Groundwater Monitoring Summary
Aug 2021 - Aug 2022

Lot 10 Mogumber Road West

For: Proten Western Australia Pty Ltd

Prepared for:

Department of Water and Environmental Regulation

29 August 2022

AquaGeo Pty Ltd

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1.0 Introduction

Proten Western Australia Pty Ltd has been granted a licence GWL182558 to take 550,000kL from the Gingin Central Scarp semi confined aquifer (Mirrabooka Aquifer) and GWL 182879 to take 150,000kL from the Gingin Red Gulley Surficial Aquifer.

1.1 Locality

The property (study area) is located at Lot 10, Mogumber Road West Victoria Plains (Figure 1) is within the Groundwater Management Area of Gingin Central Groundwater Area. The sub-areas of the region are Central Scarp Semi- confined aquifer Perth- Mirrabooka member and Groundwater Subarea Red Gully Superficial Aquifer. Three production bores were drilled in the study area and the hydrogeological logs of these bores are included in Appendix 1. The existing and proposed production bores are shown in Figure 1.

1.2 Licensed Groundwater Users and Monitoring Bores

1.2.1 Existing Groundwater Bores

A search on the Department of Water and Environmental Regulations (DWER) groundwater database shows that there were fourteen (14) groundwater bores within 3 km radius of the study area (Table 1 and Figure 2).

Table 1: Summary details of groundwater bores within 3 km of the study area (Source: DWER Groundwater database).

Bore ID	Easting	Northing	Site Reference
61713012	405706	6564554	20041678 [WIN_ID]; 2135-4-NW-0003 [AQWAB]; 61713012 [SITE_REF]
61713013	405781	6565374	20041685 [WIN_ID]; 2135-4-NW-0010 [AQWAB]; 61713013 [SITE_REF]
61713014	406384	6565311	20041686 [WIN_ID]; 2135-4-NW-0011 [AQWAB]; 61713014 [SITE_REF]
61714986	401217	6568566	20031196 [WIN_ID]; 2035-1-NE-0003 [AQWAB]; 61714986 [SITE_REF]
61714987	402747	6567809	20031197 [WIN_ID]; 2035-1-NE-0004 [AQWAB]; 61714987 [SITE_REF]
61714988	402145	6567222	20031198 [WIN_ID]; 2035-1-NE-0005 [AQWAB]; 61714988 [SITE_REF]
61714989	403289	6567488	20031199 [WIN_ID]; 2035-1-NE-0006 [AQWAB]; 61714989 [SITE_REF]
61716312	406233	6566274	20041676 [WIN_ID]; 2135-4-NW-0001 [AQWAB]; 61716312 [SITE_REF]
61716313	405790	6566067	20041677 [WIN_ID]; 2135-4-NW-0002 [AQWAB]; 61716313 [SITE_REF]
61730062	404794	6566120	2135-4-NW-0033 [AQWAB]; 61730062 [SITE_REF]; 6646 [WIN_ID]
61730063	405139	6566150	2135-4-NW-0030 [AQWAB]; 61730063 [SITE_REF]; 6647 [WIN_ID]
61730064	404794	6566120	2135-4-NW-0031 [AQWAB]; 61730064 [SITE_REF]; 6648 [WIN_ID]
61730065	404821	6566147	2135-4-NW-0032 [AQWAB]; 61730065 [SITE_REF]; 6649 [WIN_ID]
61730066	404820	6566119	23028714 [WIN_ID]; 61730066 [SITE_REF]

1.2.2 Licensed Groundwater User

There are five licensed groundwater users within 3-kilometre radius of the study area (Figure 3). The summary details of the existing production bores in the study area are shown in Table 2 and Figure 4.

Table 2: Summary details of the existing production bores in the study area

Licence Number	Licence Type	Issue Date	Expiry Date	Allocation (KL)	Parties	Area	Subarea	Aquifer
153294	Ground water	23/10/2015	19/09/2022	350000	Gingin Land Company Limited WELSHPOOL PO BOX 388 Gingin	Gingin	Red Gully	Perth - Surficial
101865	Ground water	23/10/2015	19/09/2022	2500000	Gingin Land Company Limited WELSHPOOL PO BOX 388 Gingin	Gingin	Cowalla Confined	Perth - Leederville Permelia

1.3 Property Details

The property is Lot 10 on Plan 30340, Mogumber Road West, Mogumber.

1.4 Location of Potential Groundwater Dependant Ecosystems

There are no groundwater dependent ecosystems within or next to the property. The depth to groundwater is well below 8m across the property. There are some surface water features which are seasonally waterlogged (damp lands) (Figure 5). Only one has a conservation designation and is approximately 1.5km from the existing or proposed bores.

1.5 Water Use

The water is used for raising chickens. Half of the volume of water is put through a reverse osmosis plant and be fed directly to the chickens. The balance is used for cleaning and minor grassing. A number of poultry farms have been built on this location.

2.0 Climate/Rainfall

The climate is typical of a warm temperate region with dominantly winter rainfall and hot, dry summer. The average annual rainfall is about 570 mm. The monthly rainfall data for the Wannamal Station (009040) for the last 3 years is shown in Table 3 and a summary of the long-term climate average for station Walebing (008151) is shown in Table 4.

Table 3: Monthly Rainfall of the area of Wannamal (Station no: 009040) for the period of January 2019 to July 2021 (source: Australian Bureau of Meteorology).

Year	Jan (mm)	Feb (mm)	Mar (mm)	Apr (mm)	May (mm)	Jun (mm)	Jul (mm)	Aug (mm)	Sep (mm)	Oct (mm)	Nov (mm)	Dec (mm)	Annual (mm)
2019	**0.0**	**5.0**	**7.2**	**13.0**	**3.6**	**106.2**	**47.6**	**52.0**	**8.8**	**14.4**	**0.0**	**0.0**	**257.8**
2020	**0.0**	**60.0**	**7.5**	**13.0**	**30.4**	**48.7**	**18.8**	**66.4**	**17.8**	**1.4**	**28.6**	**0.0**	**292.6**
2021	**20.0**	**51.8**	**35.0**	**20.6**	**52.8**	**36.8**	**132.8**	**39.8**	**25.8**	**57.2**	**24.0**	**0.0**	**496.6**
2022	**0.0**	**2.5**	**48.6**	**49.8**	**41.2**	**44.0**	**72.6**						

Table 4: Long Term Averages for Climate data Walebing Site number 008151

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean maximum temperature (°C)	**33.9**	**33.5**	**30.6**	**26.1**	**20.8**	**17.4**	**16.1**	**17.3**	**19.9**	**23.1**	**28.1**	**31.7**
Mean minimum temperature (°C)	**16.7**	**16.9**	**15.3**	**12.2**	**8.8**	**6.9**	**5.4**	**5.6**	**6.7**	**8.4**	**11.8**	**14.6**
Mean rainfall (mm)	**11.7**	**13.9**	**18.9**	**22.9**	**59.8**	**88.3**	**87.8**	**68.7**	**44.1**	**27.1**	**14.2**	**10.7**

3.0 Hydrogeology

3.1 Description of Aquifer from which Abstraction Occurs

The License holder is abstracting from the underlying Mirrabooka Aquifer. An existing license in the Shallow Surficial Aquifer has not been utilised.

3.1.1 Surficial Aquifer

Saturated Cenozoic deposits east of the Gingin Scarp are considered together to form a surficial aquifer separate from the Quaternary deposits on the Swan Coastal Plain comprising the surficial aquifer. The surficial aquifer is less productive, more variable, and only used for minor local stock and domestic supplies.

It typically comprises colluvium, alluvium and lacustrine sediments on slopes and within valleys; deposits filling palaeochannels, including the Capitela and Monger Palaeochannels; and deposits that have infilled the probable impact craterbasin at Yallalie.

Water levels are close to the surface with groundwater salinity ranging from fresh to saline. Sufficient groundwater for stock and domestic use can be present for exploitation by shallow wells and soaks (Commander, 1981). The recharge areas in these isolated aquifers are expected to be localised.

Although the Surficial Aquifer is generally considered low yield, an adjacent farm is abstracting 250000kL/annum from this aquifer, so it has reasonable potential in this area.

3.1.2 Mirrabooka Aquifer

The distribution and hydrogeology of the Mirrabooka aquifer are complex and poorly understood. This aquifer occurs predominantly on the Dandaragan Plateau and comprises four Late Cretaceous geological units, including Poison Hill Greensand, Gingin Chalk, Molecap Greensand and Mirrabooka Member of the Osborne Formation. The aquifer can be eroded in this area and maybe unconfined to confined dependent on where it occurs.

The water table is discontinuous making it difficult to determine a regional water table configuration. The depth to the water table is less than 10m in the eastern areas and increases towards the west (Kay and Diamond, 2001). The aquifer can be prone to water logging due to poorly developed external drainage and the near-surface presence of impermeable Kardinya Shale Member of the Osborne Formation. The existing two bores which were drilled in this aquifer provide a yield of 8l/s and 2l/s respectively.

3.2 Other Aquifers within the area

3.2.1 Leederville Aquifer

The Leederville Aquifer is unconformably overlain by the Surficial Aquifer and generally deep. It consists of sandstone and shale and it may reach 550m in thickness. The aquifer is a semi-confined to confined with variable water quality, generally fresh groundwater (<1000 mg/l TDS).

The Leederville aquifer has good bore yields (up to 3000 KL/day). It provides base flow to Gingin Brook downstream of Mungala Brook confluence. The seawater interface is likely to be offshore.

3.2.2 Yarragadee Aquifer

The Yaragadee Aquifer is not present in this area due to faulting.

3.3 Groundwater Storage and Recharge Potential

In general, recharge to the unconfined Surficial aquifers are mainly from direct rainfall infiltration. The impacts of pumping are generally to be localised and the through flow component is small. The Red Gully Surficial Aquifer has an estimated recharge of about 6.5% (DoW, 2002).

The semi-confined to confined aquifers of the Mirrabooka is hydraulically connected with the overlying Surficial aquifers and are recharged from groundwater that infiltrates vertically from the overlying sediments (Moncrieff, 1989; Kern, 1993; Davidson, 1995). Recharge is generally high where the aquifers are semi-confined. It is estimated that the Mirrabooka in Victoria Plains area has 3% recharge (DoW, 2015).

4.0 Borefield Description

Three bores were constructed on the property Lot 10, Mogumber Road West, one is in the Surficial aquifer and two in the Mirrabooka aquifer. Two bores are equipped in this reporting period. The Surficial Bore has a poor yield and not considered.

4.1 Mirrabooka Bore 1

Mirrabooka Bore 1 was constructed under the Licence Number CAW 182558(4).

4.1.1 Drilling

The bore was drilled on the 16th April 2016 to 18th April 2016 to a depth of 76m. The drilling encountered Surficial Aquifer (0-10m), Poison Hill Greensands (10-28m), Gingin Chalk (28-52m), Molecap sands 52-78m depth and intersected Kardinya shale at 78m, and a sump was drilled to 83m for fall back. The details of the bore construction and drill log are provided in Appendix 2. Short descriptions of the bore constructions are as follows.

The bore was constructed with stainless steel screens from 34m to 40m and from 52m to 76m and sealed with 8 to 12m depth of bentonite and above the bentonite seal, it was cement grouted from 8m to the surface. The bore was developed for five hours and the airlift yield was about 5l/s.

4.1.2 Test Pumping

Test pumping was carried out to establish the bore yield and determine aquifer parameters.

A step drawdown test was carried out for 4 hours at the rates of 2, 4, 6 and 8l/s and on the basis of the test results, 8l/s was selected for the constant rate test. The test was carried out for 12 hours. Initial static water levels were 17.6m. The final drawdown was approximately 40m below this at 57m depth. Recovery was 90% within one hour. An analysis of the test pumping data suggests the bore has a sustainable yield of 6l/s. Transmissivity (T) values were calculated as 21 m2/d. The Storage Coefficient was calculated at $2x10^{-3}$.

The results are shown in Appendix 4

During the pumping test, the groundwater sample was collected for chemical analysis. The on-site measurement of water quality showed TDS - 2400 mg/L, pH - 6.4 and temperature - 22oC.

4.2 Mirrabooka Bore 2

Mirrabooka Bore 2 was constructed under Licence Number CAW 182558().

4.2.1 Drilling

The bore was drilled from 11th May 2018 to 14th May 2018 to a depth of 77m. The drilling encountered Sandy Surficial Aquifer (0-6.5m), 6.5-14m Sandy clay, 14-18m Brown sandy clay, 18-57m chalky clay sand mix, 57-63m sandy silt and 63-67m black shale (Kardinya) Leederville. The details of the bore construction and drill log are provided in Appendix 2. Short descriptions of the bore constructions are as follows.

The bore was constructed with stainless steel screens from 44m to 62m. The bore had a bentonite seal from 38-40m and was fully cement grouted from 27.5 to 38m. The bore was developed for five hours and the airlift yield was about 3l/s.

4.2.2 Test Pumping

A constant rate pump test was carried out at 8l/s. The initial static water level was 4.82m and the final drawdown was at 56m depth. The bore recovered 90% within one hour. An analysis of the test pumping data suggests the bore has a sustainable yield of 2l/s, transmissivity (T) value of $21m^2/d$, storage coefficient -2×10^{-3}. The results are shown in Appendix 4

During the pumping test, the groundwater sample was collected chemical analysis. The on-site measurement of water quality showed TDS - 1130mg/l, pH - 6 and temperature - 22^oC.

4.2.3 Mirrabooka Groundwater Chemistry Summary

Groundwater chemistry for major components and trace metals are shown in Table 5. Appendix 1 shows the laboratory analyses results. All values are well below the ANZECC 2000 guideline for short term irrigation use. The groundwater is treated in a reverse osmosis plant before being supplied to the chicken shed.

There should be no impact on water quality through migration of different quality water as the water samples show both the Surficial and the Mirrabooka is brackish and have only minor differences in water quality over the last three years of monitoring with no significant changes.

In general, there are no significant changes in water quality for the abstraction bores. Mirrabooka Bore 1 has shown a slight increase in Nitrates in 2021 since commissioning however this seems to have stabilised in 2022 with no increase.

Table 5A : Groundwater Quality data for Surficial and Mirrabooka Bores 1 compared with trigger levels for ANZECC 2000 guidelines short term irrigation

Water Quality			**Surficial Bore**	**Mirrabooka Bore 1**					
Sample Date			**01/09/16**	**05/09/16**	**14/08/19**	**16/09/20**	**13/08/21**	**15/01/22**	**28/07/22**
Analytes	Units	Trigger levels (ANZECC 2000)							
pH		60-8.5	7.2	6			6.8	7.0	6.8
Conductivity@25C	µS/cm	120-300	3600	4200			3400	3300	3100
Total Dissolved Soilds at 175-185	mg/l		2300	2400			1900	1800	1700
Total Alkalinity as $CaCO_3$	mg/l	-	190	13		49	55	9	56
Carbonate Alkalinity as CO_3	mg/l	-	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as HCO_3	mg/l	-	230	16	32	60	67	11	68
Chloride, Cl	mg/l	-	1000	1300	1000	1200	1100	970	900
Sulfate, SO_4	mg/l	-	92	140	130	140	130	110	100
Nitrite, NO_2	mg/l	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate, NO_3	mg/l	-	0.2	1	7.2	13	18	16	18
Total Kjeldahl Nitrogen	mg/l	5	0.47	<0.05	0.18	0.17	0.14	0.10	0.15
Total Phosphorus (Kjeldahl Digestion) as P	mg/l	-	18	<0.01	0.03	0.05	<0.02	<0.02	<0.02
Ammonia Nitrogen, NH3 and N	mg/l	-	<0.05	<0.05	-	<0.05	<0.05	<0.05	0.09
Ammonia, NH3	mg/l	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Filterable Reactive Phosphorus	mg/l	-	16	<0.002	0.03	0.05	0.002	-	0.02
Filterable Reactive Phosphorus as PO_4	mg/l		48	<0.01	<0.01	-	-	0.23	0.02
Calcium, Ca	mg/l	-	22	13	12	13	9	10	9.8
Magnesium, Mg	mg/l	-	37	85	66	70	50	57	53
Sodium, Na	mg/l	-	660	780	540	630	520	520	510
Potassium, K	mg/l	-	14	9.1	8.2	8.8	7.9	7.5	7.7
Soluble Silicon as silica, SiO_2	mg/l	-	84	14	12	14	13	14	15
Total Hardness by Calculation	Mg $CaCO_3$/l		210	380	-	-	-	-	-
Aluminium, Al	mg/L	20	0.047	0.007	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic, As	mg/L	2	0.0003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, Cd	mg/L	0.05	<0.1	<0.0001	<0.0001	<0.0001	<0.0001	<000.1	<0.0001
Chromium, Cr	mg/L	1	0.008	<0.001	<0.001	<0.001	<0.001	<1	<1
Lead, Pb	mg/L	5	0.003	<0.001	<0.001	<0.001	<0.001	<1	<1
Manganese, Mn	mg/L	10	1	0.012	0.012	0.04	0.05	4	5
Selenium, Se	mg/l	0.05	<0.001	0.002	0.001	0.002	0.003	2	2
Zinc, Zn	mg/l	5	0.042	0.009	<0.005	<0.005	<0.005	<5	5
Mercury, Hg	mg/l	0.002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Iron, Fe	Mg/l	10	9.6	0.078	0.12	0.14	<0.005	0.05	0.05

Table 6B : Groundwater Quality data for Mirrabooka Bore 2 compared with trigger levels for ANZECC 2000 guidelines short term irrigation

Water Quality			**Mirrabooka Bore 2**					
Sample Date			**12/05/18**	**14/08/19**	**16/09/20**	**13/08/21**	**15/01/22**	**28/07/22**
Analytes	Units	Trigger levels (ANZECC 2000)						
pH		60-8.5	6			6.4	6.6	6.2
Conductivity@25C	µS/cm	120-300	2260			2400	2400	2500
Total Dissolved Soilds at 175-185	mg/l		1130			1400	1300	1400
Total Alkalinity as $CaCO_3$	mg/l	-	76		12	9	9	11
Carbonate Alkalinity as CO_3	mg/l	-	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as HCO_3	mg/l	-	92	16	14	11	11	13
Chloride, Cl	mg/l	-	640	650	690	760	730	730
Sulfate, SO_4	mg/l	-	68	60	60	66	65	68
Nitrite, NO_2	mg/l	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.02
Nitrate, NO_3	mg/l	-	<0.2	<0.2	<0.2	<0.2	<0.2	0.3
Total Kjeldahl Nitrogen	mg/l	5	1.2	0.13	0.12	<0.05	<0.05	0.06
Total Phosphorus (Kjeldahl Digestion) as P	mg/l	-	2.2	0.02	<0.02	0.03	<0.02	<0.01
Ammonia Nitrogen, NH3 and N	mg/l	-	-	-	<0.05	<0.05	<0.05	<0.05
Ammonia, NH3	mg/l	-	<0.05	<0.05	<0.05	<0.05	<0.05	-
Filterable Reactive Phosphorus	mg/l	-	2.2	0.002	<0.002	<0.002	<0.01	<0.01
Calcium, Ca	mg/l	-	15	10	11	11	10	11
Magnesium, Mg	mg/l	-	39	40	43	45	44	47
Sodium, Na	mg/l	-	360	340	380	370	360	380
Potassium, K	mg/l	-	7	6.8	7.1	7.4	6.8	7.6
Soluble Silicon as silica, SiO_2	mg/l	-	15	11	14	13	13	13
Aluminium, Al	mg/L	20	0.13	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic, As	mg/L	2	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, Cd	mg/L	0.05	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium, Cr	mg/L	1	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead, Pb	mg/L	5	0.001	0.021	0.016	<0.001	<0.001	<0.001
Manganese, Mn	mg/L	10	0.16	0.016	0.010	0.052	0.011	
Selenium, Se	mg/l	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, Zn	mg/l	5	0.14	0.66	0.3	0.01	0.07	64
Mercury, Hg	mg/l	0.002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Iron, Fe	Mg/l	10	2.8	0.13	0.14	3.2	0.06	0.071

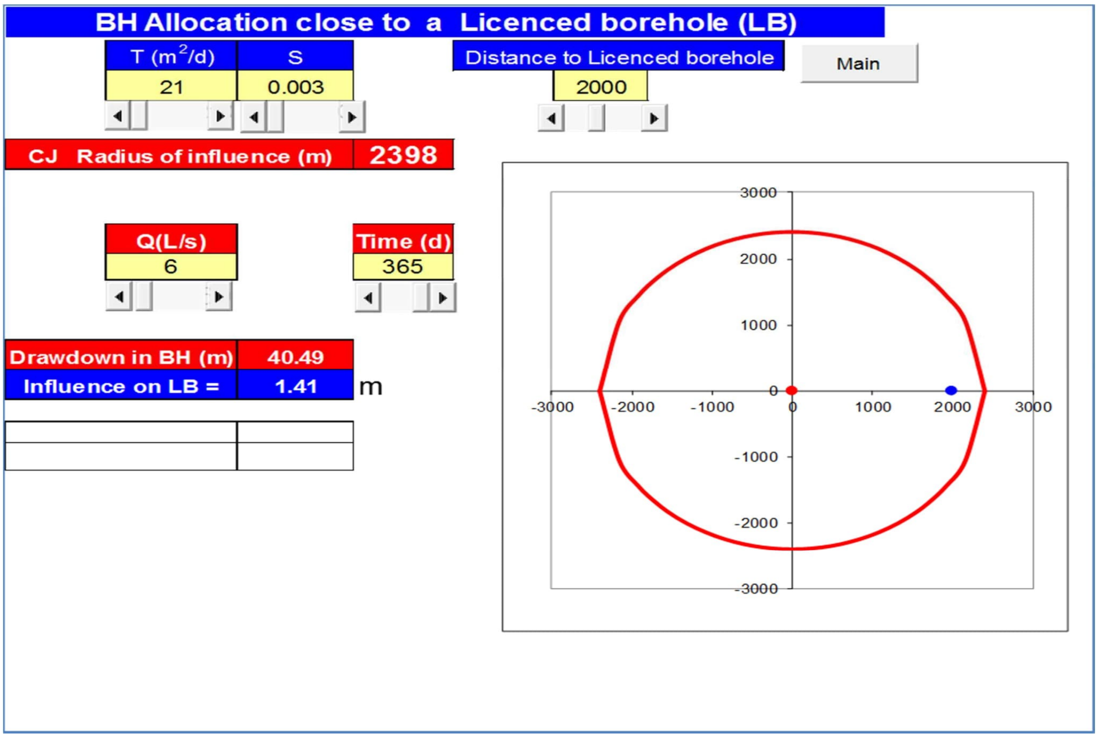
4.2.4 Assessment of Impacts for Mirrabooka Aquifer Abstraction

Currently, there is no other Mirrabooka Aquifer abstraction bore within 8 km radius of the study area. However, there are two abstraction licences are given to the Gingin Land Company to abstract 350000kL/annum of groundwater from Surficial Aquifer (Licence No 153294) and 350000kL/annum from the Parmelia-Leederville Aquifer (Licence No 1010865). The bores are located approximately 2km west of the study area.

A distance-drawdown calculation assuming full time abstraction for a year at an abstraction rate of 6l/s shows a 1.41m drawdown in the Mirrabooka Aquifer within 2km of the Mirrabooka Bore (Table 6). Since there is no other abstraction bore in the Mirrabooka Aquifer within 8km radius of the study area, the current abstraction will have no impact to any other licenced user's groundwater levels.

The Mirrabooka Aquifer is also discontinuous in this area so the drawdown is expected to be restricted to a smaller area by the boundary conditions. No groundwater dependent ecosystems occur within 3km of the property.

Table 7: Drawdown distance at Mirrabooka bore after one year of continuous pumping



BH Allocation close to a Licenced borehole (LB)

T (m^2/d)	S	Distance to Licenced borehole
21	0.003	2000

CJ Radius of influence (m): 2398

Q(L/s)	Time (d)
6	365

Drawdown in BH (m): 40.49

Influence on LB = 1.41 m

4.3 Surficial Bore

4.3.1 Drilling

One surficial bore was drilled to the east of the property and the airlift during the bore development after two hours shows yield to be about 0.2l/s. The bore was constructed and screened, however, due to its low yield, it was not pump tested. The bore log and construction information, as well as the geophysical log, are included in Appendix 3. A groundwater sample was taken for analysis (Table 5).

Additional Surficial bores are proposed to the south of the property near Red Gully Road (Figure 1). It is anticipated to have better yields on the basis of a drilling investigation carried out by mining companies along Red Gully Road.

4.3.2 Groundwater Chemistry

Table 5 shows the laboratory results of the major and minor inorganic of the groundwater sample from Surficial bore. The pH is 7.2 and TDS - 2300 mg/l. The results are compared with the ANZECC 2000 guideline for irrigation short term use. It shows Surficial groundwater is within the guideline values. Since the yield is low, the bore not being utilised.

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5.0 Groundwater Abstraction

Table 8 shows the abstracted groundwater for Mirrabooka bore 1 for the period 24/07/2020 -31/07/202. The bore has an annual abstraction rate of 173665kL/annum.

Table 9 shows the abstracted groundwater from Mirrabooka bore 2 for the 24/07/2020 -31/07/202. The bore has an annual abstraction rate of 40920kL/annum.

The total abstraction for both bores is 214585kL/annum which is well below the licence limits of 550,000kL/annum.

No Abstraction has taken place from the Surficial Aquifer.

Table 8: Abstraction Volumes 31/07/2021 -1/08/2022 (Bore 1).

Irrigation Year 1/08/2020-1/08/2021		**Licence number: GWL 182558(1)**	
Meter serial Number: 120115692 (Installed July 2017)		**Meter make and model: Sensus WP Dynamic**	
		Lot 10 West Mogumber Road, Mogumber	
Date	**Last Reading**	**Current reading**	**Consumption KL**
31/07/2021	381467	397593	16126
24/08/2021	397593	415142	17549
29/09/2021	415142	417772	2630
20/10/2021	417772	424625	6853
15/11/2021	424625	432315	7690
10/12/2021	432315	444277	11962
22/12/2022	444277	450568	6291
30/12/2022	450568	455917	5349
15/01/2022	455917	465180	9263
21/01/2022	465180	468559	3379
31/01/2022	468559	473604	5045
7/02/2022	473604	478667	5063
14/02/2022	478667	484074	5407
21/02/2022	484074	488310	4236
28/02/2022	488310	492613	4303
7/03/2022	492613	497501	4888
14/03/2022	497501	500256	2755
21/03/2022	500256	504021	3765
28/03/2022	504021	507444	3423
4/04/2022	507444	507680	236
11/04/2022	507680	511392	3712
18/04/2022	511392	515766	4374
25/04/2022	515766	520982	5216
2/05/2022	520982	523726	2744
9/05/2022	523726	526739	3013
16/05/2022	526739	529251	2512
23/05/2022	529251	531546	2295
30/05/2022	531546	532418	872
6/06/2022	532418	537451	5033
13/06/2022	537451	537869	418
20/06/2022	537869	539993	2124
27/06/2022	539993	545374	5381
4/07/2022	545374	547333	1959
11/07/2022	547333	549688	2355
18/07/2022	549688	552027	2339
25/07/2022	552027	553614	1587
1/08/2022	553614	555132	1518
TOTAL			173665

Table 9: Abstraction Volumes Abstraction Volumes 31/07/2021 -1/08/2022 (Bore 2)

Irrigation Year 1/08/2020-1/08/2021		**Licence number: GWL 182558(1)**	
Meter serial Number: 120115692 (Installed January 2019)		**Meter make and model: Sensus WP Dynamic**	
		Lot 10 West Mogumber Road, Mogumber	
Date	**Last Reading**	**Current reading**	**Consumption (KL)**
31/07/2021	69760	69760	0
24/08/2021	69760	70929	1169
29/09/2021	70929	74920	3991
20/10/2021	74920	76700	1780
15/11/2021	76700	78540	1840
10/12/2021	78540	81850	3310
22/12/2022	81850	83480	1630
30/12/2022	83480	84850	1370
15/01/2022	84850	87300	2450
21/01/2022	87300	88190	890
31/01/2022	88190	89480	1290
7/02/2022	89480	90660	1180
14/02/2022	90660	91910	1250
21/02/2022	91910	92900	990
28/02/2022	92900	93910	1010
7/03/2022	93910	95180	1270
14/03/2022	95180	95920	740
21/03/2022	95920	96920	1000
28/03/2022	96920	97860	940
4/04/2022	97860	97930	70
11/04/2022	97930	98870	940
18/04/2022	98870	100000	1130
25/04/2022	100000	101390	1390
2/05/2022	101390	102100	710
9/05/2022	102100	102880	780
16/05/2022	102880	103550	670
23/05/2022	103550	104190	640
30/05/2022	104190	104430	240
6/06/2022	104430	104670	240
13/06/2022	104670	105910	1240
20/06/2022	105910	106490	580
27/06/2022	106490	107960	1470
4/07/2022	107960	108520	560
11/07/2022	108520	109170	650
18/07/2022	109170	109810	640
25/07/2022	109810	110260	450
1/08/2022	110260	110680	420
SUBTOTAL			40920

6.0 Monitoring Results

6.1 Water levels/Quantity

For the period 31/07/2021 -1/08 /2021 a total abstraction of 173665kL/annum groundwater was abstracted from bore 1 (GWL 182558(1)). Similarly, 40920KL groundwater was abstracted from bore 2. There was a total abstraction of 214585kL/annum groundwater. This is well below the allowed limit of 550,000kl/annum. No abstraction has taken place in the Surficial Aquifer (GWL 182879(1).

Bore 1 showed a no cumulative drawdown over the calendar year. The drawdown is variable throughout the calendar year and has been above the initial water level during the calendar year. This shows that the aquifer yield is probably sustainable at the present abstraction rate.

Bore 2 shows no real impact of abstraction. The initial water level recorded at the beginning of the calendar year was 4m however the bore was not pumped for a month before this reading was taken. From the time the bore was actively pumped the active pumping level has varied between 5-5.4m during the year, showing no sign of long-term drawdown. This shows that the aquifer yield is probably sustainable at the present abstraction.

The Mirrabooka aquifer shows no depletion of storage through pumping across the calendar year.

DATE	BORE 1 HEIGHT (metres below top of casing)	BORE 2 HEIGHT (metres below top of casing)
Construction static water level Bore 1 29/04/2016	17.6	
Construction Static Water level Bore 2 15/05/2018		4.82
31/07/2021	18.2	4
24/08/2021	18.1	4.3
29/09/2021	18.4	5.4
20/10/2021	18.5	5.4
15/11/2021	18.1	5.2
10/12/2021	18.2	5
22/12/2022	18	5.1
30/12/2022	18.1	5
15/01/2022	18.3	5.2
21/01/2022	18.2	5.3
31/01/2022	18.1	5.2
7/02/2022	18.2	5.2
14/02/2022	18.1	5.3
21/02/2022	18.2	5.3
28/02/2022	18.4	5.1
7/03/2022	18.3	5.1
14/03/2022	18.3	5.2
21/03/2022	18.2	5.3
28/03/2022	18.1	5.4
4/04/2022	18.3	5.3
11/04/2022	18.2	5.2
18/04/2022	18.1	5.3
25/04/2022	18.3	5.1
2/05/2022	18.2	5.2
9/05/2022	18.1	5.2
16/05/2022	18.3	5.3
23/05/2022	18.3	5.1
30/05/2022	18.1	5.2
6/06/2022	18.3	5.3
13/06/2022	18.2	5.1
20/06/2022	18.3	5.4
27/06/2022	18.2	5.3
4/07/2022	18.4	5.1
11/07/2022	18.3	5.2
18/07/2022	18.2	5.2
25/07/2022	18.3	5.1
1/08/2022	18.1	5.4

Table 10 Water Levels recorded for period 2020-2021

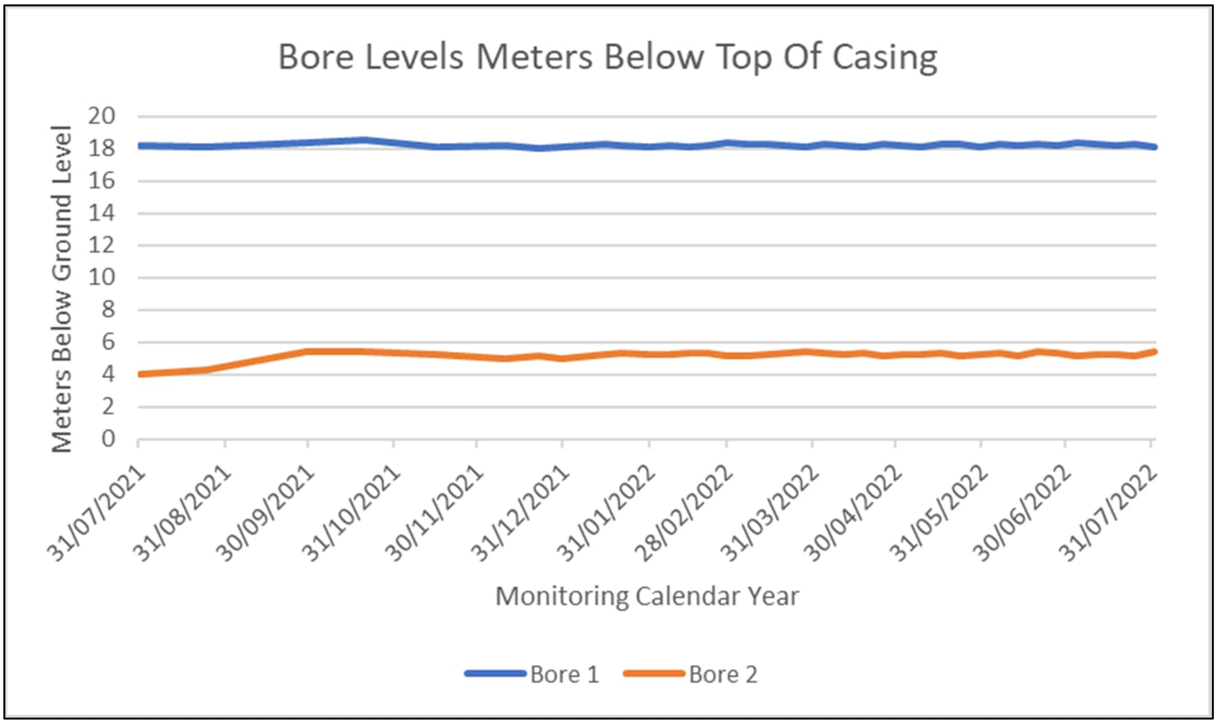

Table 11 Bore Water Levels Meters below top of casing

6.2 Water Quality

Groundwater samples of Mirrabooka bore 1 and 2 were collected for water quality analysis and the results are shown in Table 5.

6.3 Compliance

The licensee has collected the abstraction volumes for the monitoring period. They have collected water levels for each. Water Quality samples have been collected twice as per the monitoring schedule and the results are provided in Table 5.

6.4 Recommended changes to the monitoring program

Any additional bores drilled will be included in an updated monitoring program and will be reported accordingly. No other changes are recommended.

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Document Status

Rev No.	Author	Approved for Issue		
		Name	Signature	Date
1	B.van Blomestein	**B.van Blomestein**		30/08/2022

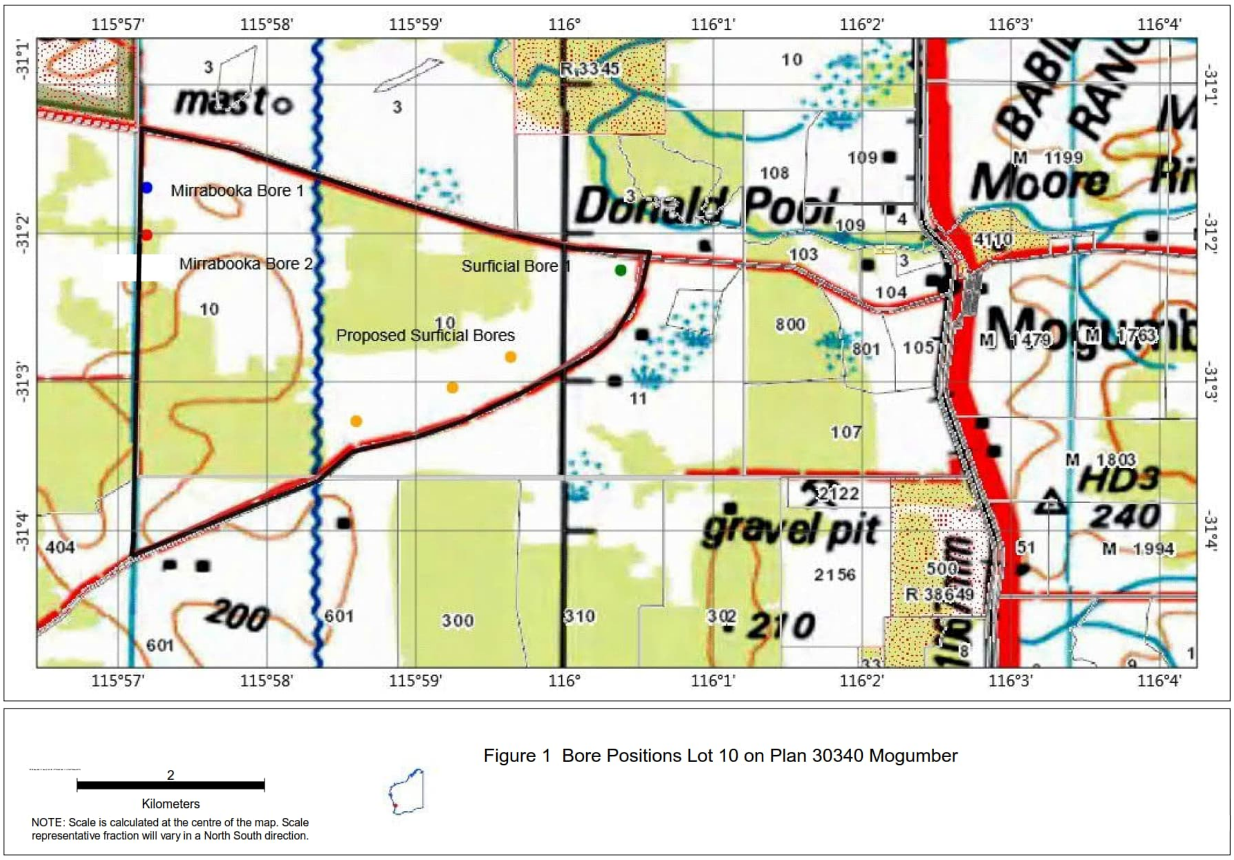


Figure 1: Groundwater bore locations at Lot 10 Mogumber

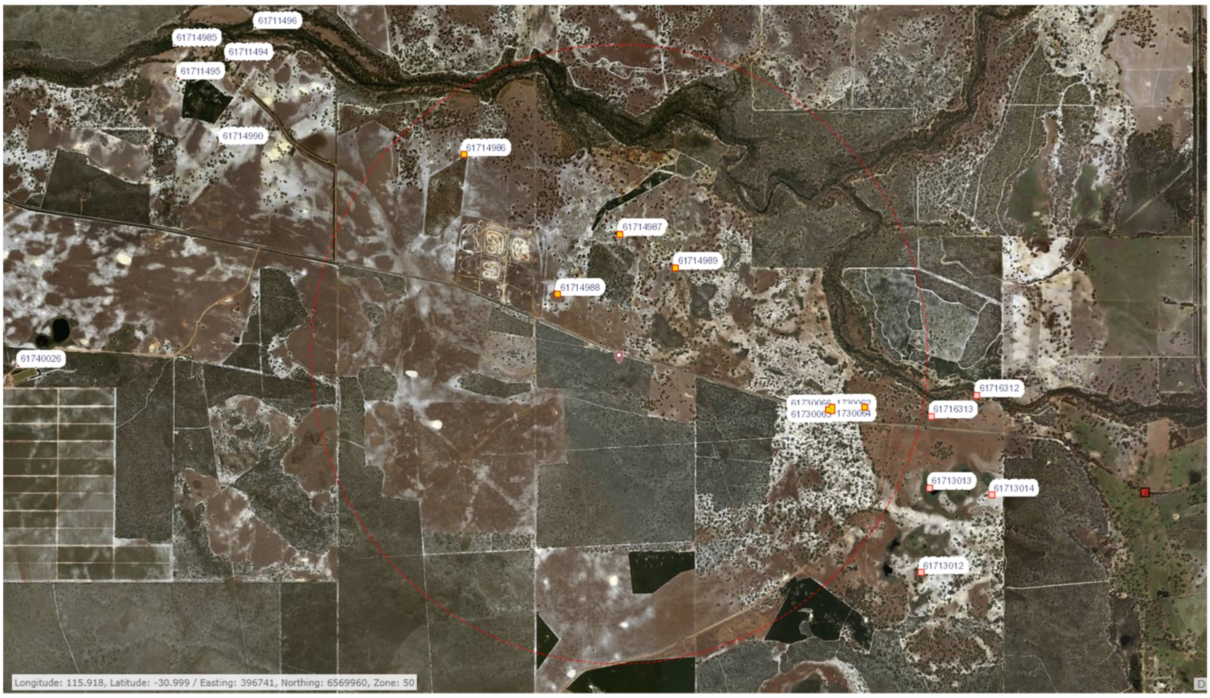
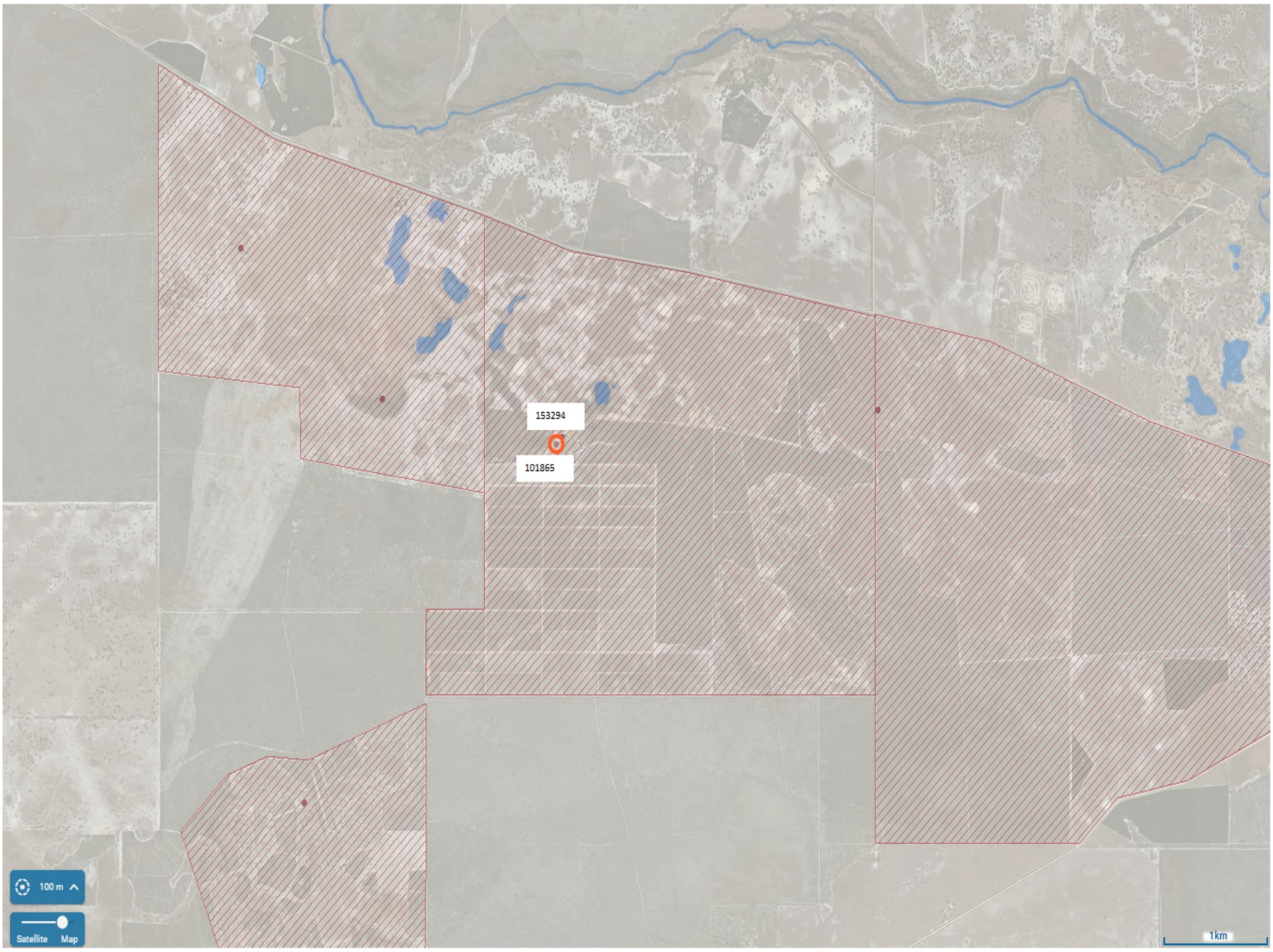
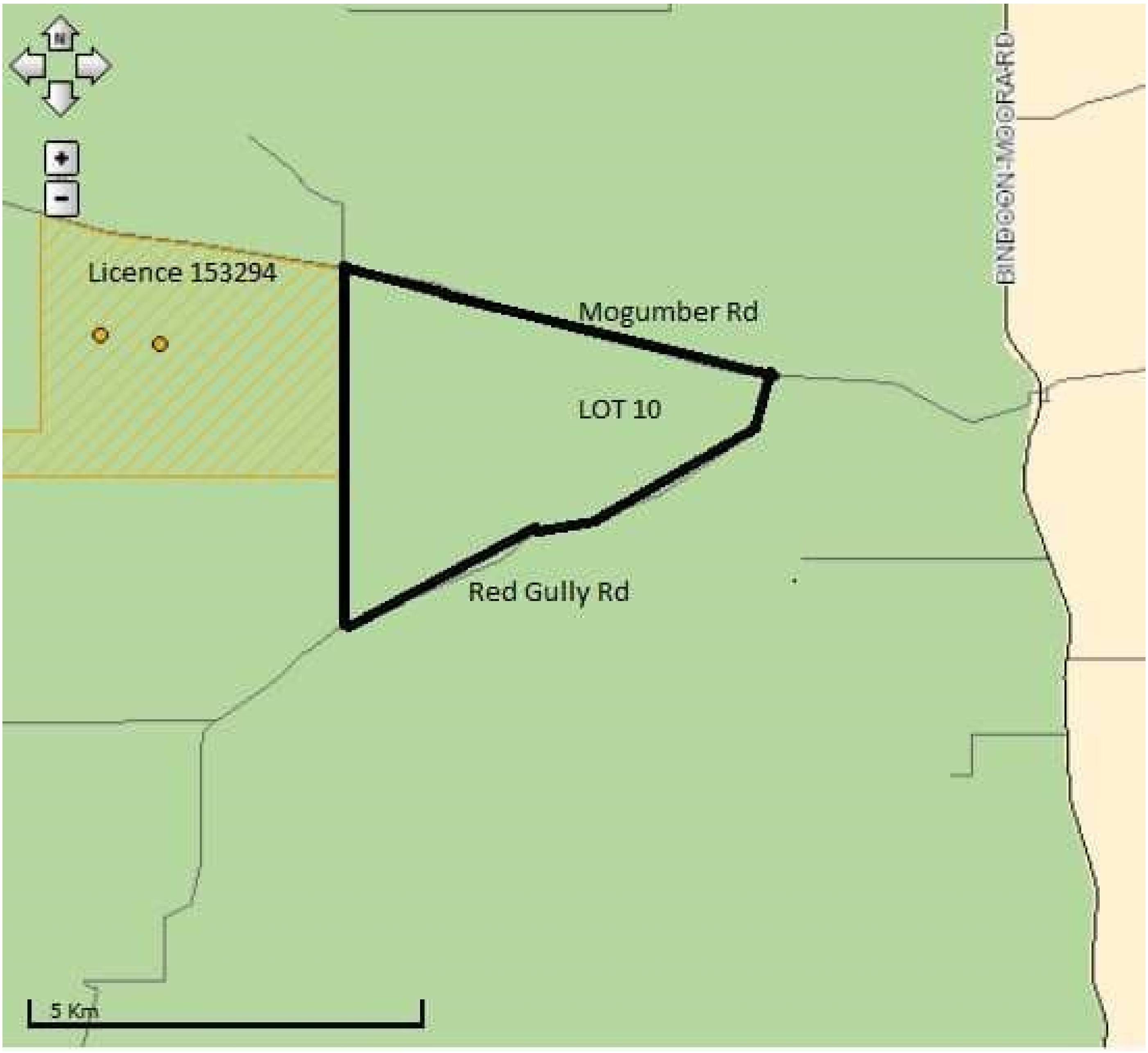


Figure 2: Groundwater bores within 3 km radius from the study area.



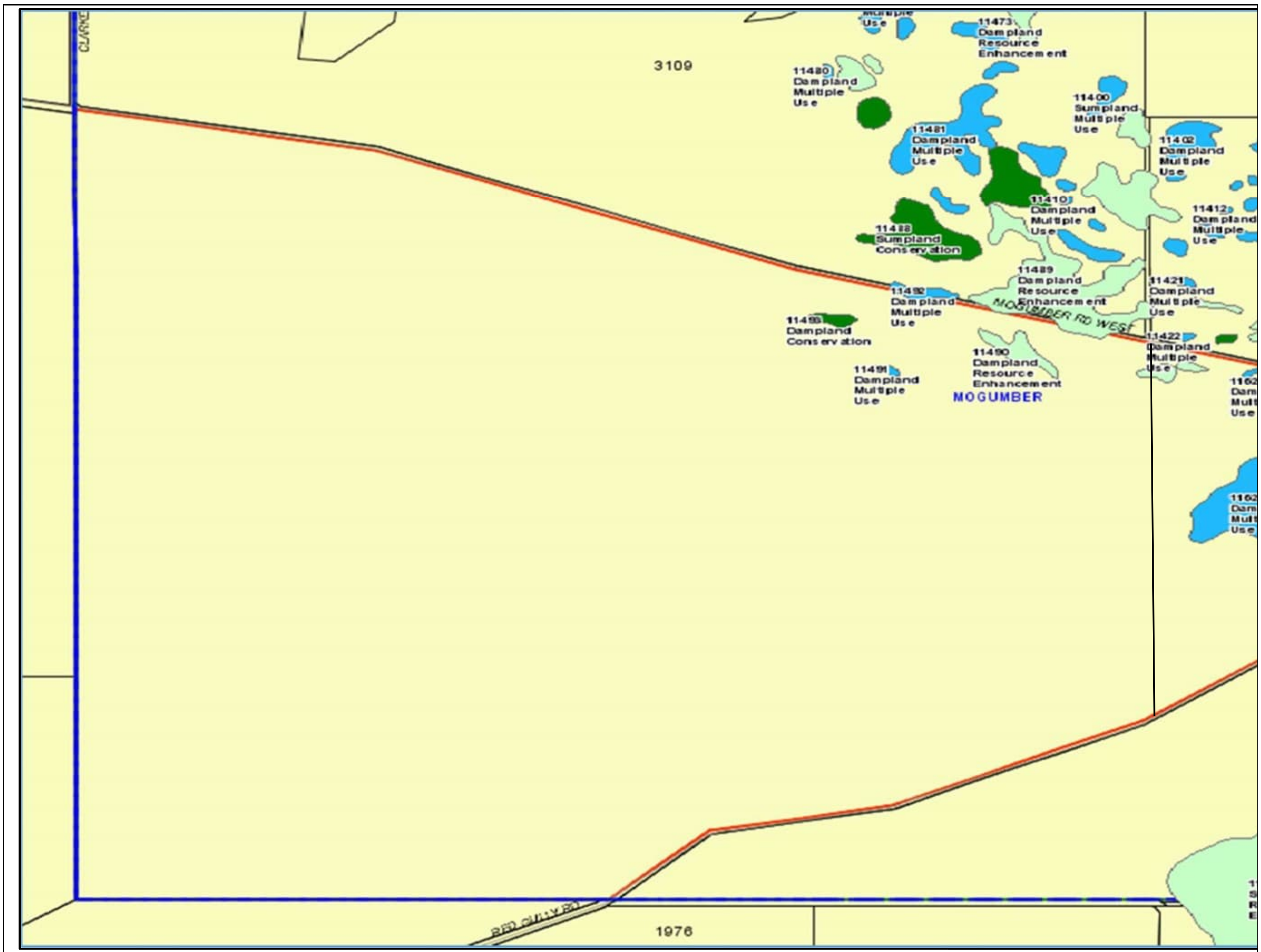
H2 REPORT-LOT 10 MOGUMBER ROAD

Figure 3: Distribution of existing groundwater licence bores within 3 kilometre radius of the study area (Source: DWER)



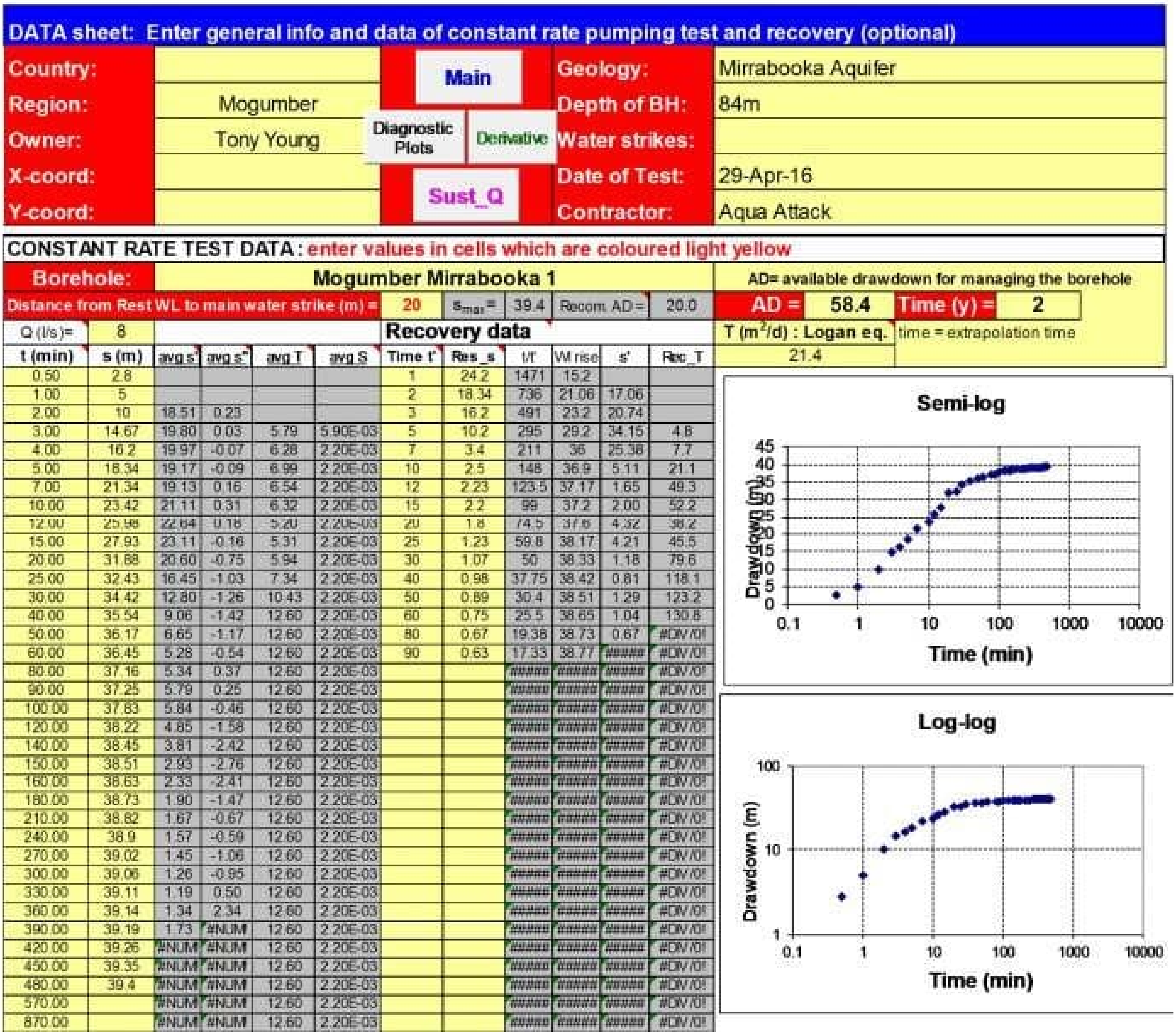
GROUNDWATER MONITORING REPORT-LOT 10 MOGUMBER ROAD

Figure 4: Locality of Licence 153294 and 101865- Surficial and Leederville-Parmelia Bore Licenses.



H2 REPORT-LOT 10 MOGUMBER ROAD

Figure 5: Dampland and Sumpland Geomorphic Wetlands, Swan Coastal Plain (DPAW-017), Lot 10 Mogumber Road



DATA sheet: Enter general info and data of constant rate pumping test and recovery (optional)

Country:		**Geology:**	Mirrabooka Aquifer
Region:	Mogumber	**Depth of BH:**	84m
Owner:	Tony Young	**Water strikes:**	
X-coord:		**Date of Test:**	29-Apr-16
Y-coord:		**Contractor:**	Aqua Attack

CONSTANT RATE TEST DATA: enter values in cells which are coloured light yellow

Borehole: Mogumber Mirrabooka 1

AD= available drawdown for managing the borehole

Distance from Rest WL to main water strike (m) = 20

s_{max}= 39.4

Recom. AD = 20.0

AD = 58.4

Time (y) = 2

Q (l/s)= 8

T (m^2/d) : Logan eq. 21.4

time = extrapolation time

						Recovery data					
t (min)	s (m)	avg s'	avg s"	avg T	avg S	Time t'	Res_s	t/t'	Wl rise	s'	Rec_T
0.50	2.8					1	24.2	1471	15.2		
1.00	5					2	18.34	736	21.06	17.06	
2.00	10	18.51	0.23			3	16.2	491	23.2	20.74	
3.00	14.67	19.80	0.03	5.79	5.90E-03	5	10.2	295	29.2	34.15	4.8
4.00	16.2	19.97	-0.07	6.28	2.20E-03	7	3.4	211	36	25.38	7.7
5.00	18.34	19.17	-0.09	6.99	2.20E-03	10	2.5	148	36.9	5.11	21.1
7.00	21.34	19.13	0.16	6.54	2.20E-03	12	2.23	123.5	37.17	1.65	49.3
10.00	23.42	21.11	0.31	6.32	2.20E-03	15	2.2	99	37.2	2.00	52.2
12.00	25.98	22.64	0.18	5.20	2.20E-03	20	1.8	74.5	37.6	4.32	38.2
15.00	27.93	23.11	-0.16	5.31	2.20E-03	25	1.23	59.8	38.17	4.21	45.5
20.00	31.88	20.60	-0.75	5.94	2.20E-03	30	1.07	50	38.33	1.18	79.6
25.00	32.43	16.45	-1.03	7.34	2.20E-03	40	0.98	37.75	38.42	0.81	118.1
30.00	34.42	12.80	-1.26	10.43	2.20E-03	50	0.89	30.4	38.51	1.29	123.2
40.00	35.54	9.06	-1.42	12.60	2.20E-03	60	0.75	25.5	38.65	1.04	130.8
50.00	36.17	6.65	-1.17	12.60	2.20E-03	80	0.67	19.38	38.73	0.67	#DIV/0!
60.00	36.45	5.28	-0.54	12.60	2.20E-03	90	0.63	17.33	38.77	#####	#DIV/0!
80.00	37.16	5.34	0.37	12.60	2.20E-03			#####	#####	#####	#DIV/0!
90.00	37.25	5.79	0.25	12.60	2.20E-03			#####	#####	#####	#DIV/0!
100.00	37.83	5.84	-0.46	12.60	2.20E-03			#####	#####	#####	#DIV/0!
120.00	38.22	4.85	-1.58	12.60	2.20E-03			#####	#####	#####	#DIV/0!
140.00	38.45	3.81	-2.42	12.60	2.20E-03			#####	#####	#####	#DIV/0!
150.00	38.51	2.93	-2.76	12.60	2.20E-03			#####	#####	#####	#DIV/0!
160.00	38.63	2.33	-2.41	12.60	2.20E-03			#####	#####	#####	#DIV/0!
180.00	38.73	1.90	-1.47	12.60	2.20E-03			#####	#####	#####	#DIV/0!
210.00	38.82	1.67	-0.67	12.60	2.20E-03			#####	#####	#####	#DIV/0!
240.00	38.9	1.57	-0.59	12.60	2.20E-03			#####	#####	#####	#DIV/0!
270.00	39.02	1.45	-1.06	12.60	2.20E-03			#####	#####	#####	#DIV/0!
300.00	39.06	1.26	-0.95	12.60	2.20E-03			#####	#####	#####	#DIV/0!
330.00	39.11	1.19	0.50	12.60	2.20E-03			#####	#####	#####	#DIV/0!
360.00	39.14	1.34	2.34	12.60	2.20E-03			#####	#####	#####	#DIV/0!
390.00	39.19	1.73	#NUM!	12.60	2.20E-03			#####	#####	#####	#DIV/0!
420.00	39.26	#NUM!	#NUM!	12.60	2.20E-03			#####	#####	#####	#DIV/0!
450.00	39.35	#NUM!	#NUM!	12.60	2.20E-03			#####	#####	#####	#DIV/0!
480.00	39.4	#NUM!	#NUM!	12.60	2.20E-03			#####	#####	#####	#DIV/0!
570.00		#NUM!	#NUM!	12.60	2.20E-03			#####	#####	#####	#DIV/0!
870.00		#NUM!	#NUM!	12.60	2.20E-03			#####	#####	#####	#DIV/0!

H2 REPORT-LOT 10 MOGUMBER ROAD

Figure 6: Test Pumping Data Mirrabooka Bore 1

APPENDIX 1 GROUNDWATER LABORATORY ANALYSES

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Kate Singh	Manager	Kieran Hopkins
Client	PROTEN WESTERN AUSTRALIA PTY LTD ATF PROTEN	Laboratory	SGS Perth Environmental
Address	PO BOX 1746 NORTH SYDNEY NSW 2059	Address	28 Reid Rd Perth Airport WA 6105
Telephone	61 2 9458 1700	Telephone	(08) 9373 3500
Facsimile	(Not specified)	Facsimile	(08) 9373 3556
Email	kates@proten.com.au	Email	au.environmental.perth@sgs.com
Project	**Proten Farms Mogumber**	SGS Reference	**PE157793 R0**
Order Number	**48594**	Date Received	18 Jan 2022
Samples	2	Date Reported	27 Jan 2022

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

For determination of soluble metals, filtered sample was not received so samples were laboratory filtered on receipt. This may give soluble metals results that do not represent the concentrations present at the time of sampling.

SIGNATORIES

LouiseHope

Louise HOPE
Laboratory Technician

Mary Ann OLA-A
Inorganics Team Leader

Murray O'NEILL
Lab Technician-Nutrients Signatory

Ohmar DAVID
Metals Chemist

		Sample Number	PE157793.001	PE157793.002
		Sample Matrix	Water	Water
		Sample Date	15 Jan 2022	15 Jan 2022
		Sample Name	BORE 1	BORE 2
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 18/1/2022

pH**	pH Units	0.1	**7.0**	**6.6**

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 18/1/2022

Conductivity @ 25 C	µS/cm	2	**3300**	**2400**

Total Dissolved Solids (TDS) in water Method: AN113 Tested: 19/1/2022

Total Dissolved Solids Dried at 175-185°C	mg/L	10	**1800**	**1300**

Total and Volatile Suspended Solids (TSS / VSS) Method: AN114 Tested: 20/1/2022

Total Suspended Solids Dried at 103-105°C	mg/L	5	<5	**8**

Alkalinity Method: AN135 Tested: 18/1/2022

Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Bicarbonate Alkalinity as HCO3	mg/L	5	**61**	**11**
Total Alkalinity as CaCO3	mg/L	5	**50**	**9**

Chloride by Discrete Analyser in Water Method: AN274 Tested: 21/1/2022

Chloride, Cl	mg/L	1	**970**	**730**

		Sample Number	PE157793.001	PE157793.002
		Sample Matrix	Water	Water
		Sample Date	15 Jan 2022	15 Jan 2022
		Sample Name	BORE 1	BORE 2
Parameter	Units	LOR		

Sulfate in water Method: AN275 Tested: 21/1/2022

Sulfate, SO4	mg/L	1	**110**	**65**

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 20/1/2022

Calcium, Ca	mg/L	0.2	**10**	**10**
Magnesium, Mg	mg/L	0.1	**57**	**44**
Potassium, K	mg/L	0.1	**7.5**	**6.8**
Sodium, Na	mg/L	0.5	**520**	**360**

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 19/1/2022

Aluminium, Al	µg/L	5	<5	<5
Arsenic, As	µg/L	1	<1	<1
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1
Iron, Fe	µg/L	5	**47**	**59**
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	**4**	**11**
Selenium, Se	µg/L	1	**2**	<1
Zinc, Zn	µg/L	5	<5	**7**

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 24/1/2022

Mercury	mg/L	0.00005	<0.00005	<0.00005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: AN258 Tested: 21/1/2022

Nitrite, NO_2 as NO_2	mg/L	0.2	<0.2	<0.2
Nitrate, NO_3 as NO_3	mg/L	0.2	**16**	<0.2

Ammonia Nitrogen by FIA Method: AN261 Tested: 21/1/2022

Ammonia, NH_3	mg/L	0.05	<0.05	<0.05

		Sample Number	PE157793.001	PE157793.002
		Sample Matrix	Water	Water
		Sample Date	15 Jan 2022	15 Jan 2022
		Sample Name	BORE 1	BORE 2
Parameter	Units	LOR		
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 20/1/2022				
Filterable Reactive Phosphorus as PO4	mg/L	0.01	**0.23**	<0.01
TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 19/1/2022				
Total Kjeldahl Nitrogen	mg/L	0.05	**0.10**	<0.05
Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 19/1/2022				
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	<0.02	<0.02
Reactive Silica by Discrete Analyser Method: AN270 Tested: 21/1/2022				
Reactive Silica, SiO_2	mg/L	0.1	**14**	**13**
Ferrous Iron in water Method: AN271 Tested: 25/1/2022				
Ferrous Iron, Fe^{2+}	mg/L	0.05	**0.05**	**0.06**

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Carbonate Alkalinity as CO3	LB192065	mg/L	1	<1		
Bicarbonate Alkalinity as HCO3	LB192065	mg/L	5	<5		
Total Alkalinity as CaCO3	LB192065	mg/L	5	<5	2%	100%

Ammonia Nitrogen by FIA Method: ME-(AU)-[ENV]AN261

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Ammonia, NH_3	LB191988	mg/L	0.05	<0.05	NA

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB192014	mg/L	1	<1	0 - 1%	105%	87 - 89%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB192104	µS/cm	2	<2	0%	98 - 106%

Ferrous Iron in water Method: ME-(AU)-[ENV]AN271

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ferrous Iron, Fe2+	LB192098	mg/L	0.05	<0.05	0%	107%

Filterable Reactive Phosphorus (FRP) Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Filterable Reactive Phosphorus as PO4	LB191970	mg/L	0.01	<0.01	0%	NA	NA

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Mercury (dissolved) in Water **Method: ME-(AU)-[ENV]AN311(Perth)/AN312**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB192044	mg/L	0.00005	<0.00005	0%	95%	88%

Metals in Water (Dissolved) by ICPOES **Method: ME-(AU)-[ENV]AN320**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Calcium, Ca	LB191949	mg/L	0.2	<0.2		102%	90%
Magnesium, Mg	LB191949	mg/L	0.1	<0.1	1%	105%	105%
Potassium, K	LB191949	mg/L	0.1	<0.1		103%	
Sodium, Na	LB191949	mg/L	0.5	<0.5	1%	105%	

pH in water **Method: ME-(AU)-[ENV]AN101**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB192104	pH Units	0.1	5.6	0%	100%

Reactive Silica by Discrete Analyser **Method: ME-(AU)-[ENV]AN270**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Reactive Silica, SiO_2	LB192018	mg/L	0.1	<0.10	0%	100%	109%

Sulfate in water **Method: ME-(AU)-[ENV]AN275**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB192014	mg/L	1	<1	0 - 2%	104 - 105%	96%

TKN Kjeldahl Digestion by Discrete Analyser **Method: ME-(AU)-[ENV]AN281**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB191926	mg/L	0.05	<0.05	0%	111%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total and Volatile Suspended Solids (TSS / VSS) Method: ME-(AU)-[ENV]AN114

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Suspended Solids Dried at 103-105°C	LB191964	mg/L	5	<5	4%	95%

Total Dissolved Solids (TDS) in water Method: ME-(AU)-[ENV]AN113

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery	MSD %RPD
Total Dissolved Solids Dried at 175-185°C	LB191896	mg/L	10	<10	0%	109%	-135%	-17%

Total Phosphorus by Kjeldahl Digestion DA in Water Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion) as P	LB191926	mg/L	0.02	<0.02	0 - 16%	110%

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB191911	µg/L	5	<5		101%	98%
Arsenic, As	LB191911	µg/L	1	<1		111%	100%
Cadmium, Cd	LB191911	µg/L	0.1	<0.1		98%	89%
Chromium, Cr	LB191911	µg/L	1	<1		104%	110%
Iron, Fe	LB191911	µg/L	5	<5	0%	105%	98%
Lead, Pb	LB191911	µg/L	1	<1		115%	104%
Manganese, Mn	LB191911	µg/L	1	<1	3%	100%	96%
Selenium, Se	LB191911	µg/L	1	<1		102%	97%
Zinc, Zn	LB191911	µg/L	5	<5		119%	87%

METHOD	METHODOLOGY SUMMARY
	Nitrate and Nitrite by FIA: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Without the cadmium reduction only the original nitrite is determined. Reference APHA 4500-NO3- F.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN113	Total Dissolved Solids: A well-mixed filtered sample of known volume is evaporated to dryness at 180°C and the residue weighed. Approximate methods for correlating chemical analysis with dissolved solids are available. Reference APHA 2540 C.
AN113	The Total Dissolved Solids residue may also be ignited at 550 C and volatile TDS (Organic TDS) and non-volatile TDS (Inorganic) can be determined.
AN114	Total Suspended and Volatile Suspended Solids: The sample is homogenised by shaking and a known volume is filtered through a pre-weighed GF/C filter paper and washed well with deionised water. The filter paper is dried and reweighed. The TSS is the residue retained by the filter per unit volume of sample. Reference APHA 2540 D. Internal Reference AN114
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN261	Ammonia by Continuous Flow Analyser: Ammonium in a basic medium forms ammonia gas, which is separated from the sample matrix by diffusion through a polypropylene membrane. The ammonia is reacted with phenol and hypochlorite to form indophenol blue at an intensity proportional to the ammonia concentration. The blue colour is intensified with sodium nitroprusside and the absorbance measured at 630 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-NH3 H.
AN270	Reactive forms of silicon in acid solution below pH 2 react with ammonium molybdate ions to form a yellow silicomolybdate which is then reduced with ascorbic acid to produce a blue silicomolybdate complex. Oxalic acid is added to destroy any molybdophosphoric acid. Colourimetric determination by Discrete Analyser.
AN271	Ferrous Iron by Discrete Analyser: Iron in the ferrous state is treated with 1,10-phenathroline at pH 3.2. The intensity of the resultant orange/red coloured solution is proportional to the amount of ferrous iron present. Reference APHA 3500-Fe B.
AN271	Ferric iron (Fe3+) is calculated as the difference between Total iron and Ferrous iron as per APHA, method 3500-Fe B, 23rd Edition. Water samples that are taken and include insoluble solids (turbid and/or contain fine sediment/precipitates) will include iron from this source as in natural waters, ferric iron is in an insoluble form (precipitate).

METHOD	METHODOLOGY SUMMARY
AN274	Chloride by Discrete Analyse: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	Sulfate by Discrete Analyse: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN278	Filterable Reactive Phosphorus by DA (determined on filtered sample): Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293(Sydney)	The sample is digested with Sulphuric acid, K2SO4 and CuSO4. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K2SO4 and CuSO4. The ammonia produced following digestion is then measured colourimetrically using the Discrete Analyser . A portion of the digested sample is buffered to an alkaline pH, and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique,, referenced to USEPA 6020B and USEPA 200.8 (5.4).
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
***	Indicates that both * and ** apply.	NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Kate Singh	Manager	Kieran Hopkins
Client	PROTEN WESTERN AUSTRALIA PTY LTD ATF PROTEN	Laboratory	SGS Perth Environmental
Address	PO BOX 1746 NORTH SYDNEY NSW 2059	Address	28 Reid Rd Perth Airport WA 6105
Telephone	61 2 9458 1700	Telephone	(08) 9373 3500
Facsimile	(Not specified)	Facsimile	(08) 9373 3556
Email	kates@proten.com.au	Email	au.environmental.perth@sgs.com
Project	**Mogumber**	SGS Reference	**PE162295 R0**
Order Number	**54678**	Date Received	28 Jul 2022
Samples	2	Date Reported	05 Aug 2022

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

SIGNATORIES

Hue Thanh LY
Metals Team Leader

Louise Hope

Louise HOPE
Laboratory Technician

Mary Ann OLA-A
Inorganics Team Leader

Murray O'NEILL
Lab Technician-Nutrients Signatory

Ohmar DAVID
Metals Chemist

		Sample Number	PE162295.001	PE162295.002
		Sample Matrix	Water	Water
		Sample Date	28 Jul 2022	28 Jul 2022
		Sample Name	Bore 1	Bore 2
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 29/7/2022

pH**	pH Units	-	**6.8**	**6.2**

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 29/7/2022

Conductivity @ 25 C	µS/cm	2	**3100**	**2500**

Total Dissolved Solids (TDS) in water Method: AN113 Tested: 2/8/2022

Total Dissolved Solids Dried at 175-185°C	mg/L	10	**1700**	**1400**

Total and Volatile Suspended Solids (TSS / VSS) Method: AN114 Tested: 3/8/2022

Total Suspended Solids Dried at 103-105°C	mg/L	5	<5	<5

Chloride by Discrete Analyser in Water Method: AN274 Tested: 1/8/2022

Chloride, Cl	mg/L	1	**900**	**730**

Sulfate in water Method: AN275 Tested: 1/8/2022

Sulfate, SO4	mg/L	1	**100**	**68**

Parameter	Units	LOR	PE162295.001	PE162295.002
Sample Number			PE162295.001	PE162295.002
Sample Matrix			Water	Water
Sample Date			28 Jul 2022	28 Jul 2022
Sample Name			Bore 1	Bore 2

Alkalinity Method: AN135 Tested: 29/7/2022

Parameter	Units	LOR	Bore 1	Bore 2
Total Alkalinity as CaCO3	mg/L	5	**56**	**11**
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Bicarbonate Alkalinity as HCO3	mg/L	5	**68**	**13**

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 2/8/2022

Parameter	Units	LOR	Bore 1	Bore 2
Calcium, Ca	mg/L	0.2	**9.8**	**11**
Magnesium, Mg	mg/L	0.1	**53**	**47**
Potassium, K	mg/L	0.1	**7.7**	**7.6**
Sodium, Na	mg/L	0.5	**510**	**380**

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 2/8/2022

Parameter	Units	LOR	Bore 1	Bore 2
Aluminium, Al	µg/L	5	<5	<5
Arsenic, As	µg/L	1	<1	<1
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1
Iron, Fe	µg/L	5	<5	**71**
Lead, Pb	µg/L	1	<1	**5**
Manganese, Mn	µg/L	1	**5**	**15**
Selenium, Se	µg/L	1	**2**	<1
Zinc, Zn	µg/L	5	<5	**64**

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 3/8/2022

Parameter	Units	LOR	Bore 1	Bore 2
Mercury	mg/L	0.00005	<0.00005	<0.00005

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: AN258 Tested: 2/8/2022

Parameter	Units	LOR	Bore 1	Bore 2
Nitrite, NO_2 as NO_2	mg/L	0.2	<0.2	<0.2
Nitrate, NO_3 as NO_3	mg/L	0.2	**18**	**0.3**

Ammonia Nitrogen by FIA Method: AN261 Tested: 2/8/2022

Parameter	Units	LOR	Bore 1	Bore 2
Ammonia, NH_3	mg/L	0.05	**0.09**	<0.05

		Sample Number	PE162295.001	PE162295.002
		Sample Matrix	Water	Water
		Sample Date	28 Jul 2022	28 Jul 2022
		Sample Name	Bore 1	Bore 2
Parameter	Units	LOR		

Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 4/8/2022

Parameter	Units	LOR	PE162295.001	PE162295.002
Filterable Reactive Phosphorus as PO4	mg/L	0.01	**0.02**	<0.01

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 3/8/2022

Parameter	Units	LOR	PE162295.001	PE162295.002
Total Kjeldahl Nitrogen	mg/L	0.05	**0.15**	**0.06**

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293(Sydney only) Tested: 3/8/2022

Parameter	Units	LOR	PE162295.001	PE162295.002
Total Phosphorus (Kjeldahl Digestion) as P	mg/L	0.02	<0.02	<0.02

Reactive Silica by Discrete Analyser Method: AN270 Tested: 3/8/2022

Parameter	Units	LOR	PE162295.001	PE162295.002
Reactive Silica, SiO_2*	mg/L	0.1	**15**	**13**

Ferrous Iron in water Method: AN271 Tested: 3/8/2022

Parameter	Units	LOR	PE162295.001	PE162295.002
Ferrous Iron, Fe2+	mg/L	0.05	<0.05	<0.05

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Alkalinity **Method: ME-(AU)-[ENV]AN135**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB197979	mg/L	5	<5	2 - 10%	102%
Carbonate Alkalinity as CO3	LB197979	mg/L	1	<1		
Bicarbonate Alkalinity as HCO3	LB197979	mg/L	5	<5		

Ammonia Nitrogen by FIA **Method: ME-(AU)-[ENV]AN261**

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Ammonia, NH_3	LB198001	mg/L	0.05	<0.05	NA

Chloride by Discrete Analyser in Water **Method: ME-(AU)-[ENV]AN274**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB197971	mg/L	1	<1	2 - 3%	105%	94 - 100%

Conductivity and TDS by Calculation - Water **Method: ME-(AU)-[ENV]AN106**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB197976	µS/cm	2	<2	-5 - 0%	103%

Ferrous Iron in water **Method: ME-(AU)-[ENV]AN271**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ferrous Iron, Fe2+	LB198037	mg/L	0.05	<0.05	-8%	111%

Filterable Reactive Phosphorus (FRP) **Method: ME-(AU)-[ENV]AN278**

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Filterable Reactive Phosphorus as PO4	LB198082	mg/L	0.01	<0.01	NA

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB198034	mg/L	0.00005	<5e-005	0 - 6%	90%	100%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Calcium, Ca	LB198003	mg/L	0.2	<0.2	3%	101%
Magnesium, Mg	LB198003	mg/L	0.1	<0.1	3%	101%
Potassium, K	LB198003	mg/L	0.1	<0.1	2%	102%
Sodium, Na	LB198003	mg/L	0.5	<0.5	3%	99%

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB197976	pH Units	-	5.6 - 6.2	0 - 1%	100%

Reactive Silica by Discrete Analyser Method: ME-(AU)-[ENV]AN270

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Reactive Silica, SiO_2*	LB197963	mg/L	0.1	<0.10	1%	105%	114%

Sulfate in water Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB197971	mg/L	1	<1	21%	102 - 105%	91 - 93%

TKN Kjeldahl Digestion by Discrete Analyser Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB198006	mg/L	0.05	<0.05	3%	103 - 120%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total and Volatile Suspended Solids (TSS / VSS) Method: ME-(AU)-[ENV]AN114

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Suspended Solids Dried at 103-105°C	LB198036	mg/L	5	<5	5 - 9%	97%

Total Dissolved Solids (TDS) in water Method: ME-(AU)-[ENV]AN113

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery	MSD %RPD
Total Dissolved Solids Dried at 175-185°C	LB198004	mg/L	10	<10	0%	108%	101%	1%

Total Phosphorus by Kjeldahl Digestion DA in Water Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion) as P	LB198006	mg/L	0.02	<0.02	16 - 25%	108 - 112%

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB197998	µg/L	5	<5	10 - 74%	98%	
Arsenic, As	LB197998	µg/L	1	<1	5 - 8%	107%	113%
Cadmium, Cd	LB197998	µg/L	0.1	<0.1	-664 - 25%	105%	105%
Chromium, Cr	LB197998	µg/L	1	<1	2 - 47%	95%	102%
Iron, Fe	LB197998	µg/L	5	<5	10 - 16%	103%	
Lead, Pb	LB197998	µg/L	1	<1	2 - 169%	97%	91%
Manganese, Mn	LB197998	µg/L	1	<1	2 - 4%	98%	
Selenium, Se	LB197998	µg/L	1	<1	29%	103%	
Zinc, Zn	LB197998	µg/L	5	<5	3 - 8%	114%	108%

METHOD	METHODOLOGY SUMMARY
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN113	Total Dissolved Solids: A well-mixed filtered sample of known volume is evaporated to dryness at 180°C and the residue weighed. Approximate methods for correlating chemical analysis with dissolved solids are available. Reference APHA 2540 C.
AN113	The Total Dissolved Solids residue may also be ignited at 550 C and volatile TDS (Organic TDS) and non-volatile TDS (Inorganic) can be determined.
AN114	Total Suspended and Volatile Suspended Solids: The sample is homogenised by shaking and a known volume is filtered through a pre-weighed GF/C filter paper and washed well with deionised water. The filter paper is dried and reweighed. The TSS is the residue retained by the filter per unit volume of sample. Reference APHA 2540 D. Internal Reference AN114
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN258	Nitrate and Nitrite by FIA: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Without the cadmium reduction only the original nitrite is determined. Reference APHA 4500-NO3- F.
AN261	Ammonia by Continuous Flow Analyser: Ammonium in a basic medium forms ammonia gas, which is separated from the sample matrix by diffusion through a polypropylene membrane. The ammonia is reacted with phenol and hypochlorite to form indophenol blue at an intensity proportional to the ammonia concentration. The blue colour is intensified with sodium nitroprusside and the absorbance measured at 630 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-NH3 H.
AN270	Reactive forms of silicon in acid solution below pH 2 react with ammonium molybdate ions to form a yellow silicomolybdate which is then reduced with ascorbic acid to produce a blue silicomolybdate complex. Oxalic acid is added to destroy any molybdophosphoric acid. Colourimetric determination by Discrete Analyser.
AN271	Ferrous Iron by Discrete Analyser: Iron in the ferrous state is treated with 1,10-phenathroline at pH 3.2. The intensity of the resultant orange/red coloured solution is proportional to the amount of ferrous iron present. Reference APHA 3500-Fe B.
AN271	Ferric iron (Fe3+) is calculated as the difference between Total iron and Ferrous iron as per APHA, method 3500-Fe B, 23rd Edition. Water samples that are taken and include insoluble solids (turbid and/or contain fine sediment/precipitates) will include iron from this source as in natural waters, ferric iron is in an insoluble form (precipitate).

METHOD	METHODOLOGY SUMMARY
AN274	Chloride by Discrete Analyse: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	Sulfate by Discrete Analyse: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN278	Filterable Reactive Phosphorus by DA (determined on filtered sample): Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293(Sydney)	The sample is digested with Sulphuric acid, K2SO4 and CuSO4. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K2SO4 and CuSO4. The ammonia produced following digestion is then measured colourimetrically using the Discrete Analyser. A portion of the digested sample is buffered to an alkaline pH, and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique,, referenced to USEPA 6020B and USEPA 200.8 (5.4).
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
***	Indicates that both * and ** apply.	NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

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