GNH IN-PIT TSF, BLUEBIRD MINE

HYDROGEOLOGICAL ASSESSMENT

REPORT FOR
WESTGOLD RESOURCES LTD

MARCH 2024

Report No. 188-17/24/01

Rockwater
HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

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1 INTRODUCTION

Westgold Resources Limited (Westgold) is planning to store tailings in the Great Northern Highway (GNH) pit at Bluebird mine-site at Yaloginda, 15 km south of Meekatharra (Figure 1). Tailings are currently being stored in Bluebird East pit, which is alongside (east) of GNH pit, but that pit is near capacity. Previously, tailings were placed in Bassetts West pit, further to the east (Fig. 2).

A hydrogeological assessment of the potential impacts – on the local groundwater -- of the tailings storage is required. This report presents the data collected and the results of the hydrogeological assessment by Rockwater.

1.1 CLIMATE

Meekatharra (and Bluebird) has a semi-arid climate. The nearest Bureau of Meteorology (BoM) station to Bluebird with a long data record is at Meekatharra Airport (Stn. 007045), located just east of the town.

Rainfall has been recorded at Meekatharra airport since 1944. Annual rainfall has averaged 234 mm, and although irregular, much of the rain falls in the months January to July (Table 1). Rainfall over the winter months is generally associated with the passage of cold fronts. Summer rainfall mostly results from thunderstorms, or cyclonic weather activity in the north.

Table 1: Average Rainfalls at Meekatharra, and Dam Evaporation (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Av. Rainfall	29.4	36.1	30.8	18.8	21.6	28.5	20.0	10.6	4.9	5.9	11.6	14.2	233.8
Dam Evap.	380	314	267	190	131	87	92	121	170	259	293	333	2,637

Dam evaporation at Meekatharra (Luke, Burke, and O'Brien, 1988) averages 2,637 mm/year, and on average exceeds rainfall in all months of the year and by a factor of 11 overall.

Monthly mean minimum temperatures at Meekatharra range from 7.5^{0}C in July to 24.5^{0}C in January; and mean maximum temperatures range from 19.4^{0}C in June to 39.0^{0}C in January.

2 HYDROGEOLOGICAL ASSESSMENT

2.1 GEOLOGY

The geology of the GNH – Bluebird East pit is described by Timms (2006). The GNH lobe of the larger pit includes a foliated ultramafic (talc carbonate and talc schist) and high-Mg basalt, with a north-easterly trending dolerite dyke along the axis of the pit, pinching out in the south-west. There is a north-westerly trending fault zone that dips steeply to the ENE and juxtaposes basalt to the west with ultramafic schist to the east.

There are broad areas of mineralisation, mainly in an alteration zone within the ultramafics; this zone includes ferruginous quartz-carbonate.

2.2 MINING HISTORY

Mining of the Bluebird East / GNH pit commenced in 1993 and ended with underground mining at GNH from 2001 to September 2002.

Dewatering was mostly from pit-perimeter bores that were screened in permeable quartz-carbonate; and then from mid-1999 from pit (and underground) sumps (Rockwater, 2003).

Volumes of water pumped from the GNH/Bluebird East pit gradually decreased from about 60,000 m^3/mth (1,940 m^3/d) in 1994, to about 40,000 m^3/mth in year 2000; and then about 5,000 to 10,000 m^3/mth (160 to 320m^3/d) during underground mining (160 to 320 m^3/d).

2.3 HYDROGEOLOGY

2.3.1 GENERAL

There are a number of pastoral bores and wells in the Yaloginda region, as well as Bluebird project bores; they are recorded in the Department of Water and Environmental Regulation (DWER) Water Information Reporting (WIR) database, and shown on the Meekatharra 1:100 000 Geological Sheet (Romano, Ivanic and Chen, 2017). Note that the WIR data are mostly old, and the bore locations in the database are inaccurate.

Bluebird project bores have been drilled around mine pits for water supply, dewatering, or monitoring.

2.3.2 WATER INFORMATION REPORTING DATA

Hydrogeological data for the area that are available in the WIR database are summarised in Table 2 (Page 3). Some of the mining project bores that had few data or were recorded in the same location, have been omitted from the table, as there are a substantial number of groundwater data-points for the area.

They indicate generally low to groundwater yields from the bores, with a maximum of 360 KL/d; and generally low groundwater salinity (less than 1,400 mg/L TDS.

2.3.3 AQUIFER CHARACTERISTICS

Aquifers at Great Northern Highway/Bluebird East pits are largely restricted to the discontinuous, ferruginous quartz-carbonate mineralised rocks, where fresh or slightly weathered, and these were targeted for dewatering bores installed before and during mining of the pits.

Other areas of talc chlorite, basalt and dolerite, and clayey weathered rocks are generally of low hydraulic conductivity.

2.3.4 GROUNDWATER LEVELS, FLOW DIRECTION

Water levels in bores in the Yaloginda area – that are recorded in the WIR database – were reduced to m AHD using recorded ground levels or topographic contours drawn from the DEM-H version of the one-second SRTM dataset (Geoscience Australia, 2011), and are contoured in Fig. 3. The levels indicate that pre-mining, groundwater was flowing to the south-east from a mound centred on the ridge west of Bluebird, towards a drainage line that flows southwards to Lake Annean, where groundwater discharges and evaporates. The groundwater level at GNH pit would probably have been at about 455 m AHD prior to mining, about 15 m below ground level.

A few of the water levels are impacted by dewatering or pumping from the bores/wells themselves or nearby, and there is some uncertainty in bore locations and the SRTM levels used to reduce water-level data to m AHD.

Table 2: Summary of WIR Data

Site Ref	Name	Easting	Northing	RLGL	Depth	KL/d	TDS	(WL, mbgl)	RLWL	Aquifer
		(m)	(m)	(m AHD)	(m)		(mg/L)		(m AHD)	
70200062	Wbbs1	647036	7035330	463.6	99			11	452.6	BIF
70200064	Wbbs3	646848	7034976	463.9	63			11.6	452.3	Ag
70211574	Three Mile W	645621	7056403		0	22				
70211575	White W	639531	7056536	483.6	29.87	251		13.72	469.9	
70211579	Blacktank W	635935	7057049	474.1	14.02	14		11.58	462.5	
70211581	Mount Obal	630929	7058205	462.6	21.95	41	1050	9.75	452.9	
70211582	Red W	633876	7058215	468.8	26			20	448.8	
70211586	Yaloginda	642956	7049939	490.6	21.34	38	1230	18.29	472.3	
70211589	No 3	641616	7045000	485.1	80	360	<1,000	17.8	467.3	
70211591	ER 6	641616	7045000		107	>300				Talc-Chl-Schist
70211592	ER 5	641616	7045000		107	52				Talc-Chl-Schist
70211595	Wb17	641752	7043981	469.7	120	175		19.7	450.0	
70211601	Bob	641752	7043981		70	0				Chl schist
70211602	Bob 21	641752	7043981		65	5				Chl schist
70211606	C.W.B. 7	641414	7043216	450.46	74			10	440.5	
70211607	Myp 1	640865	7044805	492.9	66		1280	20.5	472.4	
70211608	Myp -2	640817	7043909	496.8	70		4700	20.4	476.4	
70211609	H006-729.20	640936	7041911		33		500			calcrete
70211611	Bassetts	645871	7037556	469.2	21.64	8	620	17.68	451.5	silcrete
70211612	Geoff	645145	7034258	459.5	23.16	9	1365	8.53	451.0	
70211613	Railway W	639729	7036978	458.1	13.41	4		9.1	449.0	
70211618	H006-718.86	638004	7034084	454	30		580	5.5	448.5	ironstone
70211620	Gap (Govt) W	633370	7036897	483.9	2.74	2		2.13	481.8	
70211622	Homestead W	633370	7036897		7.01	55		5.18		Limestone
70211624	Gap W	634341	7038031	474.3	0		770	4.3	470.0	
70211626	Little Gap W	631957	7034756	473.4	0		960	4.9	468.5	
70211899	Ted W	650456	7032758	469.8	76.2		1430	12.5	457.3	greeenstone
70211965	Fardell	651003	7047671	492	19.81	36	1000	12.8	479.2	calcrete
70211967	Stock Yard W	650783	7044670	482.6	13.72	36	888	10.5	472.1	silcrete
70213018	12 Mile W	641621	7042381	439.6	67	5	820	16.5	423.1	
70213019	Johnses W	639180	7044072	478.7	0		740	10	468.7	
70213020	C.W.B.1	641414	7043216	457.64	86			15	442.6	
70213021	C.W.B. 4	641414	7043216	454.4	64			12	442.4	
70213022	C.W.B. 5	641414	7043216	461.19	64			19	442.2	
70213023	H006-735.30	643064	7047420		102					
70213025	Chunderloo	635658	7044960	513	16.46	76	730	15.24	497.8	granite
70213026	Rabbit	645107	7031842	456.3	9.14	32	680	5.49	450.8	
70213028	2 Mile	637061	7039389		0		800			
70213029	Railway	640964	7037835		0		660			
70213030	H006-729.01	640079	7040090		60					
70213031	H006-725.01	640079	7040090		49.5					
70213033	Little Gap W	632697	7035607	477.6	9.14	4		6.71	470.9	limestone
70213034	Norie	633150	7036492	487.1	24.38	3		17.07	470.0	granite
70213036	Rabbit Fence	635597	7034719		0		660			
70219171	2-97	644075	7056292		0		725			
70219172	3-97	644075	7056292		0		680			
70219173	Electric	644071	7056291		0		680			

2.3.5 GROUNDWATER QUALITY

The bores and wells in the WIR database (Table 2) had salinities of generally less than 1,000 mg/L TDS near Bluebird (Fig. 4), with some higher salinities at depth.

Water in the GNH pit lake (probably groundwater with minor surface-water runoff) was sampled from 2011 to 2020 and subjected to chemical analysis. The results are given in Table 3.

Table 3: Results of Analyses, GNH Pit Lake

Date	10-Jun-11	17-Dec-12	14-Dec-15	23-May-18	26-Mar-19	03-May-20
Conductivity (µS/cm@ 25 C)	5,600	6,200	6,200	6,200	9,100	7,500
Total Dissolved Solids (mg/L)	4,000	3,350	3,800	3,800	5,154	4,600
pH	8	8.5	8.5	8.4	8.36	8.3
Alkalinity (mg/L CaCO3)	140	140	140	110	110	130
Alkalinity as HCO3 (mg/L)	140	150	150	120	120	150
Alkalinity CO3 (mg/L)	1	9	9	4	8	2
Hardness (mg CaCO3/L)	1,200	1,100	1,600	1,800	2,200	2,300
Potassium (mg/L)	45	34	54	30	39	37
Sodium (mg/L)	730	700	960	550	820	670
Calcium (mg/L)	130	110	160	190	200	220
Magnesium (mg/L)	200	190	260	330	420	430
Chloride (mg/L)	1,800	1,800	2,000	1,600	1,800	2,000
Sulphate (mg/L)	270	260	290	860	940	1,100
Iron (Sol.) (mg/L)	0.02	0.03	0.007	0.005	0.005	0.005
Manganese (mg/L)	0.005	0.005	0.004	0.002	0.002	0.001
Zinc (mg/L)	0.03	0.02	0.005		0.005	0.005
Aluminium (mg/L)	0.02	0.03	0.018	0.005	0.005	0.005
Nickel (mg/L)	0.005	0.009	0.001	0.002	0.004	0.005
Arsenic (mg/L)	0.04	0.049	0.048	0.4	0.43	0.45
Cadmium (mg/L)	0.002	0.001	0.0001	0.0001	0.0001	0.0001
Chromium (mg/L)	0.042	0.047	0.038	0.004	0.004	0.005
Cobalt (mg/L)	0.005	0.01	0.001	0.009	0.012	0.011
Copper (mg/L)	0.005	0.005	0.001	0.001	0.001	0.001
Cyanide (mg/L)	0.01	0.004				
Fluoride F (mg/L)		0.3		0.2	0.1	0.1
Lead (mg/L)	0.001	0.005	0.001	0.001	0.001	0.001
Mercury(mg/L)	0.0001	0.0001	0.00005	0.00005	0.00005	0.00005
Nitrate as NO_3 (mg/L)	83	76		51	87	71
Nitrite as NO_2 (mg/L)		0.76		0.2	0.6	0.5
Fluoride F (mg/L)		0.3		0.2	0.1	0.1

The results show that the water is weakly saline, ranging from 3,400 to 5,200 mg/L TDS and overall salinity increased slightly with time. It is alkaline, and of a sodium chloride type, with low concentrations of metals. Many of the low metal concentrations recorded probably represent reporting limits rather than measured concentrations. Nitrate concentrations are high, ranging from 51 to 83 mg/L.

Groundwater levels and quality are also monitored in six bores around the Bassetts West pit/TSF, and in four bores around the Bluebird East pit TSF. Bore locations are shown in Figure 2, and the results from BEMB1–4 and BWEMB 1–6 for key parameters from the analyses and field measurements for 2022 and 2023 are given in Tables 4 and 5.

Table 4: Bluebird East TSF Monitoring Bores BEMB 1–4, Analysis Results for Key Parameters

	Units	BEMB1	BEMB1	BEMB1	BEMB1
Date		09-Jul-22	11-Oct-22	08-Jan-23	22-Apr-23
Total CN	mg/L	0.025	0.007	< 0.004	< 0.004
WAD CN	mg/L	0.007	< 0.004	< 0.004	< 0.004
pH	pH	7.9	7.9	7.8	7.9
pH Field	pH	7.1	7.13	7.13	6.95
Total Dissolved Solids	mg/L	1300	1200	1100	1300
SWL	mbtc	57.26	55.47	55.94	55.09

	Units	BEMB2	BEMB2	BEMB2	BEMB2
Date		10-Jul-22	11-Oct-22	08-Jan-23	22-Apr-23
Total CN	mg/L	0.057		0.01	
WAD CN	mg/L	0.038		0.011	
pH	pH	7.9		7.9	
pH Field	pH	7.28		7.13	
Total Dissolved Solids	mg/L	1100		1100	
SWL	mbtc	50.28		49.64	
Comment			Dry		Dry

	Units	BEMB3	BEMB3	BEMB3	BEMB3
Date		09-Jul-22	11-Oct-22	08-Jan-23	22-Apr-23
Total CN	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
WAD CN	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
pH	pH	7.9	7.9	7.9	8
pH Field	pH	7.27	7.13	7.16	7.04
Total Dissolved Solids	mg/L	880	920	910	890
SWL	mbtc	35.74		35.44	35.09

	Units	BEMB4	BEMB4	BEMB4	BEMB4
Date	Date	10-Jul-22	12-Oct-22	09-Jan-23	02-Apr-04
Total CN	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
WAD CN	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
pH	pH	8.1	8.2	8.1	8.2
pH (Field)	pH	7.66	7.53	7.39	7.31
Dissolved Solids	mg/L	1400	1400	1400	1400
SWL	mbtc	25.15	23.42		24.39

The results from both sets of monitoring bores indicate circum-neutral pH, salinities within the range of the pre-mining groundwater, and low cyanide (particularly WAD cyanide) concentrations. Metal concentrations were also very low. The minimal impacts could be explained at Bluebird East by the low groundwater levels in the bores that indicate much of the flow of water is from the groundwater into the pit, rather than from the pit to the surrounding groundwater. However, the groundwater levels in the Bassetts West bores have recovered to around pre-mining levels since tailings emplacement there ceased in July 2016, and there are also only minor impacts on groundwater quality there.

Table 5: Bassetts West TSF Monitoring Bores, Analysis Results for Key Parameters

	Units	BWMB1	BWMB1	BWMB1	BWMB1
Date		08-Jul-22	12-Oct-22	08-Jan-23	21-Apr-23
Total CN	mg/L	0.007	0.014	0.067	< 0.004
WAD CN	mg/L	< 0.004	< 0.004	0.055	< 0.004
pH	pH	7.8	7.9	7.9	8.1
pH (Field)	pH	7.22	7.23	7.16	7.31
Total Dissolved Solids	mg/L	1100	1100	1000	1100
SWL	mbtc	13.27	12.86		13.11

	Units	BWMB2	BWMB2	BWMB2	BWMB2
Date		08-Jul-22	12-Oct-22	09-Jan-23	21-Apr-23
Total CN	mg/L	0.007	< 0.004	< 0.004	< 0.004
WAD CN	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
pH	pH	7.9	8.1	8.1	8.2
pH (Field)	pH	7.33	7.26	7.65	7.38
Dissolved Solids	mg/L	960	990	970	980
SWL	mbtc	14.13	14.23		14.04

	Units	BWMB3	BWMB3	BWMB3	BWMB3
Date		08-Jul-22	13-Oct-22	08-Jan-23	21-Apr-23
Total CN	mg/L	0.22	0.034	0.041	< 0.004
WAD CN	mg/L	0.15	< 0.004	0.018	< 0.004
pH	pH	7.9	8	7.8	8
pH Field	pH	7.23	7.29	7.12	7.14
Dissolved Solids	mg/L	1600	1300	1500	1600
SWL	mbtc	34.75			13.72

	Units	BWMB4	BWMB4	BWMB4	BWMB4
Date		08-Jul-22	13-Oct-22	09-Jan-23	21-Apr-23
Total CN	mg/L	0.011	0.011	< 0.004	< 0.004
WAD CN	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
pH	pH	8	8.1	7.9	8.1
pH (Field)	pH	7.38	7.26	7.21	7.16
Dissolved Solids	mg/L	1000	1200	1000	880
SWL	mbtc		11.04		13.34

	Units	BWMB5	BWMB5	BWMB5	BWMB5
Date		09-Jul-22	13-Oct-22	08-Jan-23	20-Apr-23
Total CN	mg/L	0.2	0.19	0.13	0.011
WAD CN	mg/L	0.004	0.039	0.016	0.009
pH	pH	7.7	7.8	7.8	7.9
pH Field	pH	7.13	7.09	7.04	6.61
Dissolved Solids	mg/L	3000	3100	3000	2800
SWL	mbtc	34.48	33.89		34.47

	Units	BWMB6	BWMB6	BWMB6	BWMB6
Date		08-Jul-22	13-Oct-22	09-Jan-23	21-Apr-23
Total CN	mg/L	0.18	0.16	0.17	0.031
WAD CN	mg/L	0.006	0.013	0.034	0.027
pH	pH	8.3	8.1	8	8
pH Field	pH	8.66	8.67	8.06	7.85
Dissolved Solids	mg/L	1400	1400	1600	1600
SWL	mbtc			13.72	13.72

2.3.6 POTENTIAL IMPACTS OF TAILINGS DISPOSAL

GNH pit has comparable geology with the neighbouring Bluebird East and Bassetts West pits, with discontinuous areas of permeable quartz-carbonate rock separated by rocks of low permeability, and so similarly-low impacts are expected once tailings are deposited in GNH pit.

If tailings are emplaced to a level above the pre-mining groundwater level, i.e. about 455 m AHD, there is the potential for seepage from the tailings to surrounding groundwater, particularly down-hydraulic-gradient to the south, although the rates of seepage would be expected to be low and restricted by the sealing of pores and fractures by the tailings, with minimal impacts on groundwater quality and levels.

The nearest bore or well that could be impacted is 12 Mile Well located 2 km south of GNH pit. The status of the well is not known. There are no known Groundwater Dependent Ecosystems that could be affected.

2.3.7 RECOMMENDED MONITORING PROGRAMME

There are four existing monitoring bores in the walls of GNH pit – PWD1 to PWD3, and BEMB4 (Fig. 2). These bores should continue to be monitored, before and during tailings emplacement in GNH pit. It is recommended that additional bores be installed on the down-gradient (southern) side of the pit to depths of about 70 m.

Conceptual bore locations are shown in Fig. 2 and are listed in Table 6.

Table 6: Recommended Monitoring Bore Locations

Name	mE	mN
GNHMB1	642450	7043890
GNHMB2	642560	7043950

The bores should be monitored quarterly for the following parameters:

- Water Level
- pH
- EC/TDS
- Weak Acid Dissociable (WAD) Cyanide

3 CONCLUSIONS

The main aquifers in the GNH pit are disconnected mineralised zones of ferruginous quartz-carbonate altered rocks as in the neighbouring Bluebird East and Bassetts West pits, which have also been used to store tailings.

The results of groundwater monitoring around Bassetts west and Bluebird East have indicated minimal impact on groundwater, with circum-neutral pH, low WAD cyanide levels, and low salinity. Metal concentrations have also been low. Based on this, it is expected that any impacts of tailings emplacement in GNH pit would also be small.

Two additional monitoring bores are recommended to be installed on the southern side of GNH pit; together with the existing bores, they would be used to monitor groundwater levels and quality.

Dated: 11 March 2024 **Rockwater Pty Ltd**

REFERENCES

Geoscience Australia, 2011. Geoscience Australia, 1 second SRTM Digital Elevation Model (DEM). Bioregional Assessment Source Dataset.

Luke, G.J., Burke, K.L., and O'Brien, T.M., 1988, Evaporation data for Western Australia. Tech. Report No. 65 (2nd Ed), W.A. Dept. of Agriculture.

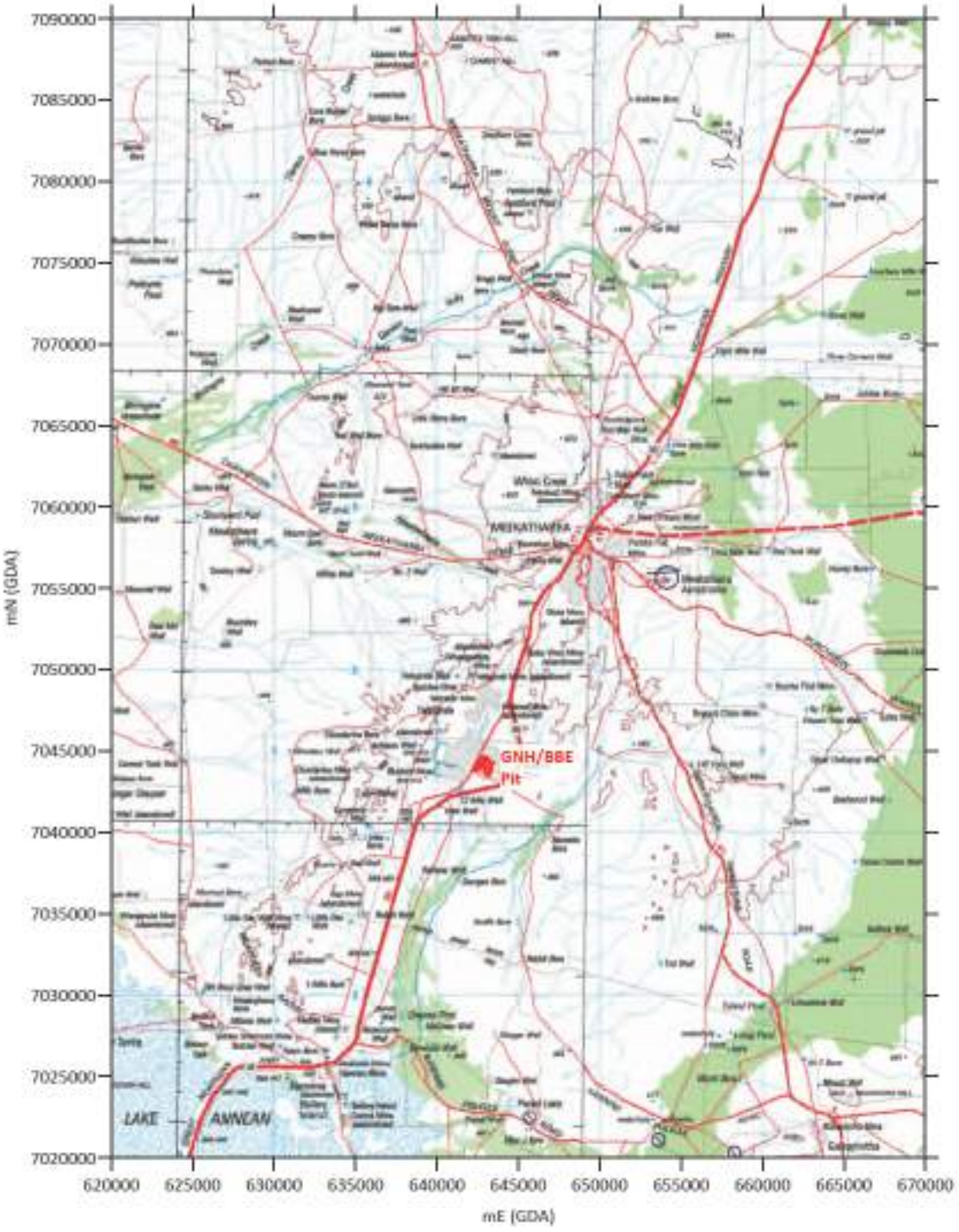
Rockwater, 2003, Bluebird gold mine Meekatharra, groundwater monitoring report July 2002 to June 2003. Report to St Barbara Mines Ltd.

Romano, S.S., Ivanic, T.J., and Chen, S.F., 2017, Meekatharra, WA Sheet 2544, Geological Survey of WA 1:100,000 Geological Series.

Timms, N, 2006, Geological mapping report, Yaloginda area, Murchison Region, Western Australia. Report to Mercator Gold Australia Pty Ltd. Geological Survey of Western Australia Record 2011/21.

FIGURES

FIGURE 1



location ref

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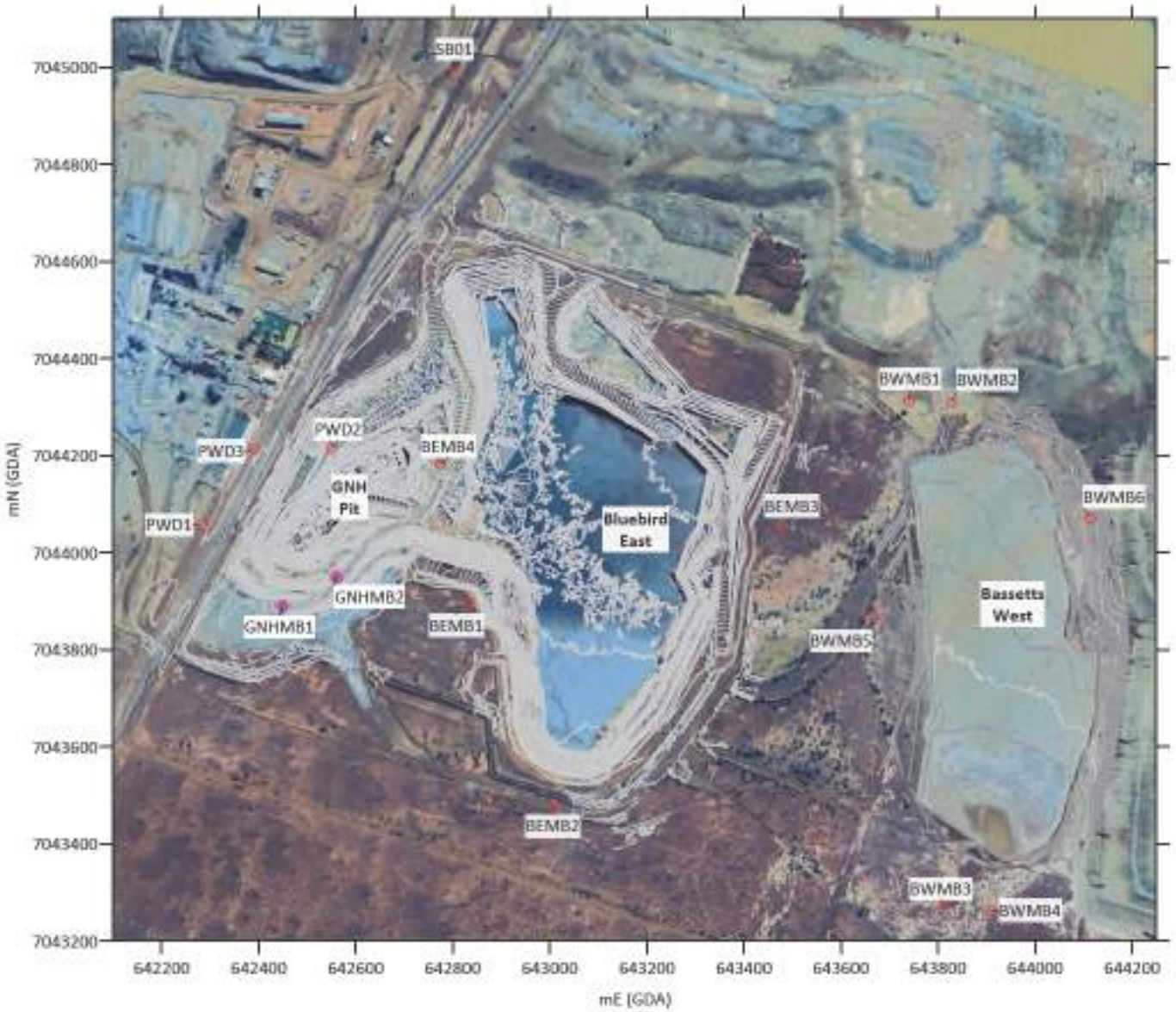
PROJECT: GNH Pit TSF	
DATE: March 2024	
Dwg No: 188-17/24/1-1	Rockwater Pty Ltd

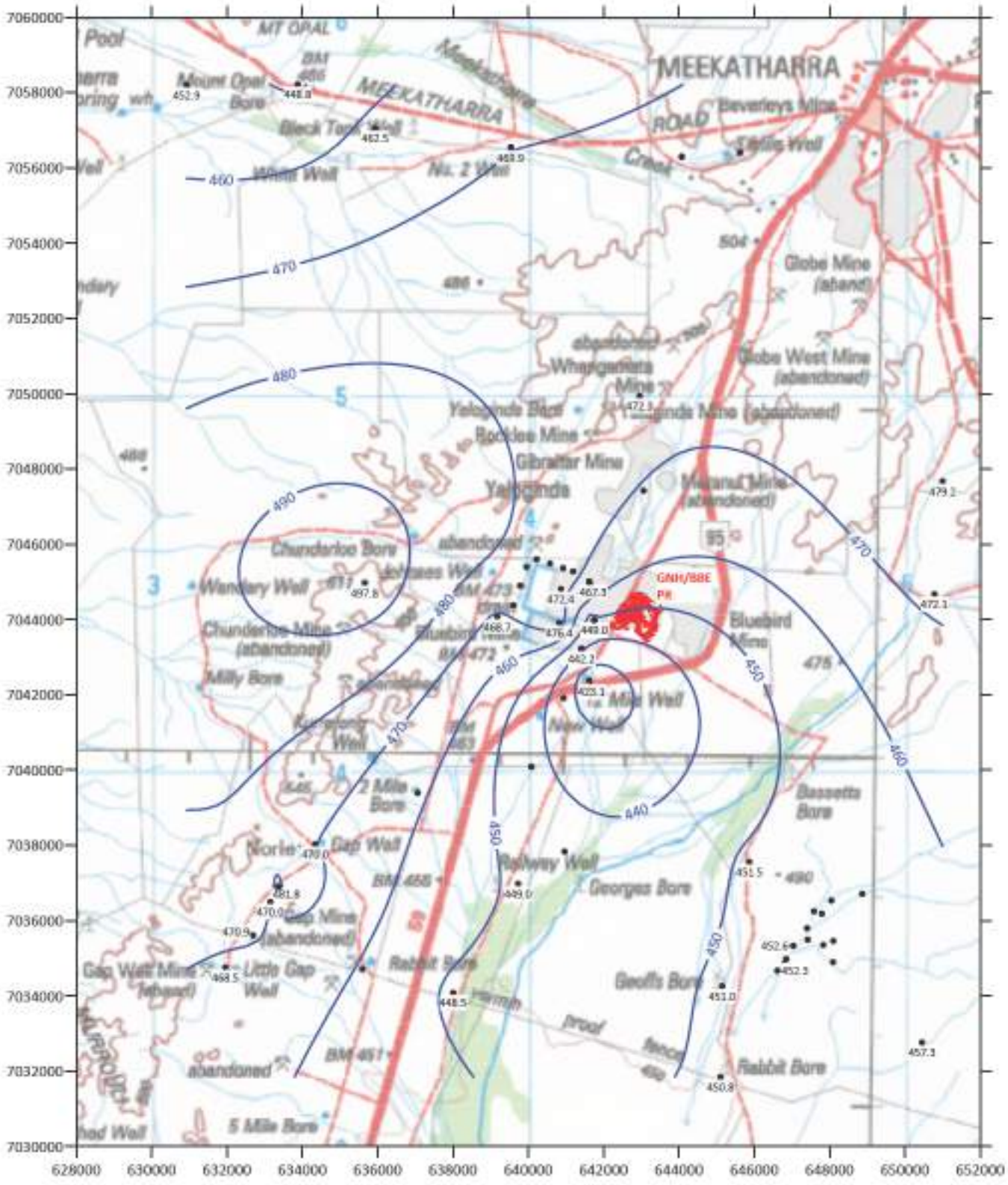
FIGURE 2



mon bore locs.srf

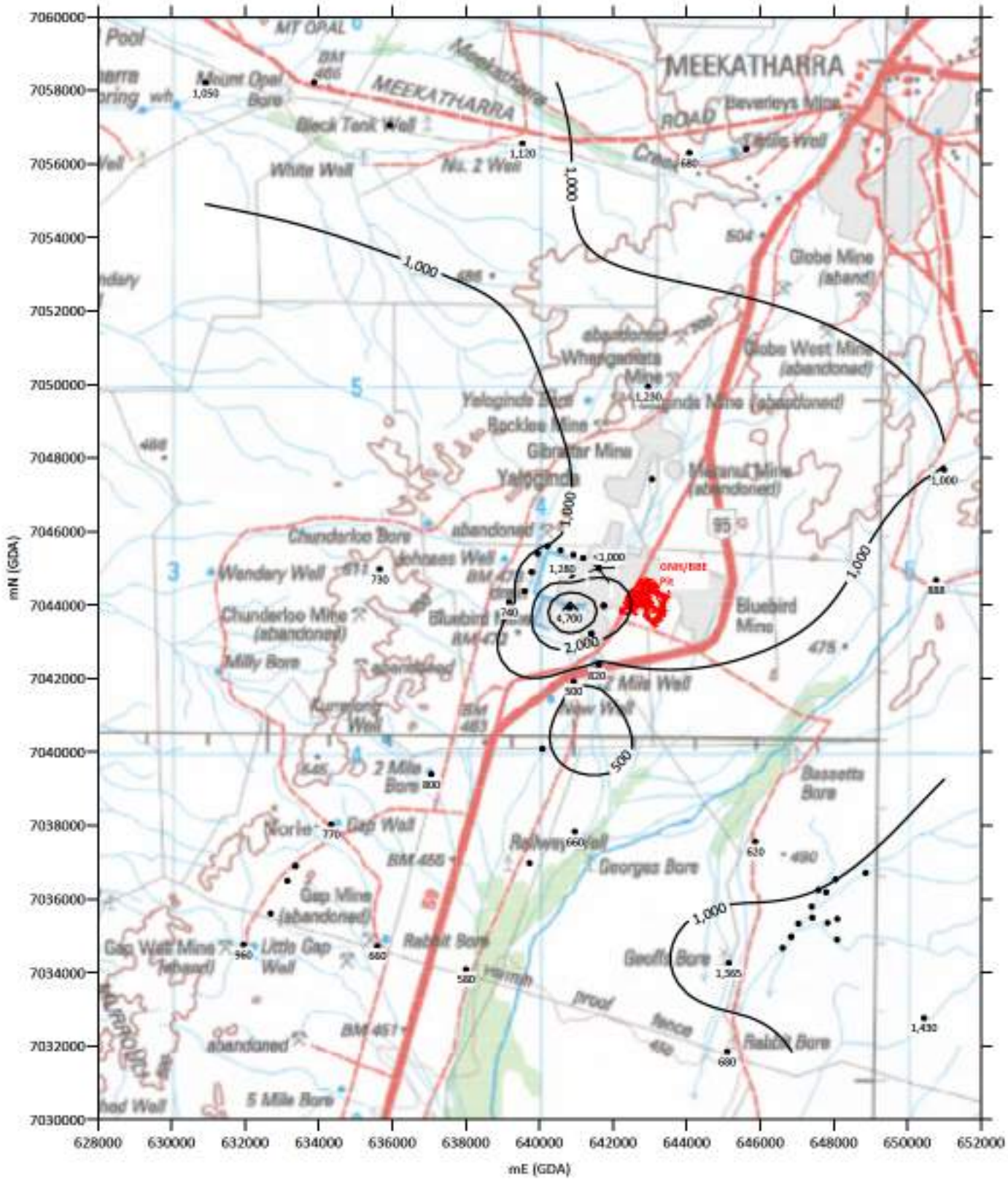
CLIENT: Westgold	PITS & MONITORING BORE LOCATIONS
PROJECT: GNH Pit TSF	
DATE: March 2024	
Dwg No: 166-17/24/1-2	Rockwater Pty Ltd

FIGURE 3



CLIENT: Westgold Resources	GROUNDWATER LEVELS (m AHD), WIR DATABASE
PROJECT: GNH Pit TSF	BLUEBIRD AREA
DATE: March 2024	
Dwg No: 186-17/24/1-3	Rockwater Pty Ltd

FIGURE 4



tds.srf

CLIENT: Westgold Resources	GROUNDWATER SALINITY (mg/L TDS), WIR DATABASE
PROJECT: GNH Pit TSF	BLUEBIRD AREA
DATE: March 2024	
Dwg No: 186-17/24/1-4	Rockwater Pty Ltd