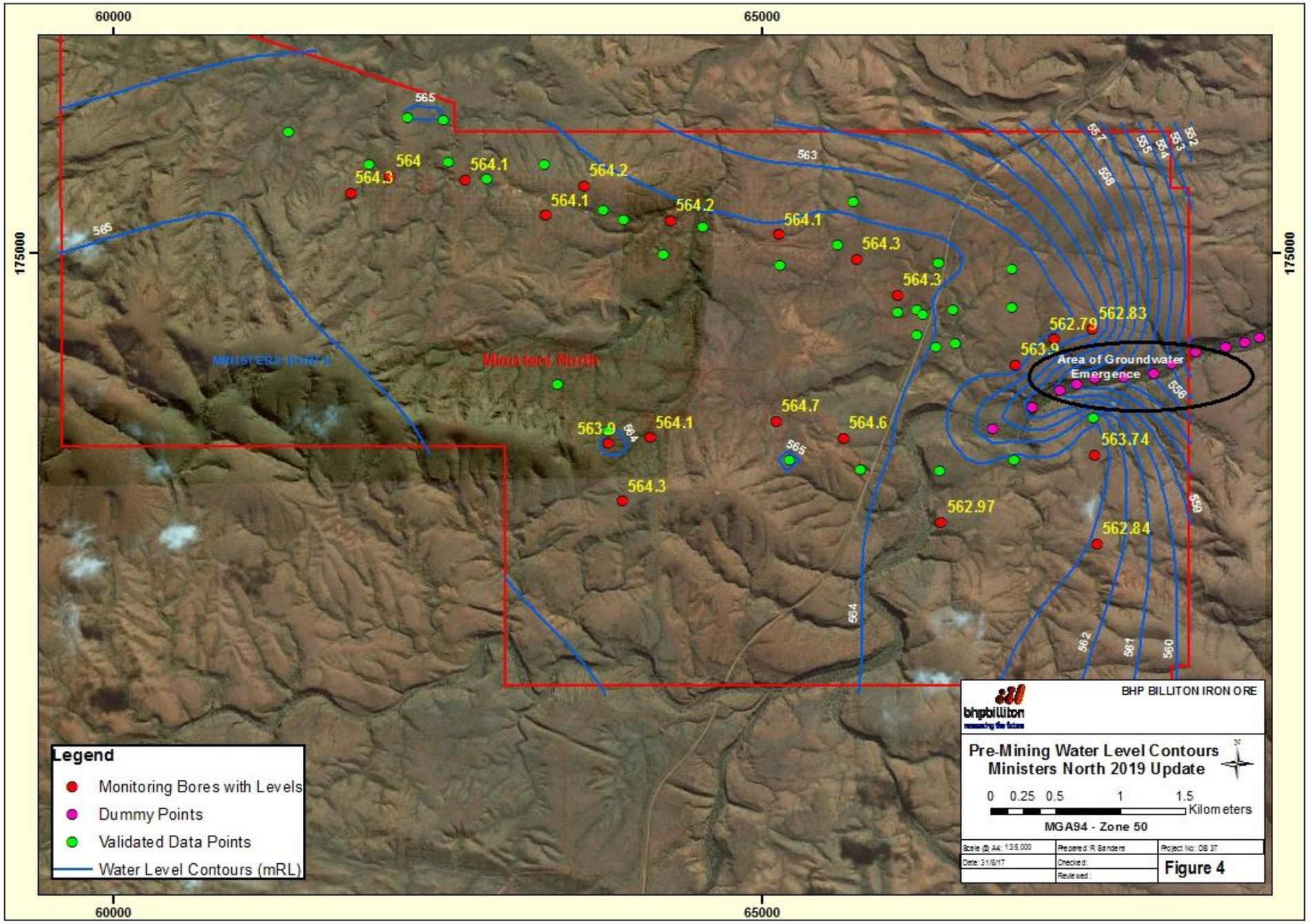

Figure 4 Water level contours based on water level survey on March 9 2017

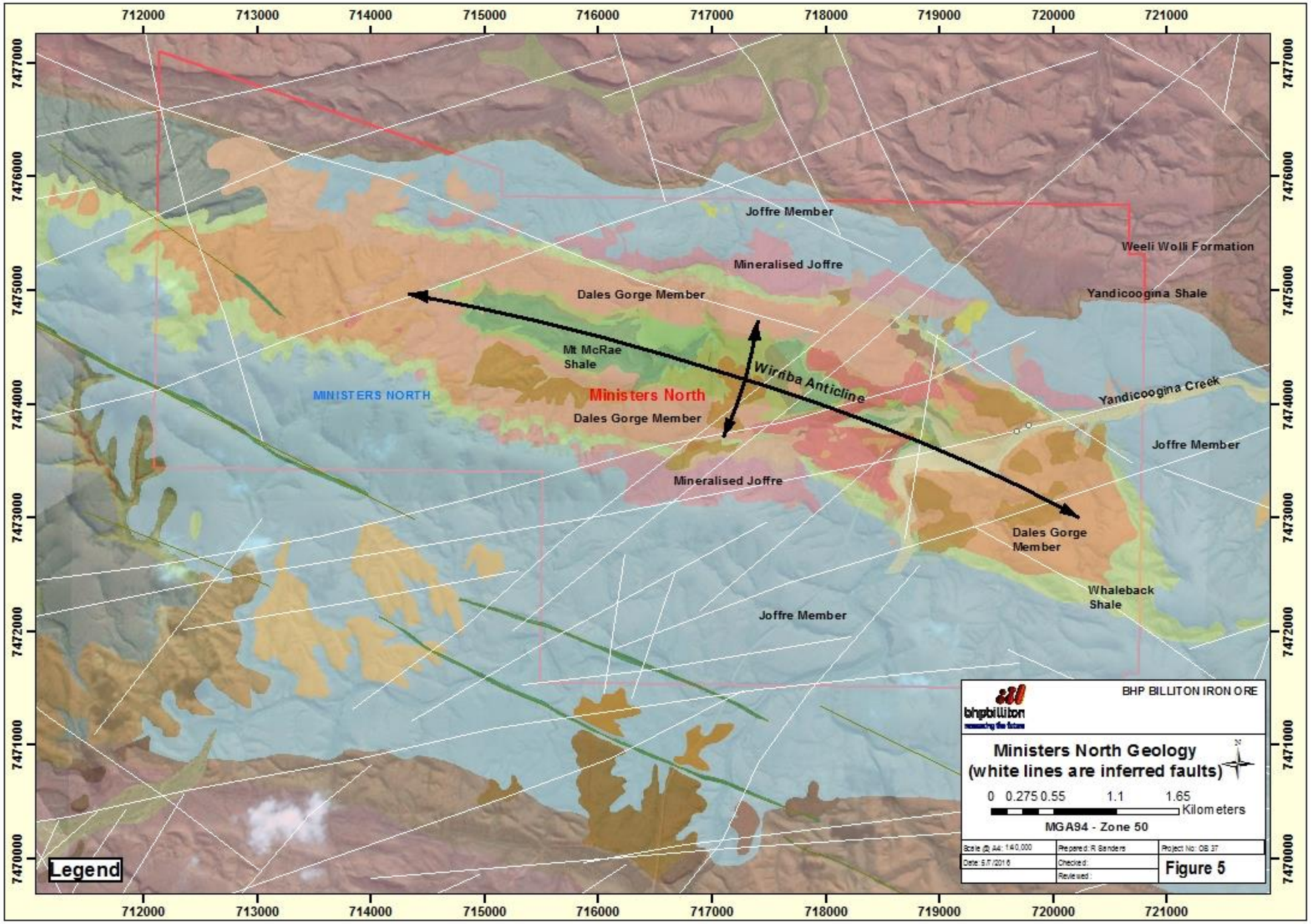

Figure 5 Ministers North geology

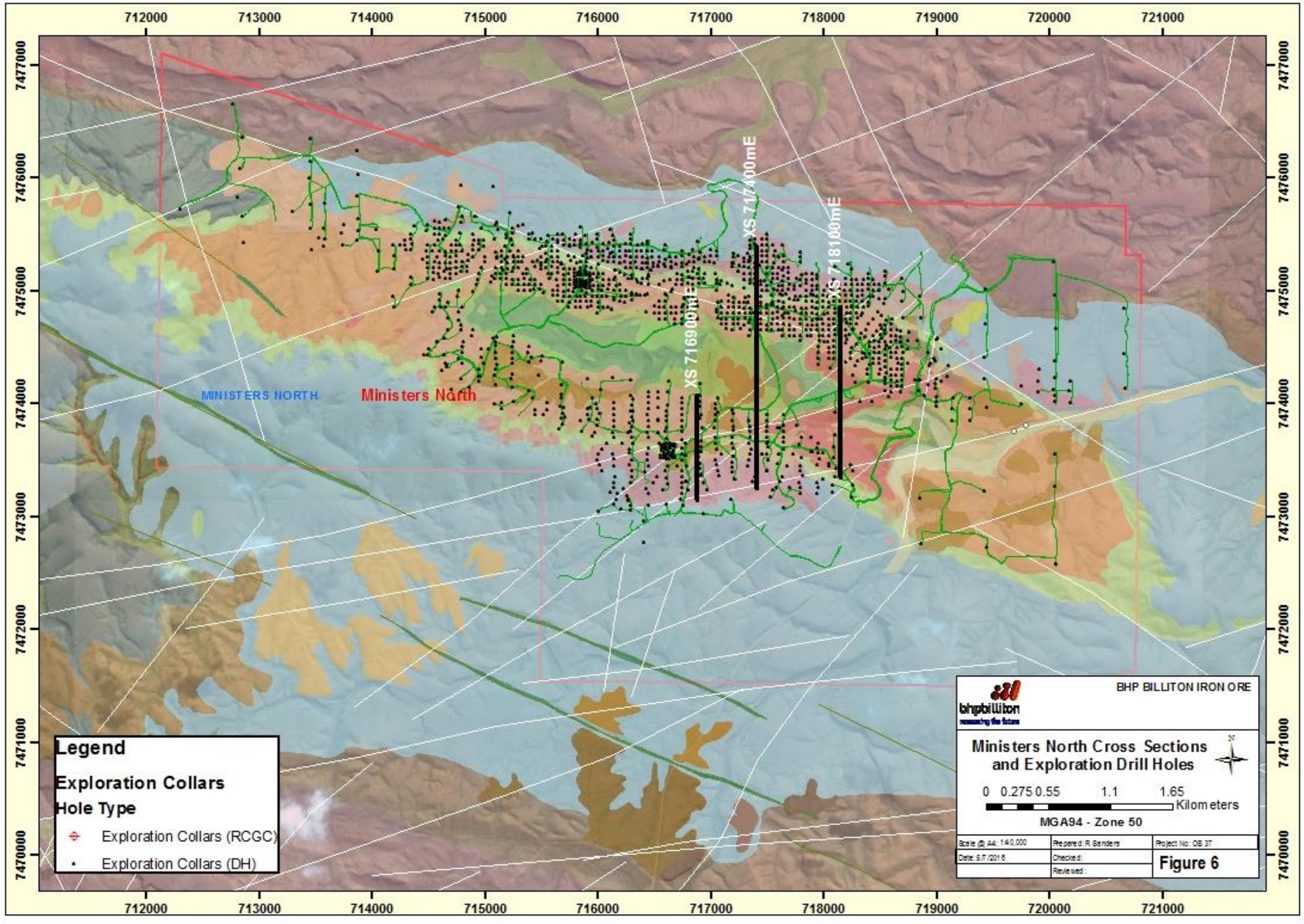

Figure 6 Ministers North cross sections and exploration drill holes

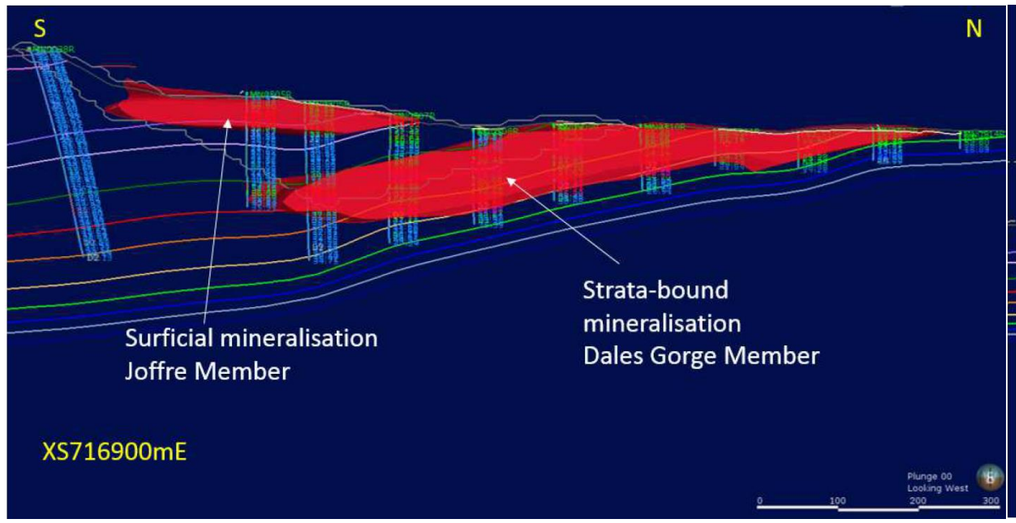

Figure 7: Mineralisation styles on the southern limb of Wirriba Anticline.

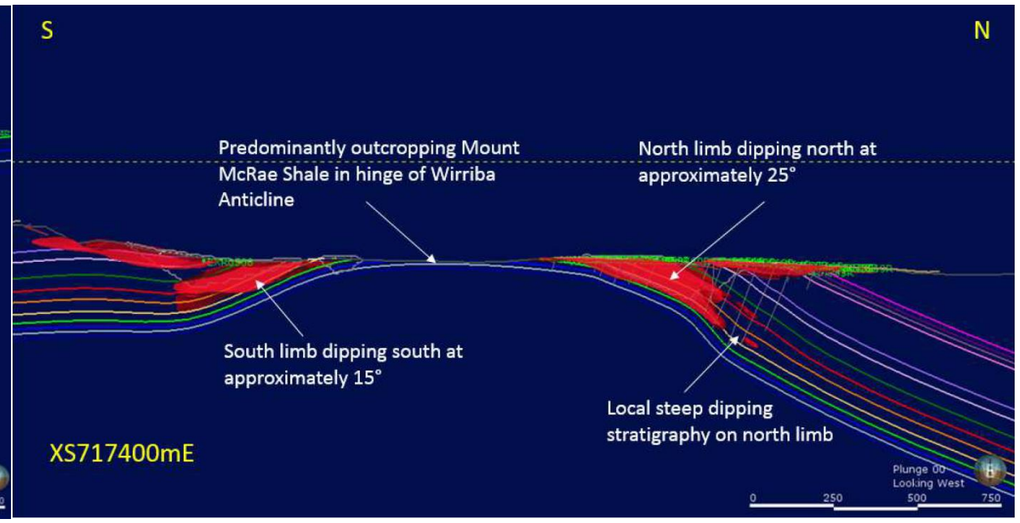

Figure 8: Wirriba Anticline cross section

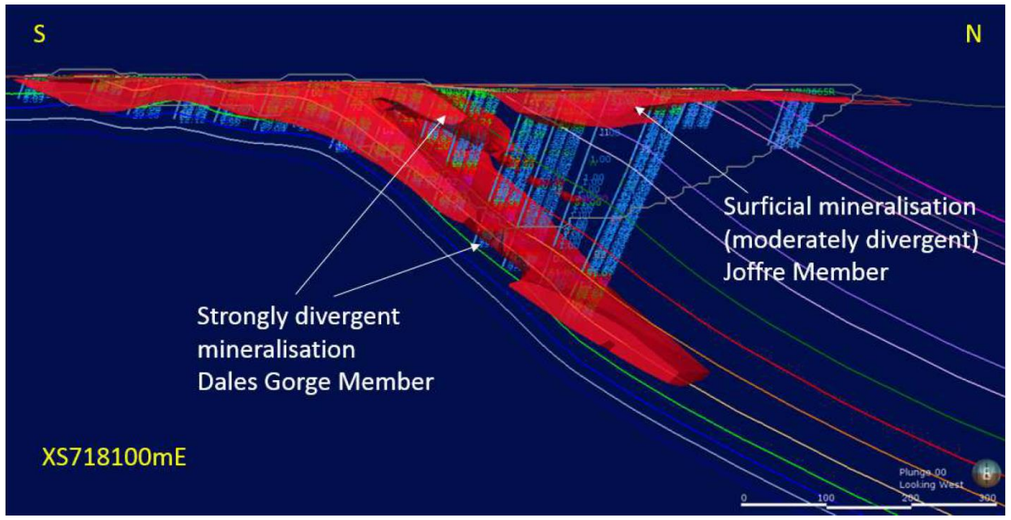

Figure 9: Mineralisation styles on the northern limb of Wirriba Anticline.

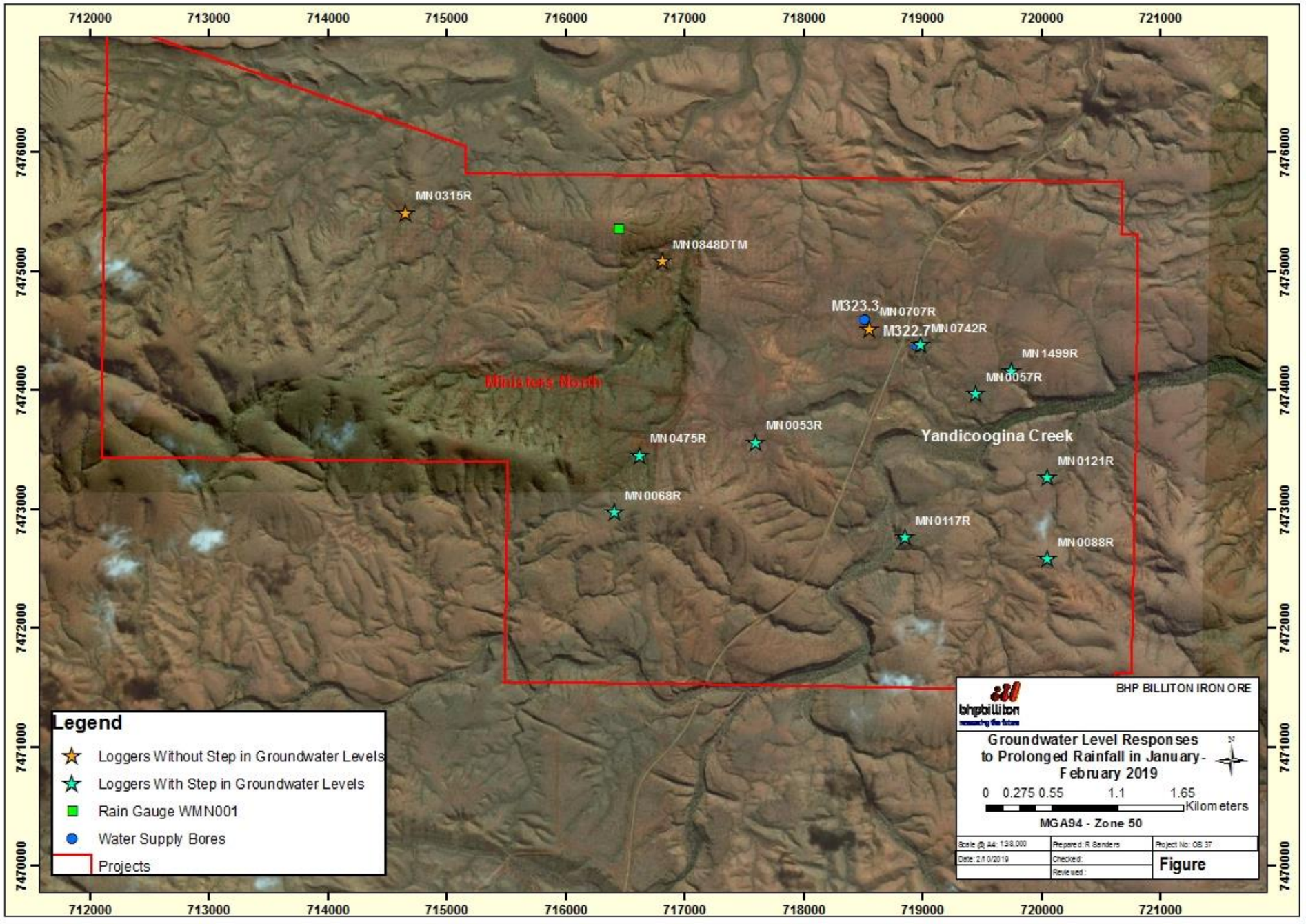

Figure 9a: Groundwater level responses to prolonged rainfall in January – February 2019

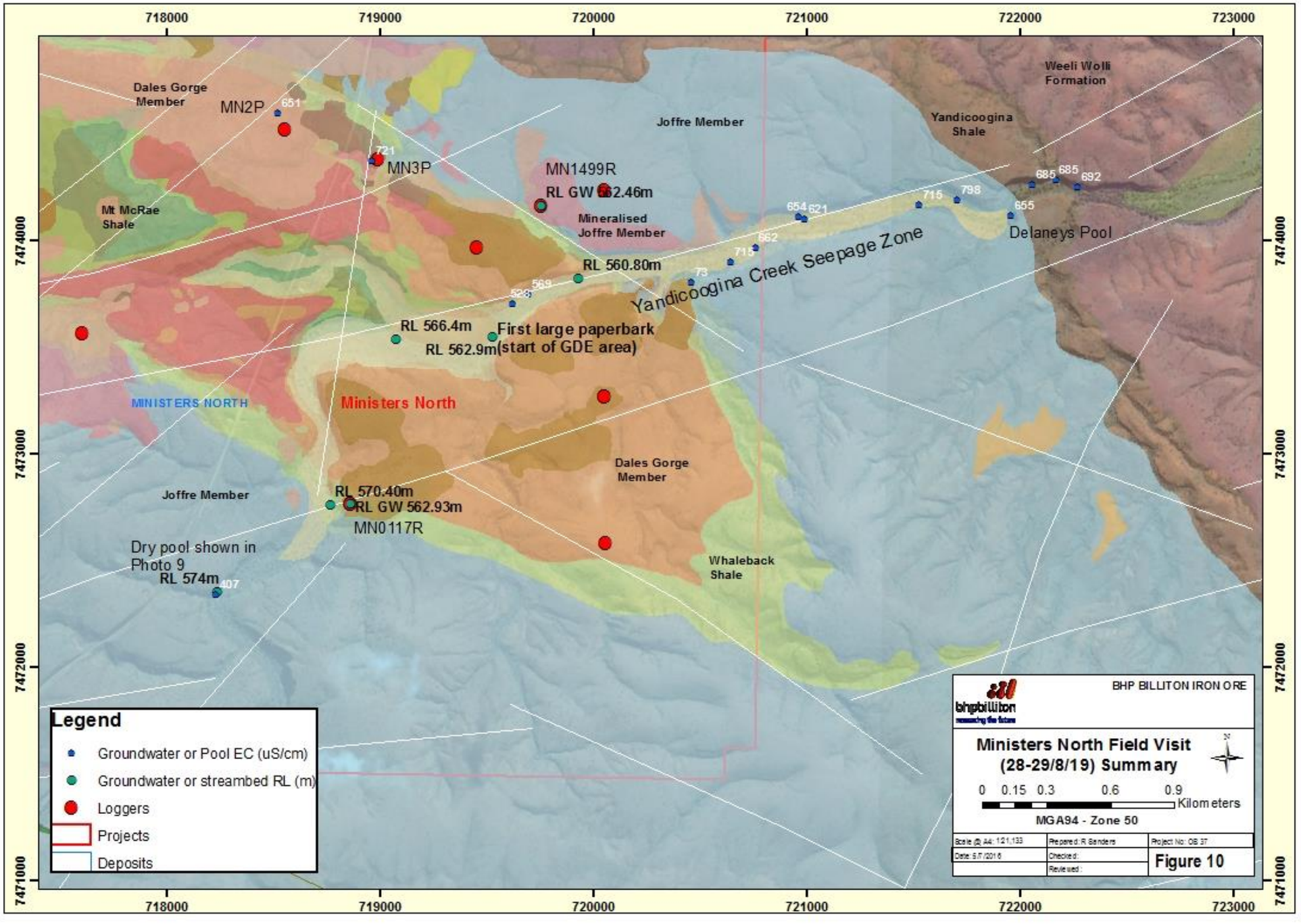

Figure 10: Field data from 28-29 August 2019 Yandicoogina reconnaissance

APPENDIX A

COMPOSITE BORE LOGS

aquaterra
22 Bowman Street
South Perth
WA 6151
Australia
Tel: (+61) (08) 9368 4044
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COMPOSITE WELL LOG

Well No: MN2p

Client: Fluor **Project:** Mining Area C Railway

Commenced: 23/01/02 **Completed:** 25/01/02 **Drilled:** Nudrill **Logged By:** JE

Method: 0-100 DTH **Fluid:** 0-100 Foam **Bit Record:** 0-3: 17.5", 3-100:12.25"

Area: Ministers North **East:** 718372 **North:** 7474438 **Elevation:**

Static Water Level: 51.25 mbgl **Date:** 26/01/02

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion: Diagram	Well Completion: Notes
0	HC		CAP: Red brown, Hardcap.	MN2e reamed to become MN2p Bore completed with cement pad and lockable steel cap		406 mm ND Steel Surface Casing
-10	Dales Gorge Member		ORE: Grey to brown, goethite and goethitic hematite, with some hematite, moderately hard.			
-20			ORE: Grey to mauvish purple, goethite, with some hematite (siliceous).			
-30			BIF: ORE (?), Grey to brown, goethitic hematite, shale, goethite.	Broken ground from 54 to 70 m		195 mm ID Class 12 Blank PVC Casing
-40			BIF: and ORE, goethite, goethitic hematite, hematite.			
-50			ORE: Grey brown, goethite, goethitic hematite and hematite.	Unable to measure drilling airlift yields due to quantities of foam used		3.2 to 6.4 mm Graded Gravel
-60			CLAY: Brown red-brown, yellow, goethite, limonite(?).			195 mm ID Class 12 Slotted PVC Casing
-70			ORE: Grey brown, hematite, goethitic hematite, and goethite. Some siliceous hematite at 66-69 m, some BIF.			
-80			SHALE/CLAYSTONE: Red brown, moderately soft.			
-90			BIF: Grey with some red brown fragments, large fragments up to 40 mm.			
-100	S		SHALE/CLAYSTONE: Red brown and yellow brown.	Final airlift development = 7.5 L/s Field EC = 635 uS/cm		Fallback
-110			BIF: ORE (?), Grey.			
			CHERT: and ORE (?), goethite, siliceous hematite, goethitic hematite.			
			SHALE: Black to dark brown.			
			EOH at 100 m			

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COMPOSITE WELL LOG

Well No: MN3p

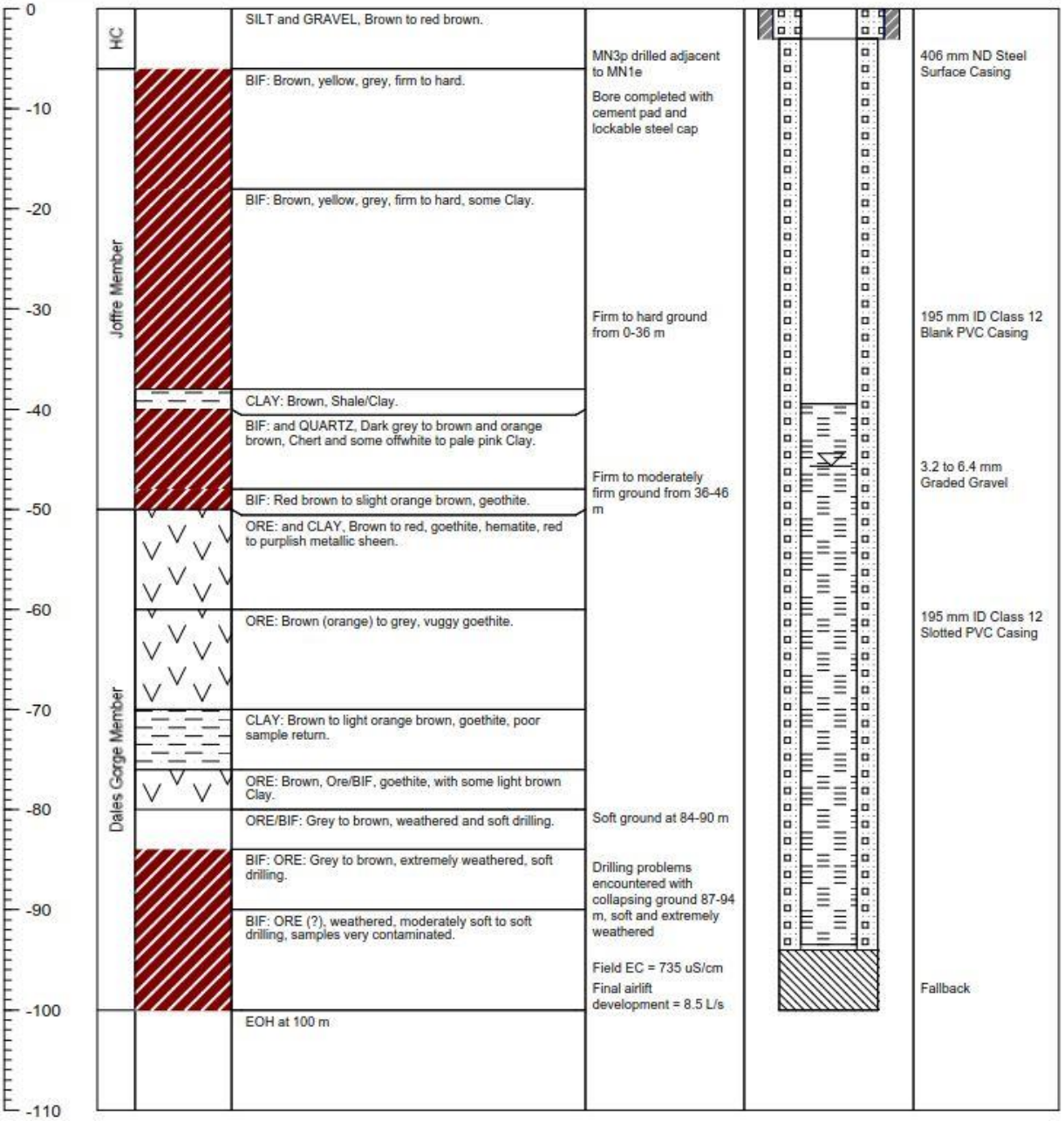
Client: Fluor **Project:** Mining Area C Railway

Commenced: 25/01/02
Completed: 27/01/02
Drilled: Nudrill
Logged By: JE

Method: 0-100 DTH
Fluid: 0-100 Foam
Bit Record: 0-3: 17.5", 3-100:12.25"

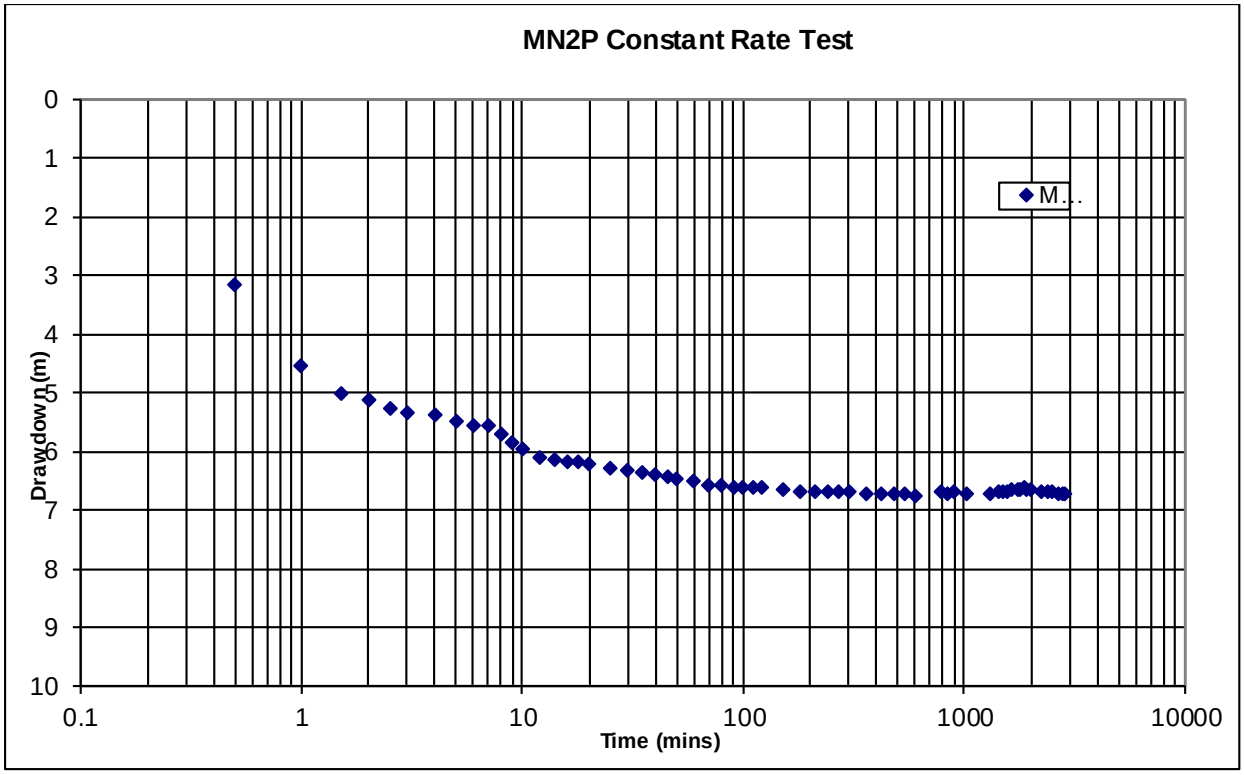
Area: Ministers North
East: 718815
North: 7474206
Elevation:

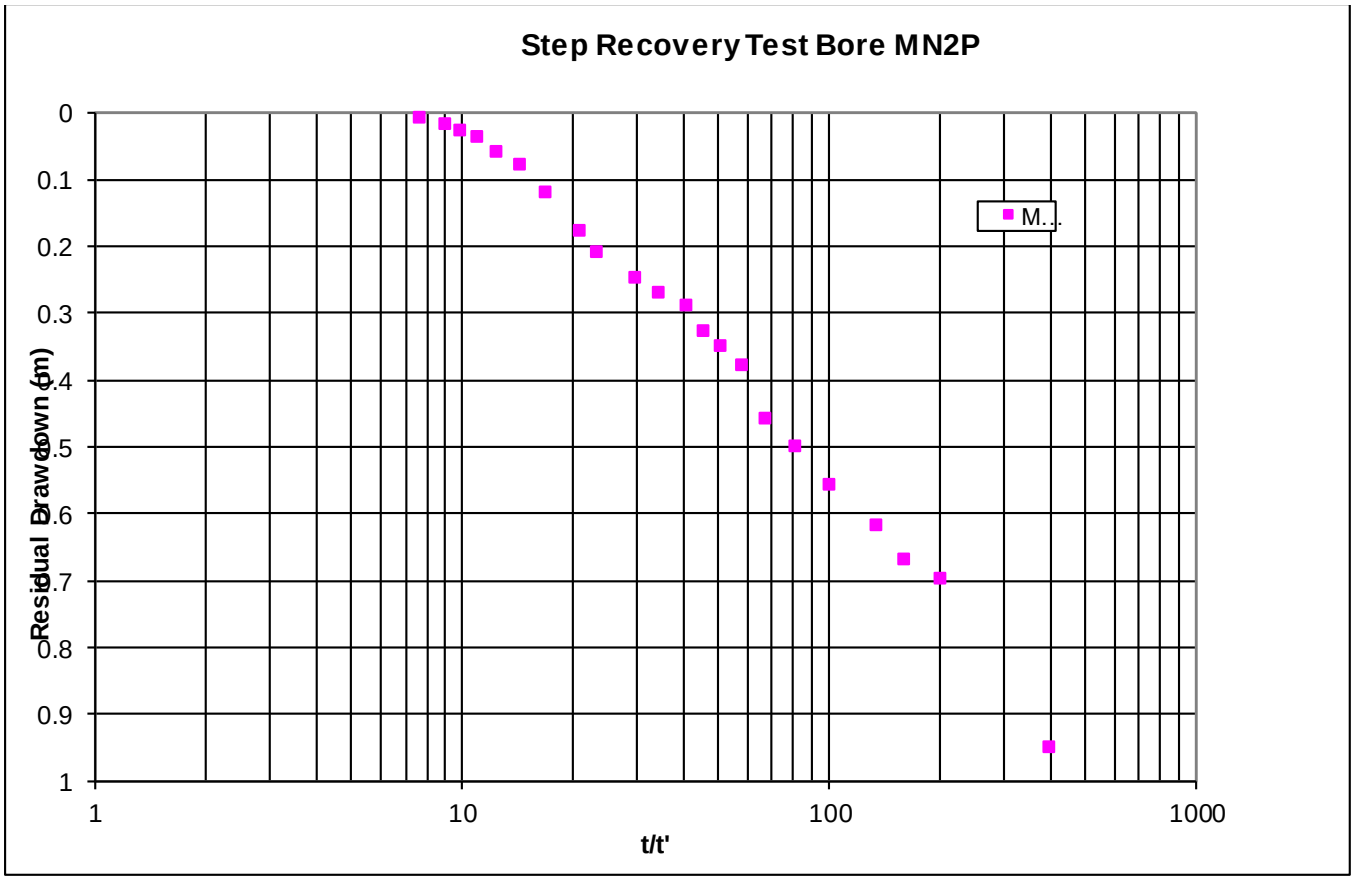
Static Water Level: 45.69 mbgl **Date:** 27/01/02

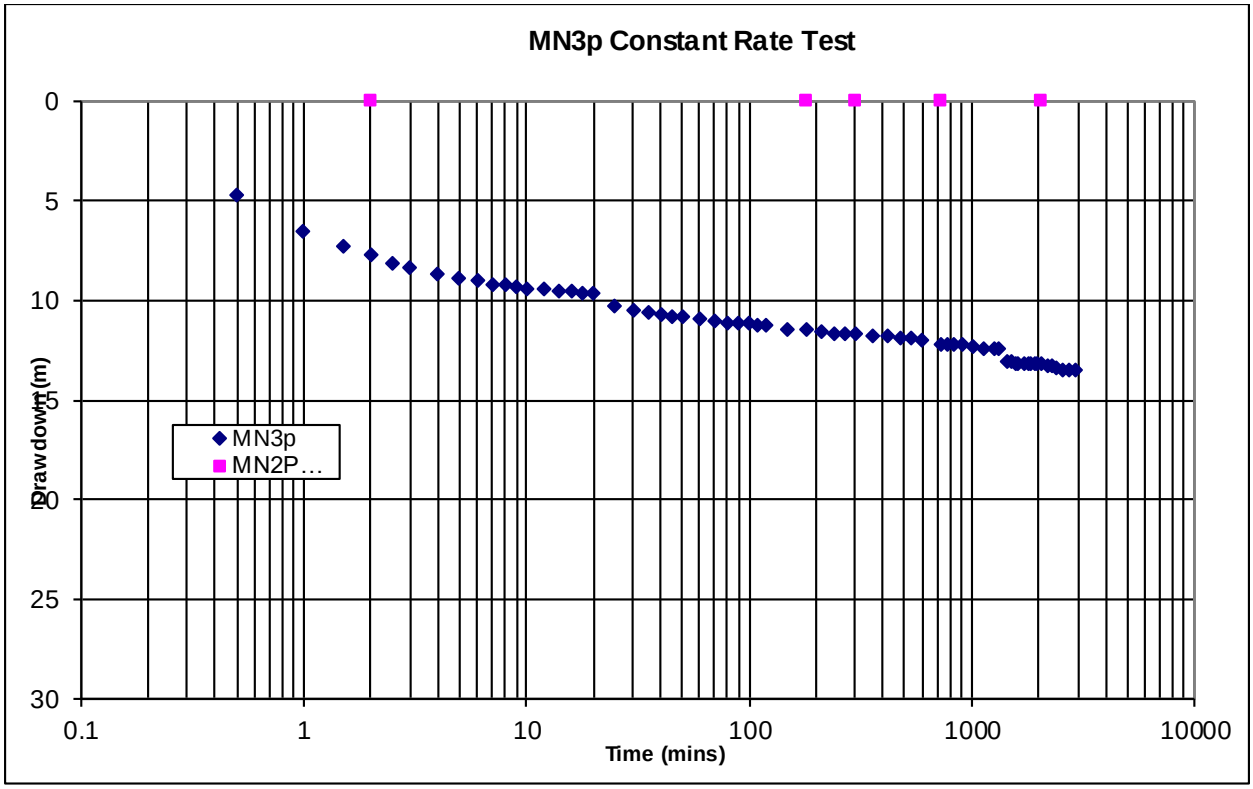


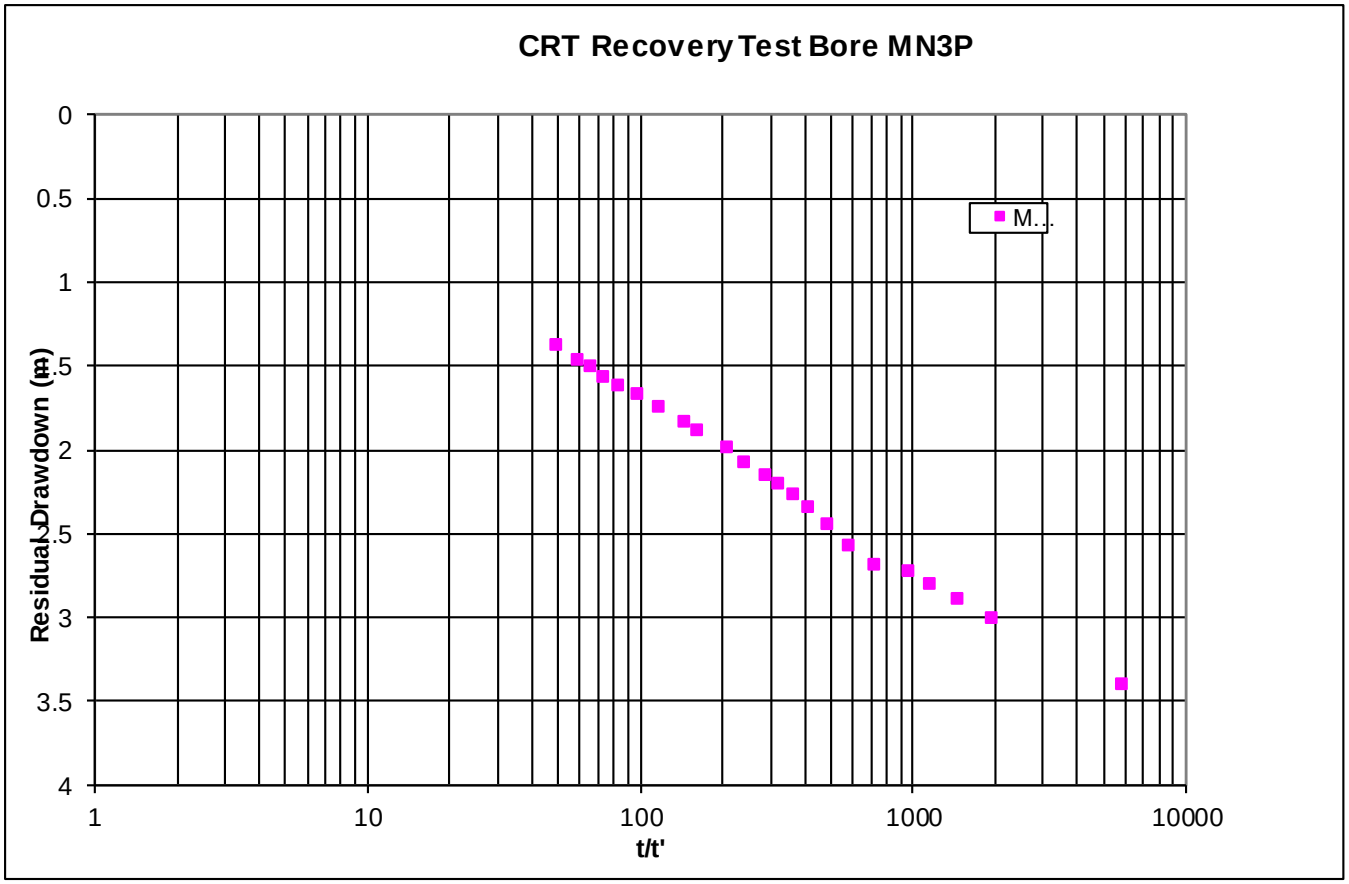
APPENDIX B

TEST PUMPING PLOTS


MN2P Constant Rate Test
Drawdown (m)
0
1
2
3
4
5
6
7
8
9
10
0.1
1
10
100
1000
10000
Time (mins)
M...


Step Recovery Test Bore MN2P
Residual Drawdown (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1
10
100
1000
t/t'
M...


MN3p Constant Rate Test
Drawdown (m)
0
5
10
15
20
25
30
0.1
1
10
100
1000
10000
Time (mins)
MN3p
MN2P…


CRT Recovery Test Bore MN3P
Residual Drawdown (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
1
10
100
1000
10000
t/t'
M…

APPENDIX C

TIME SERIES WATER LEVEL DATA

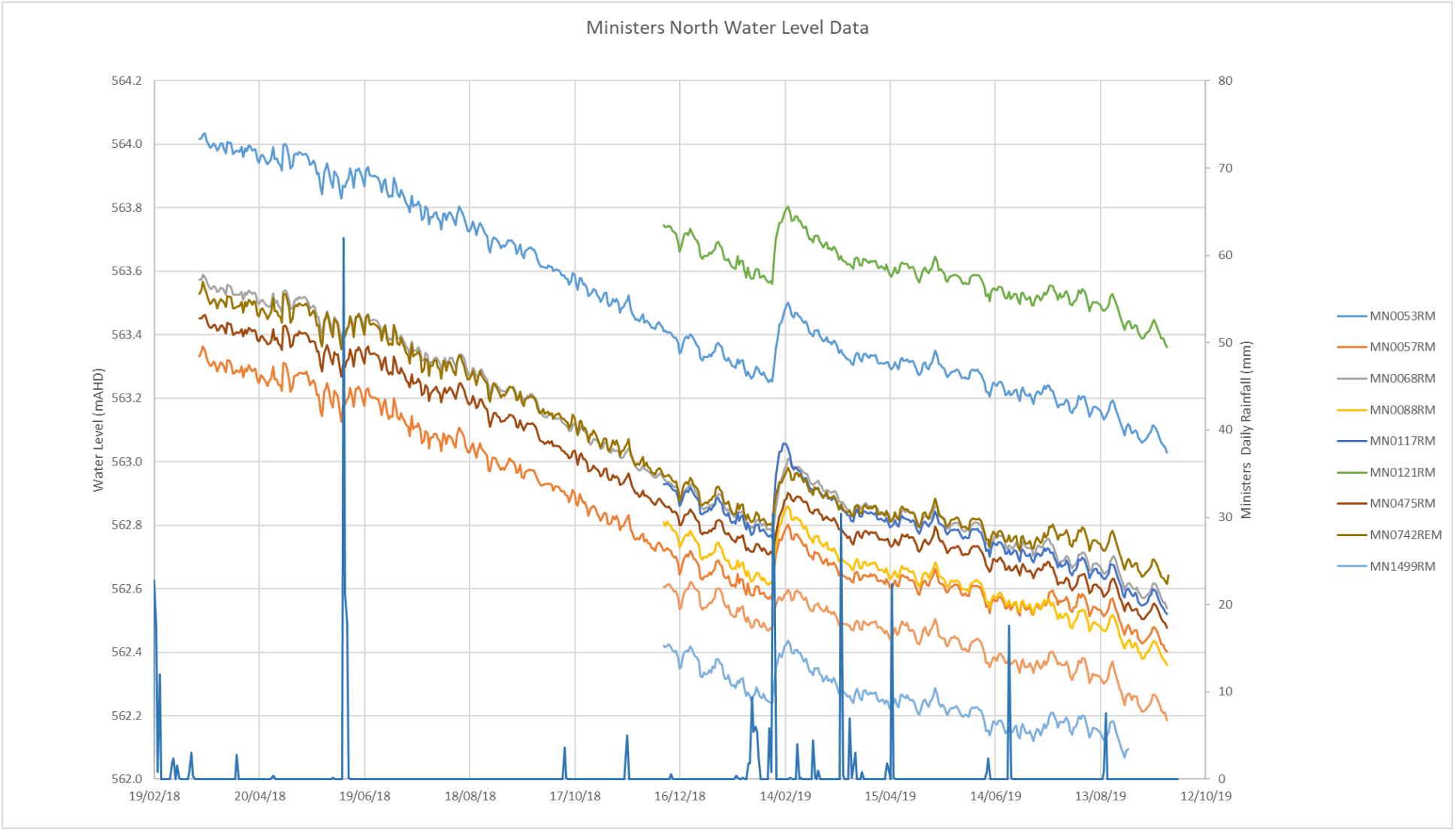


Figure C1: Logger holes showing stepped response to persistent rain in January/February 2019.

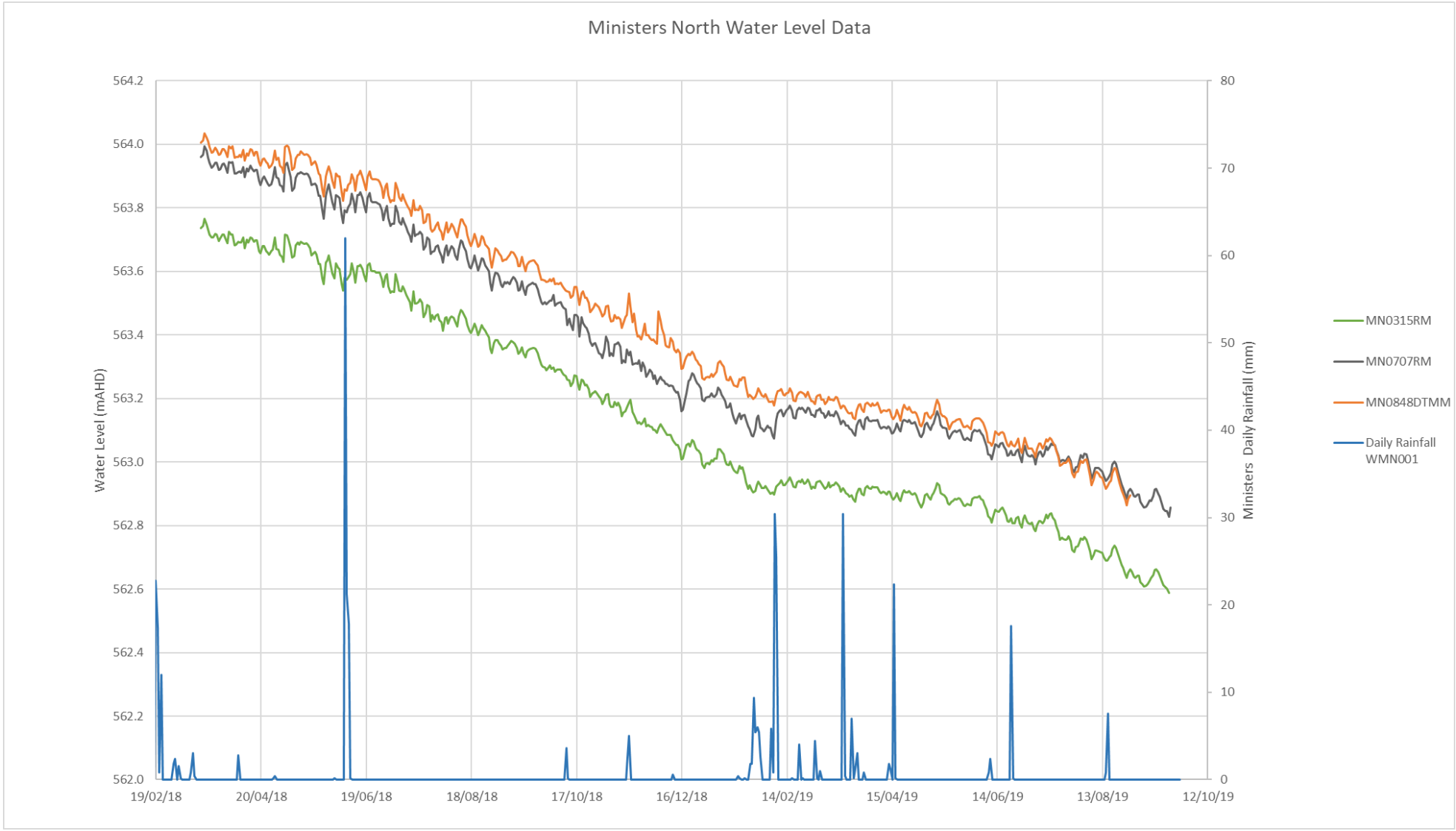


Figure C2: Logger holes showing muted response to persistent rain in January/February 2019.