CRESSWELL'S TRANSPORT PTY LTD

PROPOSED DOLOMITE QUARRY
DONALDS ROAD, ROGER RIVER WEST

HYDROGEOLOGICAL REPORT
and
GROUNDWATER MANAGEMENT PLAN

December 2023
Revision 2

Cover photo

View west towards the proposed quarry site, showing stockpiled screened dolomite after extraction and on-site crushing during a bulk sampling trial. The excavator is near the bulk sample pit.

The ground surface (35.5mAHD) is essentially flat; the open surface drain crossing left to right in the foreground is one of a series of drains at a (LiDAR-derived) gradient of 1:1,300 (0.05^0) leading to the Montagu River 500m to the north (right of photo). The white patches this side of the stockpiles, and in the drain in the foreground, is dolomite bedrock. Dolomite also crops out in the shallow (0.5m deep) drain which contains the straightened Montagu River. The rock everywhere in this area is high strength, with no or sealed fractures. The Quaternary-age alluvium and marsh deposits in the district and shown on the published *Roger* 1:25,000 geological map are absent, or less than 0.5m thick.

Photo: Bill Cromer, 1 May 2023

Refer to this report as

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SUMMARY

A desk-top review supported by a May 2023 site inspection and water sampling event, and a follow-up November 2023 water sampling event, has assessed groundwater conditions at and near a proposed dolomite quarry on mining lease 2115P/M near Roger River West in northwestern Tasmania.

The proposed quarry will nominally be about five metres deep, with a 4ha extraction footprint at end of life. The site is on almost flat ground 500m south of the Montagu River, which in this section of its course has a *High* integrated conservation value. It rates a *Very High* classification for its immediate and potential *Conservation Management Priority*.

Dolomite bedrock crops out at the surface. There is no surface evidence of karst features in the vicinity. However, karstic features might be encountered during operations because a water bore drilled in November 2023 by the landowner about 300m northeast of the current trial pit reportedly intersected a dry, gravel-filled cavity at 4 – 5m below ground.

Conceptual hydrogeological models have been compiled for local-, intermediate- and regional-scale groundwater movement. Quarrying will potentially affect only local-scale groundwater, but there is no site-specific information on directions of flow and depth to the water table in the vicinity of the quarry. However, it is likely that excavation to 5m depth will encounter groundwater.

A nation-wide assessment by the Bureau of Meteorology has classed the area as an aquatic surface-based groundwater dependent ecosystem of high potential.

A 1000t bulk sampling pit has recently been blasted and excavated for crushing trials. Water sampling from the pit in May 2023 suggested that the explosives used may affect background groundwater quality by elevating nitrogen compounds, pH, electrical conductivity, and calcium, magnesium and sulfate levels. Follow-up sampling in November 2023 of the pit then flooded with runoff/groundwater returned much lower concentrations of the same analytes.

Extractive operations will be confined to November through to April, and it is likely the pit will contain pre-mining accumulated groundwater and surface runoff which will need to be removed before operations start. Water may also enter the pit during mining, at variable rates. Cresswells Transport Pty Ltd and the landowner have entered into a Compensation Agreement enforceable under ML2115P/M whereby for the duration of mining operations the landowner has agreed to take all water from the pit for his irrigation system.

There will be no direct discharge of pit water to the Montagu River.

A groundwater management plan (including installing and sampling two monitoring bores), and a karst management plan, are recommended.

On this basis, the proposed quarry should proceed from a hydrogeological perspective,

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1 INTRODUCTION

1.1 Background

Cresswell's Transport Pty Ltd ("Cresswells") proposes a 20,000m^{3}pa dolomite quarry on mining lease ML2115P/M near Roger River West, about 25km south of Smithton in northwestern Tasmania (Figures 1, 2 and 3). Quarrying will be to depths up to 5m, over a footprint of up to 4ha.

This hydrogeological report is intended to accompany an *Extractive Industry Environmental Effects Report* (EER) for the activity. It describes existing local-, intermediate- and regional-scale groundwater conditions (including karst) at and near the proposed quarry, assesses risks to groundwater from operations, and proposes a groundwater and karst management plan (EPA 2022).

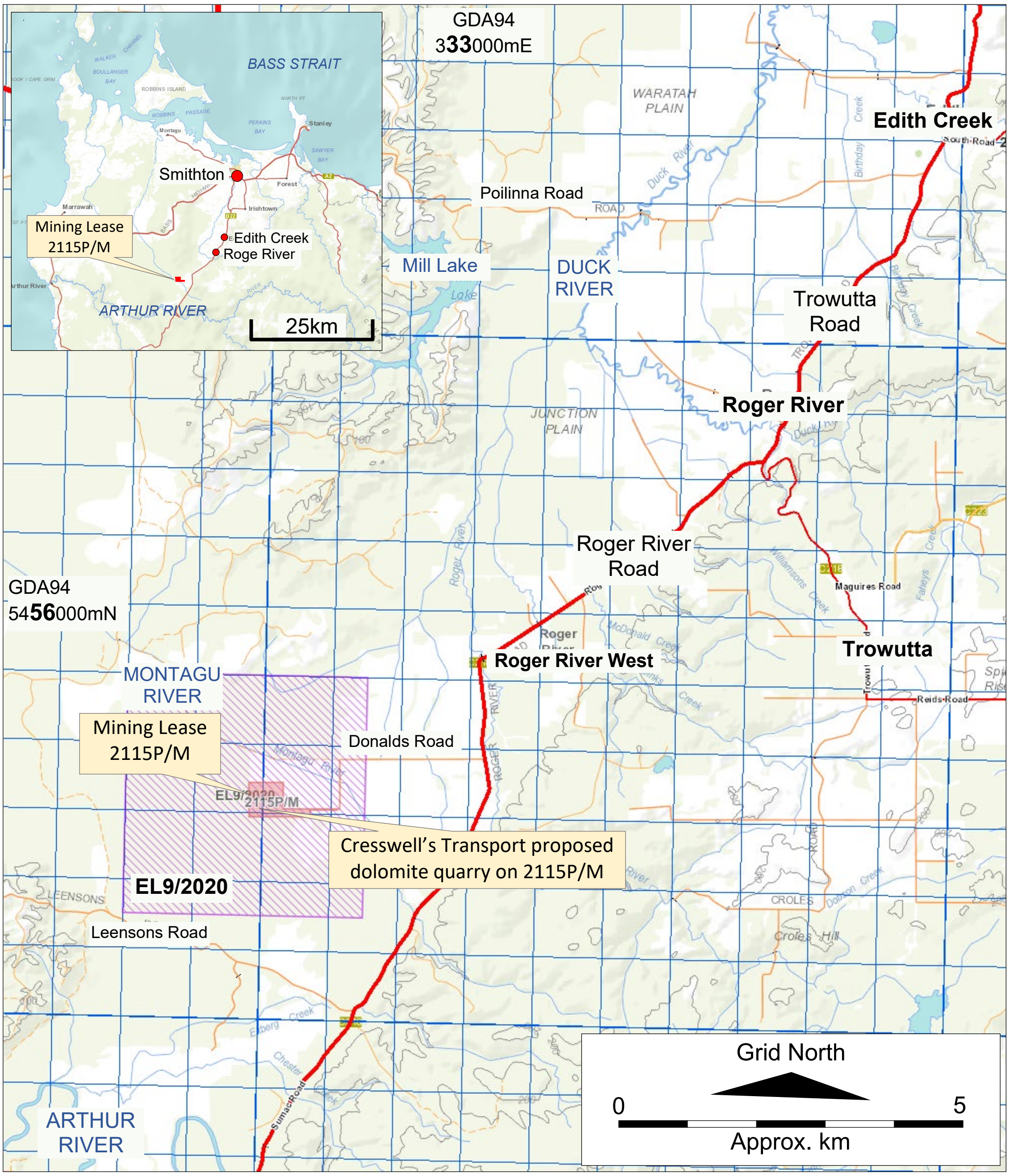


Figure 1. Location of Cresswells Transport proposed dolomite quarry on mining lease 2115P/M off Donalds Road near Roger River West.
Source of base map: www.thelist.tas.gov.au

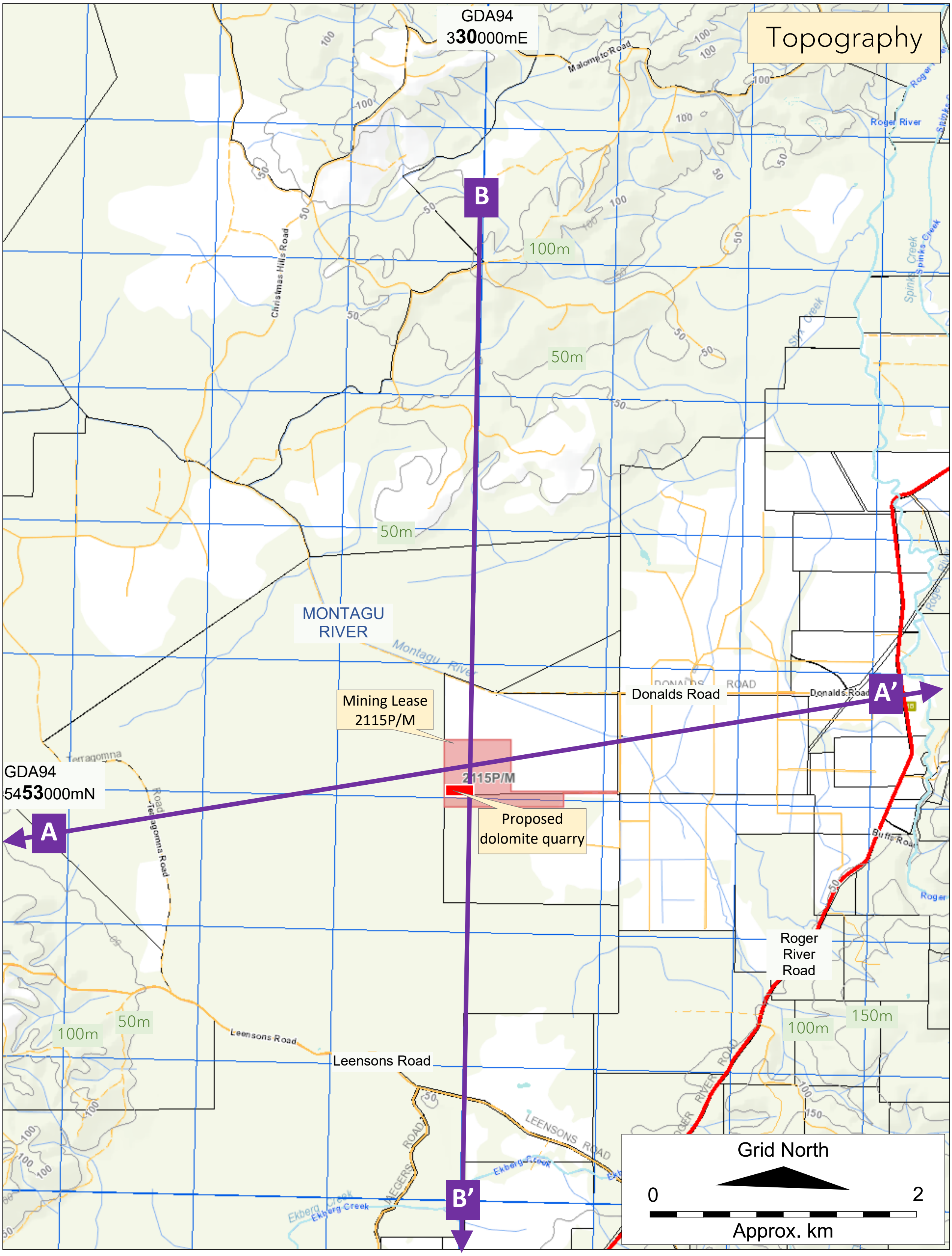


Figure 2. Location of the proposed dolomite quarry in relation to mining lease 2115P/M, roads, drainage, cadastre and topography.

Contour interval 10m. Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).

Source of base map: www.thelist.tas.gov.au

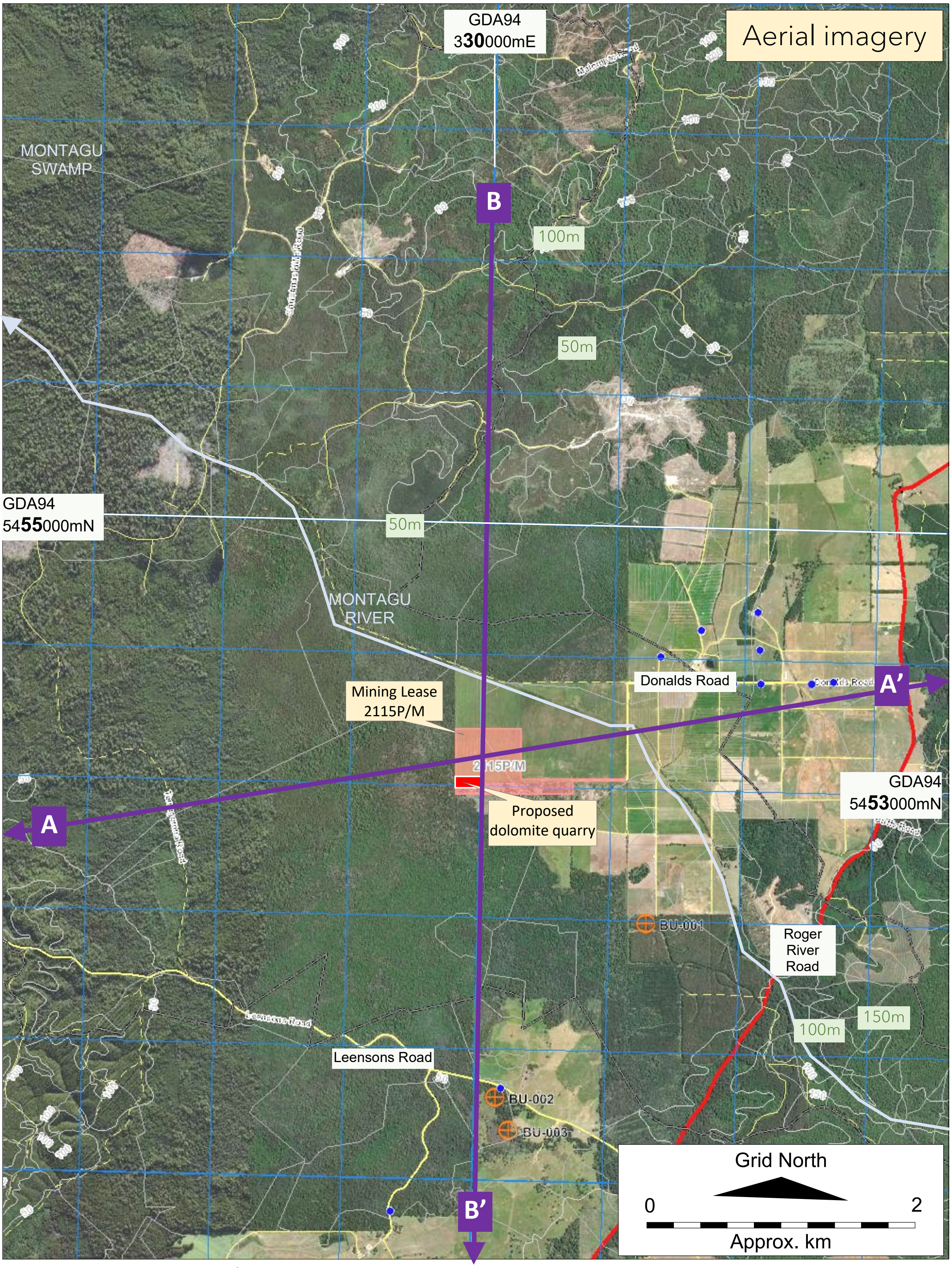


Figure 3. Aerial imagery of the district.
Contour interval 10m. Lines A – A′ and B – B′ are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).
Source of image: www.thelist.tas.gov.au

1.2 Brief for this report

The site-specific Brief for this report is outlined in an EPA *Table of Issues* responding to Cresswells draft EER dated 13 December 2022 (Williams, 2022). The groundwater section of the *Table of Issues* is repeated here as Figure 4.

EER/EIS section no.	**Page no.**	**Issues for resolution**

Part C, section 2.3 - Groundwater	19	Please correct the heading name for Management Measure 2.
		A groundwater management plan (GMP) is required to address potential identified hazards and impacts on groundwater dependent ecosystems and offsite surface water quality by the proposed activity. As a minimum, the following scope of works for a GMP are to be addressed:
		• Site description
		• Hydrogeological characterisation
		  ○ Geology, including geology map (i.e., a figure of the 1:25000 MRT local geological setting)
		  ○ Identified aquifers
		  ○ Bore installation (including engineering logs to Australian Standard 1726:2017 [including dry bores] and map of piezometer network. One piezometer upgradient, cross gradient, and down gradient, as a minimum).
		  ○ Identification of neighbouring bores and interpretation of drillers logs (available at the Groundwater Information Access Portal (GIAP) at https://wrt.tas.gov.au/groundwater-info/)
		  ○ Aquifer properties
		  ○ Groundwater levels
		  ○ Groundwater flow (including groundwater flow map of the piezometric surface with respect to the proposed excavation)
		  ○ Conceptual Hydrogeological Model (including schematic conceptual model)
		• Groundwater Dependent Ecosystems (GDEs)
		  ○ Local aquatic, terrestrial, subterranean GDEs (GDE Atlas Map: Water Information: Bureau of Meteorology (bom.gov.au))
		  ○ Potential impacts on GDEs
		• Water quality summary
		  ○ Characterisation of water quality and quantity
		• Risk assessment of proposal
		  ○ Identification of site-specific hazards
		  ○ Risk mitigation measures
		• Groundwater and surface water monitoring plan, including;
		  ○ Groundwater levels
		  ○ Surface and groundwater quality
		• Conclusions and recommendations
		Assessment reports for the above should be appended to the EER for reference, however the water quality section of the EER should describe the existing environment in relation to the impact (including the vulnerability of the potentially affected environment), the potential impacts (identifying plausible worst-case scenarios and the reversibility of the impact), and a description of the management or contingency measures proposed to avoid, mitigate or offset potential adverse impacts.

Part C, section 4	24	The karst name on which the proposed site is located should be stated in full, i.e., Roger River – Ekberg 2 karstic aquifer and cave groundwater dependent ecosystem. Please refer to the requirements on p.12 of the EER Guidelines in relation to karst. The potential for proposed quarry activities to impact on the karst system and surrounding GDEs and wider land uses, including the potential for the creation of karst hazards (i.e., sink holes) should be described with sufficient detail. Additionally, the management measures and operational strategies that will be implemented to minimise or avoid impacts on karstic features, including protocols should an unanticipated karst feature be identified during quarrying operations, need to be clearly detailed. The EER states that *"the drill logs from this program and the supervising Geologist's assessment of the karst substrate is included in Attachment I and states that during exploration drilling no cavities were encountered"*. Drill logs were not included however, only exploration testing results and locations. Although no cavities were encountered, a description of the weathering state of the bedrock is required as paleo karst can fill with sediments. Please refer to pages 3 & 4 of this document for further comment on groundwater and hydrogeological impacts in relation to Part C, section 2 of the EER.

Figure 4. Extract from undated Tasmanian EPA *Table of Issues* Version No. 1 in response to Cresswells draft EER Version 1 (ie Version 2) of the Donalds Road Quarry, Roger River West.

1.3 Groundwater investigations for this report

Investigations in relation to the Brief for this report included desk-top studies and field work.

The desk-top studies comprised on-line searches for relevant hydrogeological reports, water bore records, geological maps, and karst hydrology and management, and produced LiDAR-generated cross sections[1].

Discussions were also held with consultant geologist Ken Morrison, who produced the Year 1 Annual Report (Morrison 2022) for operations on exploration licence EL9/2020, and who re-visited the proposed quarry site in June 2023 and provided additional information for the current report.

The field work included a 1 May 2023 inspection (in the company of the proponent) of the bulk sampling test site at the proposed quarry. The inspection included surface water and groundwater sampling, for laboratory analysis by Australian Laboratory Services (ALS) in Melbourne.

A second surface water and groundwater sampling event occurred on 14 November 2023. The sampling was undertaken by consultants *Environmental Services & Design* (ES&D) on behalf of Cresswells, and compared water qualities six months apart. On the same date, *Spaulding Drillers* (commissioned by the owner of the property) was drilling a groundwater extraction bore in the vicinity, and an opportunistic water sample from the bore was collected and analysed.

1.4 Previous hydrogeological and related investigations

Apart from the first annual report for Cresswells exploration activities (Morrison, 2022), a search of Mineral Resources Tasmania publication database found no previous relevant investigations specific to the immediate area of the proposed dolomite quarry.

1.4.1 Mines Department regional groundwater survey (1959)

Gulline (1959) produced the first review of groundwater in the Smithton District. The work preceded much of the subsequent water bore drilling and most of it is general in nature. The only comment relevant to the current report was that the Edith Creek, Copper Creek and Irishtown district "*have good underground water prospects but up to the present no boring has been required possibly because other sources have given an adequate supply*." (page 44).

In relation to the Smithton Dolomite, Gulline (page 35) states: "*Bore records show that underground water is struck in the weathered rock under recent deposits, but up to 50 feet into solid rock were bored in some cases before a satisfactory supply was obtained*."

1.4.2 Groundwater bore records and regional maps (1960s, 2006)

Following on from Gulline (1959), Matthews (1961, 1962, 1964, 1965, 1966) summarised the results of drilling for water in northwestern Tasmania (including the Smithton district). The summaries provide good information about groundwater prospectivity in various rock types, including the Smithton Dolomite. The information is now digitised as records in the DPIPWE Groundwater Access Information Portal.

[1] *Laurie Veska Geological Services* produced tabulated LiDAR-generated grid coordinates and elevations from which were produced the conceptual hydrogeological cross sections in this report.

Some of the same records have been brought together on the Northwest Tasmania Groundwater Map (Matthews and Latinovic, 2006a), and the Northwest Tasmania Groundwater Quality Map (Matthews and Latinovic, 2006b). The information is of limited use for the Cresswells quarrying proposal, because drilling for groundwater has been a relatively recent activity in the southern extremity of the Smithton Basin. Twelve bores are recorded within a few kilometres of the site, but eight on Donalds Road postdate the publication of the groundwater map and groundwater quality maps, and two (and possibly all) of the remaining four are listed as decommissioned or abandoned.

Records from these twelve bores are presented in the current report.

1.4.3 Mineral exploration drilling (1968)

Various company reports describe previous exploration activities in the general area of the Arthur River. Pacific-Nevada Mining Pty Ltd explored for copper and gold in Proterozoic rocks, and reported (Westbrook 1999) the logs of three diamond holes drilled to depths of 25m in 1998 south of and within 1.5 – 3km of the Cresswells site. The holes were collared in a veneer of Quaternary marsh deposits, and all three intersected weathered material interpreted as basalt. Dolomite was not reported on any of the logs, which is interesting because three (numbered 41356, 41357 and 42645 In Table 2) of the twelve groundwater bores mentioned above (Section 1.4.2) are in the vicinity and all three reported dolomite to 60m.

1.4.4 Cresswells Year 1 exploration report on EL9/2020 (2022)

As part of Year 1 exploration activities, Cresswells drilled 20 exploration holes to depths of 7 – 18m (average 15m) on the perimeter of a 150m square in the southwestern corner of mining lease 2115P/M within EL9/2020 (Morrison, 2022).

Dolomite bedrock was present as scattered flat-lying exposures over the site. The dolomite was open at depth and extended north and east.

Eighty two dolomite samples were laboratory-analysed and grades ranged from an estimated 94.6 – 98.6% $MgCO_3$ + $CaCO_3$. Sufficient resource was present to justify bulk sampling to evaluate material handling properties. The bulk crushing of 1,000t followed in early 2023 as a Year 2 exploration activity.

1.4.5 Spaulding Drillers groundwater bore (November 2023)

This bore (referred to in this report as the "Owner's bore") was drilled under Permit 1443 by *Spaulding Drillers* on 13 – 14 November 2023 about 300m northeast of the proposed dolomite quarry (GDA94 330165mE, 5453416mN; Figures 5, 6, 8 and others). The bore was drilled entirely in variously hard and fractured dolomite to a (driller's) reported depth of 126m. A "cavity gravelly" was intersected between 4m and 5m depth, with no groundwater. Groundwater was encountered from about 15m onwards, with the air-lifted flow remaining in the 2 – 3L/s range until 30 – 40L/s was encountered in the 120 – 126m interval at the base of the hole.

It is understood the bore will be used for irrigation by the landowner.

2 HYDROGEOLOGY OF THE CRESSWELLS SITE

2.1 Physical description

2.1.1 Topography, relief, and surface drainage

2.1.1.1 Topography and relief

The area surrounding the Cresswells site (Figures 5 and 6) comprising the flood plain of the Montagu River is essentially flat, at elevations between about 34 – 38mASL The proposed quarry site is at about 35.5mASL, with a surface gradient of 0.05^0 north to the river. Low, un-named hills to the east, north and west rise to about 150mASL.

2.1.1.2 Surface drainage

Three scales of surface drainage systems are recognised in Tasmania (including the Smithton district):

- on a regional scale, the Cresswells site lies within the *Montagu* CFEV[2] Catchment of 581km^2.
- on a subregional scale, the Cresswells site lies within the *Upper Montagu* CFEV Subcatchment of 129km^2 (Figures 5 and 6)
- on a local scale, mining lease 2115P/M straddles CFEV Sub-subcatchments 166726 of 113ha, and 166176 of 622ha, and the proposed quarry site is wholly within the latter (Figures 5 and 6).

Within 166176, surface drainage from the proposed quarry is to the Montagu River, about 500m north of the quarry site. This section of the river is rated *High* with respect to its *Integrated Conservation Value* (Figures 5 and 6), and *Very High* to its immediate and potential *Conservation Management Priority*.

There is an extensive system of subparallel open drains throughout the immediate area but none of them extends into the quarry site. There are no other drainage lines in the vicinity.

Because of the general connectivity between surface water and groundwater, there is a direct one-to-one correspondence between surface water catchments, subcatchments and sub-subcatchments, and regional-, intermediate- and local-scale groundwater systems (Section 3.3).

2.1.2 Rainfall and evaporation[3]

Mean annual rainfall for Edith Creek (10km north northeast of the Cresswells site) is 1212mm, ranging from 44mm in February to 174 in August. Annual evaporation is estimated to total 905mm, with monthly totals ranging from about 130mm in January, to 20mm in July (Table 1 and its graph).

[2] CFEV = Conservation of Freshwater Ecosystem Values. A DPIPWE database provides conservation evaluations for freshwater dependent ecosystems in catchments and subcatchments, and the smallest division of catchment, CFEV River System Catchments (RSCs; in this report called sub-subcatchments).

[3] In the absence of evaporation data for Edith Creek and the Smithton district generally, evaporation is estimated from Bureau of Meteorology monthly contours for Australia.

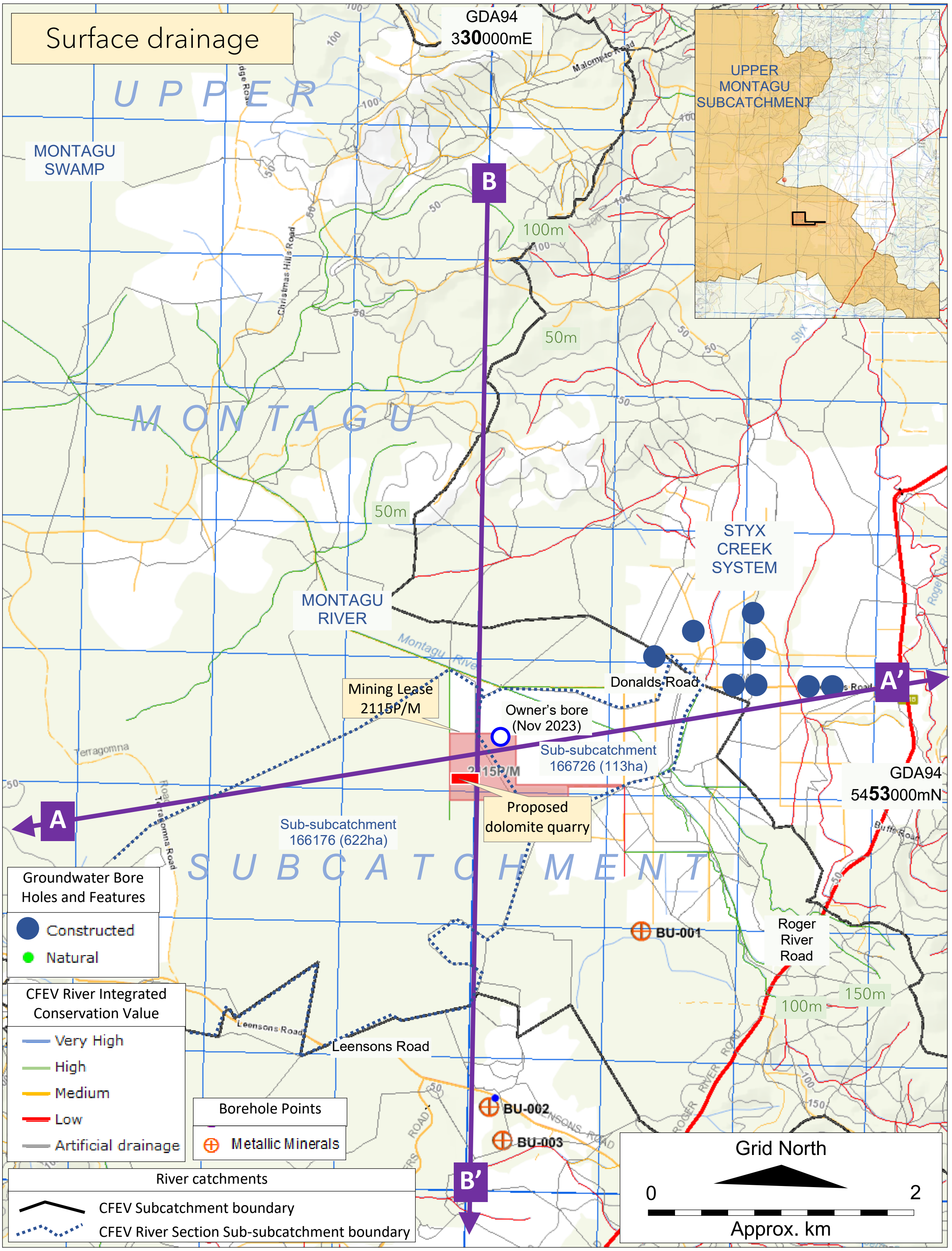


Figure 5. Location of the proposed dolomite quarry in relation to river subcatchments and sub-subcatchments, river integrated conservation values, and boreholes for groundwater and metallic minerals. The river integrated conservation value of the Montagu River passing mining lease 2115P/M is "High". That of Styx Creek and associated drains in the neighbouring subcatchment is "Low".
Contour interval 10m. Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).

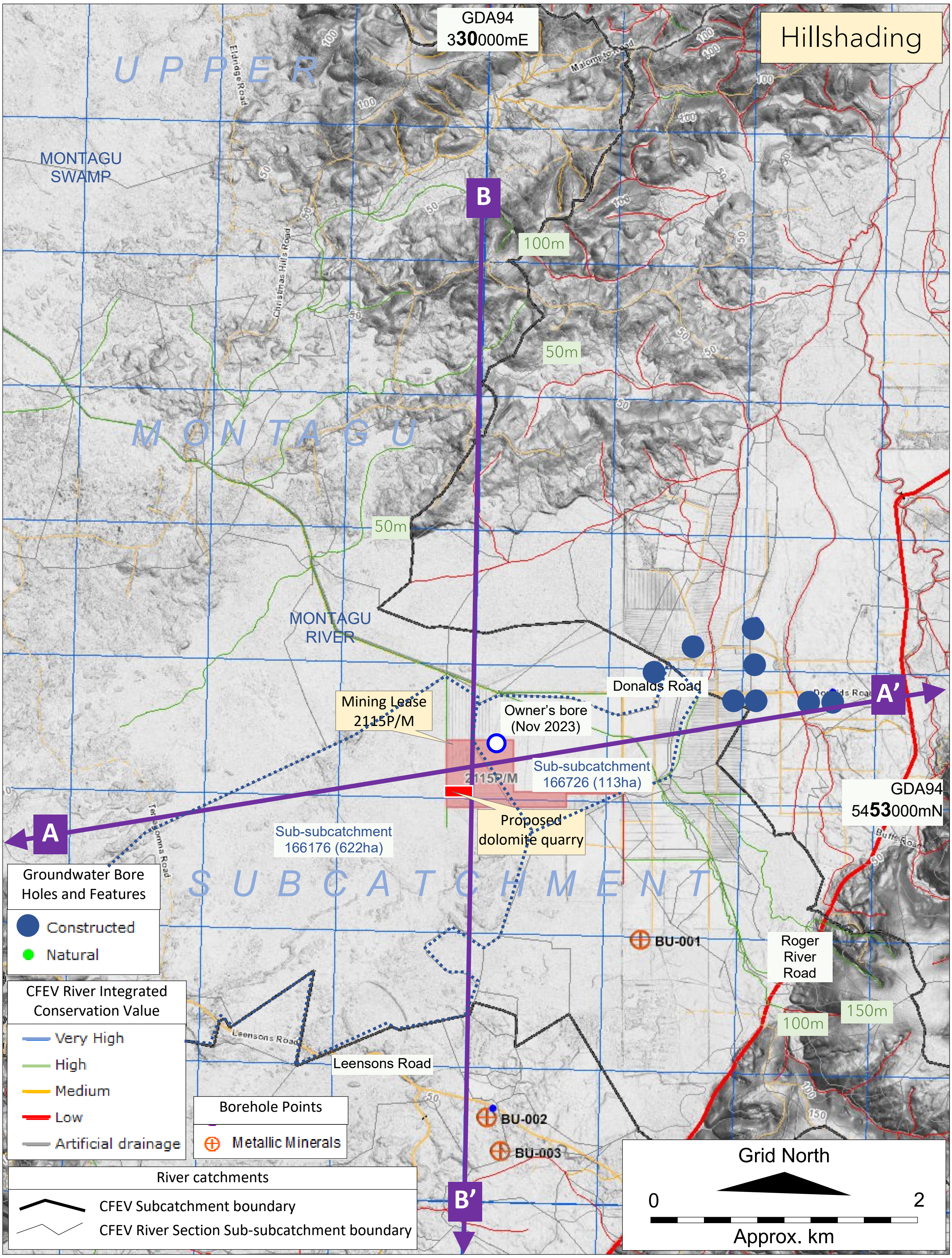


Figure 6. Hillshade image of the proposed dolomite quarry in relation to river subcatchments and sub-subcatchments, river integrated conservation values, and boreholes for groundwater and metallic minerals.

Contour interval 10m. Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).

Source of base image: www.thelist.tas.gov.au

Table 1. Rainfall statistics for Edith Creek, 10km north northeast of the Cresswells site.

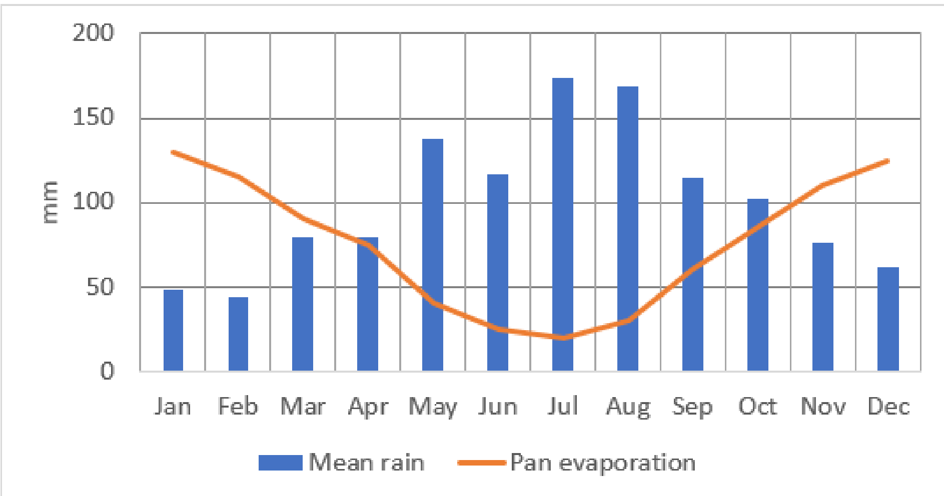
Monthly rain (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011	120	56	62	52	51	148	141	154	88	143	124	37	**1176**
2012	64	34	126	95	160	130	106	177	142	55	55	77	**1222**
2013	28	16	62	78	106	55	228	382	148	152	113	58	**1427**
2014	42	39	58	121	123	115	159	69	70	92	33	77	**999**
2015	58	27	122	25	189	94	191	138	42	5	39	53	**983**
2016	25	54	74	64	229	184	262	134	194	163	133	86	**1601**
2017	64	53	48	49	152	75	165	121	175	96	26	41	**1066**
2018	29	64	118	69	87	131	282	213	82	25	60	100	**1263**
2019	8	66	56	101	205	129	224	122	105	50	117	68	**1250**
2020	63	48	82	167	117	117	56	134	102	101	52	95	**1135**
2021	76	47	86	86	90	110	201	139	131	170	56	19	**1210**
2022	23	19	42	38	157		75	245	93	179	103	33	
2023	19	42	95	83	125								

Monthly statistics (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	48	44	79	79	138	117	174	169	114	103	76	62	**1212**
Lowest	8	16	42	25	51	55	56	69	42	5	26	19	**983**
5th %ile	15	18	46	33	73	65	67	97	57	16	30	27	**991**
10th %ile	20	21	50	40	88	75	79	121	72	28	34	33	**999**
Median	42	47	74	78	125	117	178	138	104	99	58	63	**1210**
90th %ile	74	63	122	117	202	148	258	242	173	169	123	94	**1427**
95th %ile	94	65	124	139	215	166	271	307	184	174	128	97	**1514**
Highest	120	66	126	167	229	184	282	382	194	179	133	100	**1601**
Pan evap	130	115	90	75	40	25	20	30	60	85	110	125	**905**

Bureau of Meteorology
Edith Creek (Birthday Creek)
Number: 91357 **Lat:** 40.98° S
Opened: 2010 **Lon:** 145.09° E
Now: Open **Elevation:** 50 m



2.2 Geology

2.2.1 Regional geological setting

The Cresswells site lies at the southern extremity of the Smithton Basin – geologically, the Smithton Synclinorium[4] – which includes Neoproterozoic[5] and Cambrian rocks in a V-shaped area extending about 40km south through Smithton from Bass Strait, and a similar west-east distance from Marrawah to Forest (Figure 7).

The Neoproterozoic rocks include clastic carbonate rocks (including the Smithton Dolomite) interbedded with basalts and related volcaniclastic sequences. They are gently folded in a broad syncline with a north-south axis, so the rocks dip both easterly and westerly. They are underlain by the older Proterozoic Rocky Cape Group sandstones and siltstones. A major structural feature in the synclinorium is the Roger River Fault, which trends SSW – NNE near the Cresswells site, and which is interpreted as a thrust fault dipping steeply east (Everard *et al,* 2007).

Large tracts of Quaternary (mostly Holocene?) age alluvium and marsh deposits are shown on the published geological maps[6] of the district, obscuring the older bedrock (mostly dolomite) across the low-laying areas bordering the Montagu and Duck Rivers. The thickness of the deposits is not known in detail, but cobble beds up to 5m thick occur in several locations along and north of the Arthur River, and near Smithton up to 21m of sediments are present in the lower Duck River (Everard, 2007).

2.2.2 Geology at and near the Cresswells site

Quaternary (Holocene?)-age alluvium and marsh deposits are shown on the published geological map (Figure 8) across the flat ground in the vicinity of mining lease 2115P/M. However, these materials are less than 0.5m thick, or are absent altogether, at the proposed quarry site, and along parts of Donalds Road, and in the nearby Montagu River. Instead, Smithton Dolomite occurs as patchy outcrops and subcrops of hard, pale grey-cream, high-strength, slightly weathered flat-lying rock with sealed vertical fractures (Plates 1 – 4).

The 2022 exploratory drilling of the proposed quarry site [Figure 8, and Morrison (2022)] established a vertical dolomite thickness of at least 18m in the immediate vicinity.

The recent Owner's bore about 300m northeast of the proposed dolomite quarry was drilled entirely in dolomite to a depth of 126m (Section 1.4.5).

Consulting geologist Ken Morrison inspected the site and sampled stockpiles on 23 May 2023. He provided the following comments[7] about rock properties and fracturing in the bulk sampling pit (Plate 5):

"Three joint-controlled fracture directions are prominent in the western wall of the pit; two sub vertical and one sub horizontal. Several compass readings on each gave the following average orientations (converted to true north bearings):

1. Strike 320 Dip 80 to NE
2. Strike 230 Dip 75 to SE
3. Strike 340 Dip 05 to NE

[4] A synclinorium is a relatively large-scale synformal syncline (ie a trough) with smaller superimposed folding.
[5] The Neoproterozoic Era is the youngest era of the Proterozoic (formerly Precambrian) eon. It extends from about 1,000 million years ago, to about 540 million years ago at the beginning of the Cambrian Period.
[6] The *Roger*, *Togari* and *Mella* 1:25,000 digital geological map sheets published by Mineral Resources Tasmania.
[7] Email K. Morrison to W. C. Cromer Pty Ltd, 25 May 2023.

The residual water level in the pit was about 4 metres below surface at the time and there was no evidence of ground water transmitting through the open fractures at that depth. However, surface rain water was trickling down some of the open sub vertical fractures and slowly recharging the pit water. Not all fractures are open. Particularly in the sub horizontal set annealed insipient joints are more common than open fractures. It is not possible to tell if the open fracture have been enhanced by blasting, or even by stress release from the wall bounding the excavated void.

In the southern wall of the pit there is a sub vertical crush zone of brecciated dolomite fragments, quite tightly packed and not making water. This structure is interpreted as an annealed fault zone about 50 cm wide. Individual rock fragments look very fine grained and tightly packed, with no evidence of textural porosity or permeability. Any ground water below the depth of the pit will be transmitted through fractures. There is no evidence of karst features in the pit, which is consistent with the drilling results. The dolomite (strictly it should be called dolostone) is very consistent in texture, colour, fragment shape and softness. No cherty or shaley bands were noted in pit outcrop or on the stockpile, in contrast to some of the other Proterozoic dolomites quarried in Tasmania."

2.2.3 Local karst features in the Smithton Dolomite

On a regional scale, the Smithton Dolomite is variously rated *High* or *Medium* with respect to its CFEV *Karst Integrated Conservation Value*. The district surrounding the Cresswells site is in the *Roger River – Ekberg 2 Karst System*, and the CFEV rating is *Medium* (Figure 9).

Sinkholes[8] are common east of the proposed quarry, but there is no surface expression of them in mining lease 2115P/M (Figures 10 and 11). The difference may be at least partly explained by different lithologies or degrees of dolomite purity[9] in the Smithton Dolomite.

[8] The term "sinkhole" in this report means the same as "doline". Both are roughly circular surface depressions with internal drainage, at any scale but in the Roger River West district up to about 50m across.

[9] Dolomite is less soluble than limestone: the areas of sinkholes in Figures 10 and 11 may reflect rocks with less magnesium content compared to those further to the west.

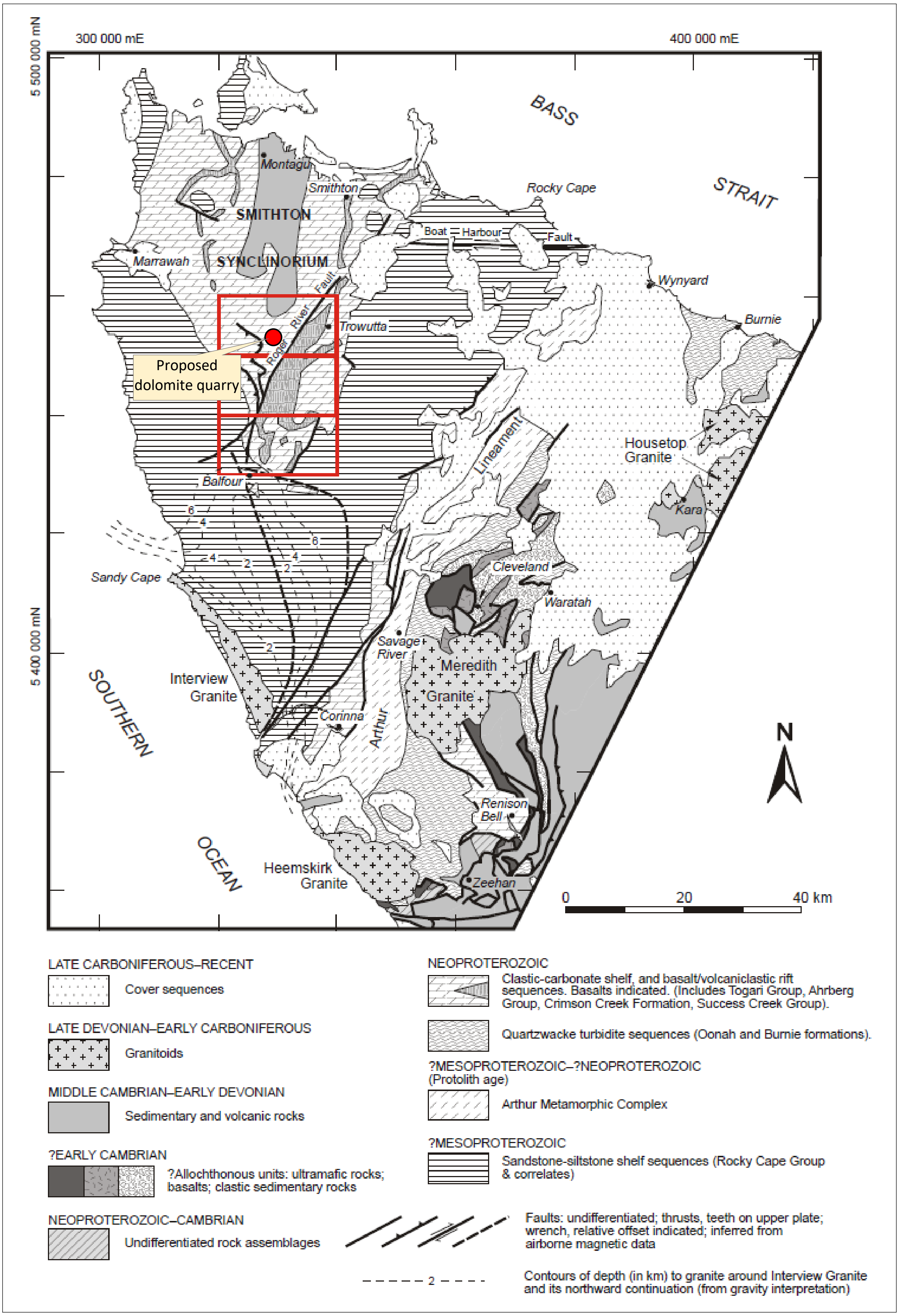


Figure 7. Simplified regional geological map of far northwestern Tasmania, showing the Smithton Synclinorium.

Source: Figure 1 of Everard *et. al.* (2007). The red rectangles are (from north to south) 1:25,000 scale geological map sheets Roger, Sumac and Dempster. The approximate location of Cresswell's Transport proposed dolomite quarry has been added.

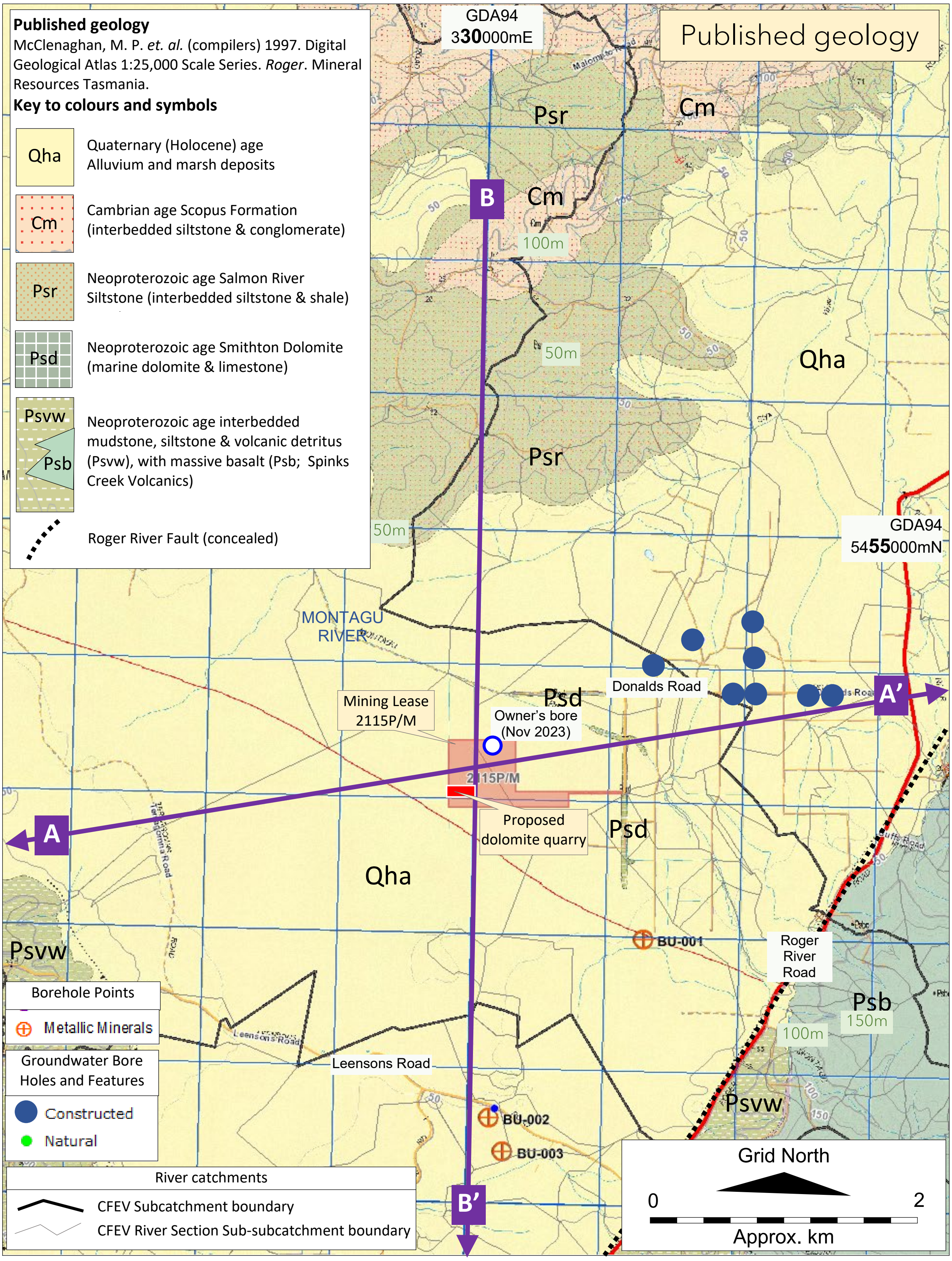


Figure 8. Published geology of the district surrounding mining lease 2115P/M.
Contour interval 10m. Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).
Source of base map: www.thelist.tas.gov.au Source of rock descriptions: McClenaghan, M. P. *et. al.* (compilers) 1997. Digital Geological Atlas 1:25,000 Scale Series. *Roger*. Mineral Resources Tasmania.

2.3 Groundwater

2.3.1 Regional groundwater bores

The DPIPWE Groundwater Access Information Portal records about 800 water bores drilled in the Smithton Basin – most of them since the 1950s (Figure 12; and Section 1.4.2).

2.3.2 Groundwater occurrence in the district

Twelve water bores have been drilled within about 5km of the Cresswells site (Figure 13). Eight bores are within 1.5 – 3km along Donalds Road leading west from Roger River Road. Four have been drilled in the past year.

All twelve bores reportedly intersected dolomite (Table 2). The average depth was 45m (range 18 – 66m), and yields ranged broadly from 1 – 45L/s (average 15L/s). The higher yields[10] are some of the highest reported from water bores in Tasmania, and are interpreted as due to secondary porosity in karstic features. The standing water level (approximating the water table depth) reportedly ranged from 4 – 15m, but these probably immediately follow drilling and may not have stabilised.

Groundwater quality on drilling ranged from 233 – 720mg/L of Total Dissolved Solids (TDS), roughly equating to electrical conductivities (EC) in the 360 – 1,100µS/cm range[11].

2.3.3 Groundwater occurrence at the Cresswells site

2.3.3.1 Evidence from rotary-percussion drillholes RR1 – RR20

Locations of the 2022-drilled holes RR1 – RR20 are shown in Figures 14 and 15.

RR3, RR5, RR6 and RR16 were terminated at shallower-than-intended depths of 10.8m, 10.8m, 7.2m and 18m respectively, when groundwater produced sticky wet drill returns unsuitable for sampling (Morrison, 2022, p6). No groundwater was reported from the remaining 15 holes to depths ranging from 10.8– 18m. The holes were backfilled on completion, so depths to groundwater could not be measured during the site inspection on 1 May 2023.

It is inferred from this drilling that groundwater exists probably at depths less than 7m or so at the site.

2.3.3.2 Bore BH1

Uncased bore BH1 is located in the extreme northwestern corner of mining lease 2115P/M (Figures 14 and 15). It was reportedly drilled in 2022, as an exploratory hole for Cresswells proposed operations. No groundwater was encountered during drilling to its final depth of 18m.

On 1 May, 2023, the water table was 4.0m below ground

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10 Reported by the driller, and usually not pump-tested. The yields were probably obtained by air-lifting from the hole, may have been limited by the volume capacity of the air compressor, and in karst may in practice be sustainably higher than reported. Secondary porosity is porosity developed after the formation of a rock type, and includes fractures, faults, karst openings.

11 EC (µS/cm) = TDS (mg/L) divided by 0.65

Plate 1. View northwest along the Montagu River from the small bridge on Donalds Road, about 1km east of the Cresswell site (near the tree line at left middleground). Smithton Dolomite crops out in its bed, at ground level, here and elsewhere along its artificially straightened course. (Photo: 1 May 2023)

Plate 2. View looking west over the Cresswell site. Smithton Dolomite crops out at ground level throughout the immediate area. The staff is one metre long. (Photo: 1 May 2023)

Plates 3 (left) and 4 (below). Vertical photos of outcropping Smithton Dolomite at the Cresswell site. The rock is high-strength and slightly weathered, with sealed subvertical fracturing. The staff is one metre long. (Photos: 1 May 2023)

Plate 5 (above). The bulk sampling pit on1 May 2023, looking southwest. Two metres of the staff project above the 2m deep water. The strong fracturing of the dolomite is due to blasting. The two dark circular areas at water level in the photo centre may be due to dislodgment of joint blocks, but the right hand one has some depth to it and it may be a small karst feature. The evidence is inconclusive. (Photo: Bill Cromer).

Plate 6 (below). The bulk sampling pit on 14 November 2023, looking east from the same location as Plate 5. It is likely the full water level is mainly due to surface runoff from surrounding ground. (Photo: Maja Aspaas, ES&D).

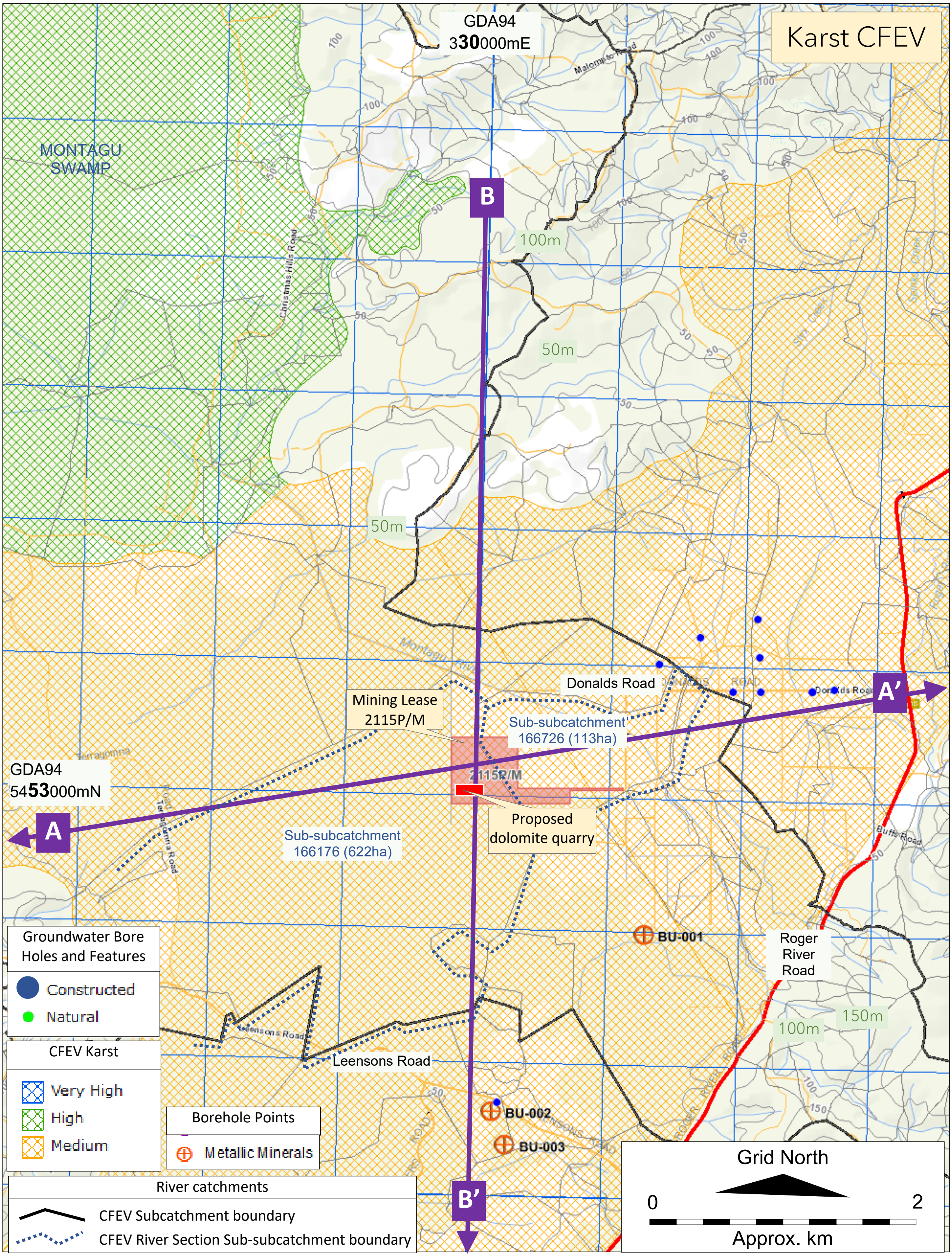


Figure 9. Karst CFEV of the district in relation to river subcatchments and sub-subcatchments, river integrated conservation values, and boreholes for groundwater and metallic minerals.
Contour interval 10m. Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).
Source of base map: www.thelist.tas.gov.au

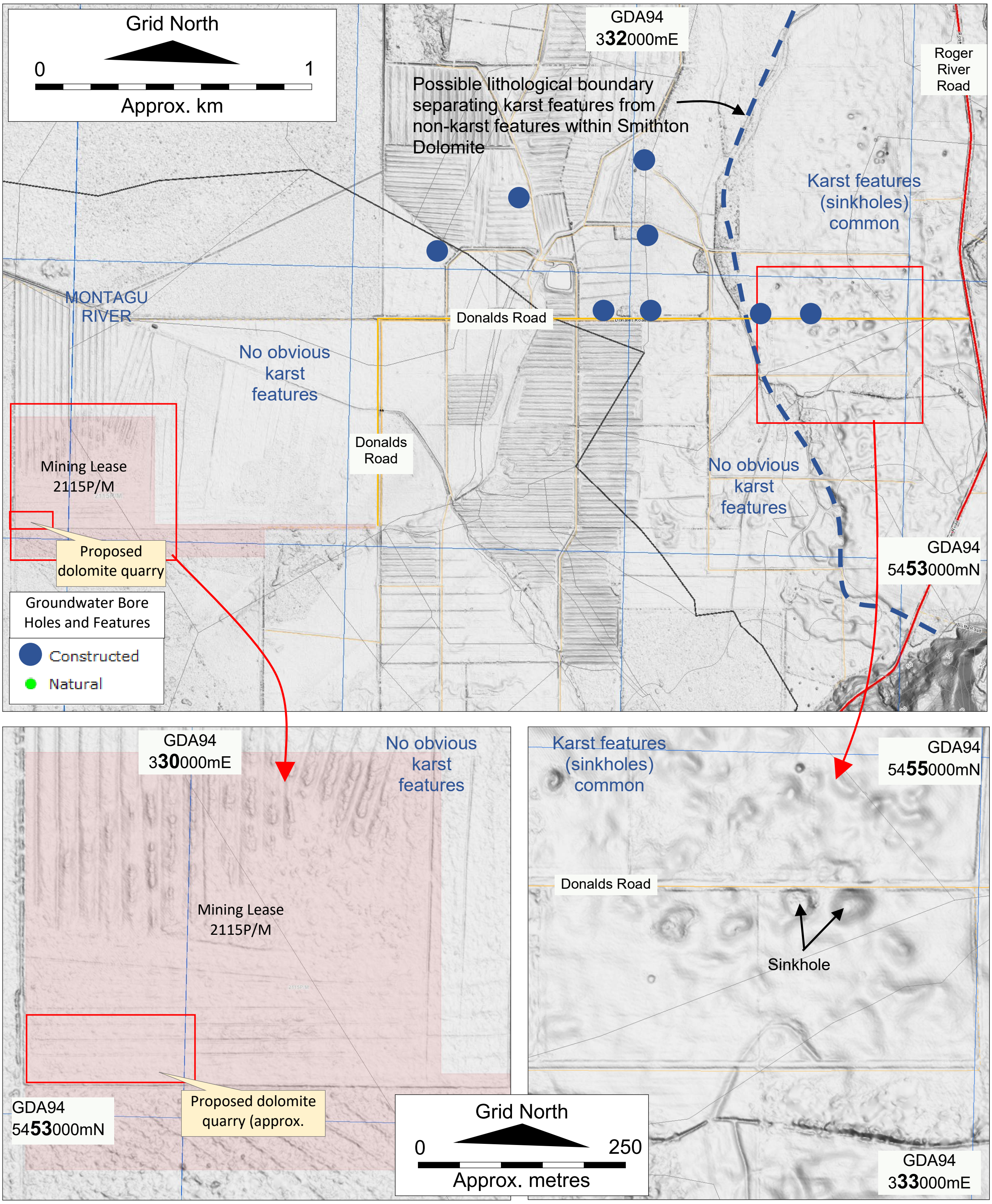


Figure 10. Hillshading in the vicinity of the proposed dolomite quarry, showing karstic features (sinkholes) in the Smithton Dolomite near the Roger River Road-Donalds Road intersection, but an apparent absence of similar features near the proposed quarry.
Source of base image: www.thelist.tas.gov.au

Figure 11. Flooded sinkholes on 12 September 2013 near the Roger River Road – Donalds Road intersection. This situation very likely reflects a high groundwater table related to unusually heavy rain: Table 1 shows that the 382mm of monthly rain recorded in August 2013 at Edith Creek was the highest since records began in 2011. This followed 228mm in July 2013, also a 90%ile rain month.
Source: Google Earth

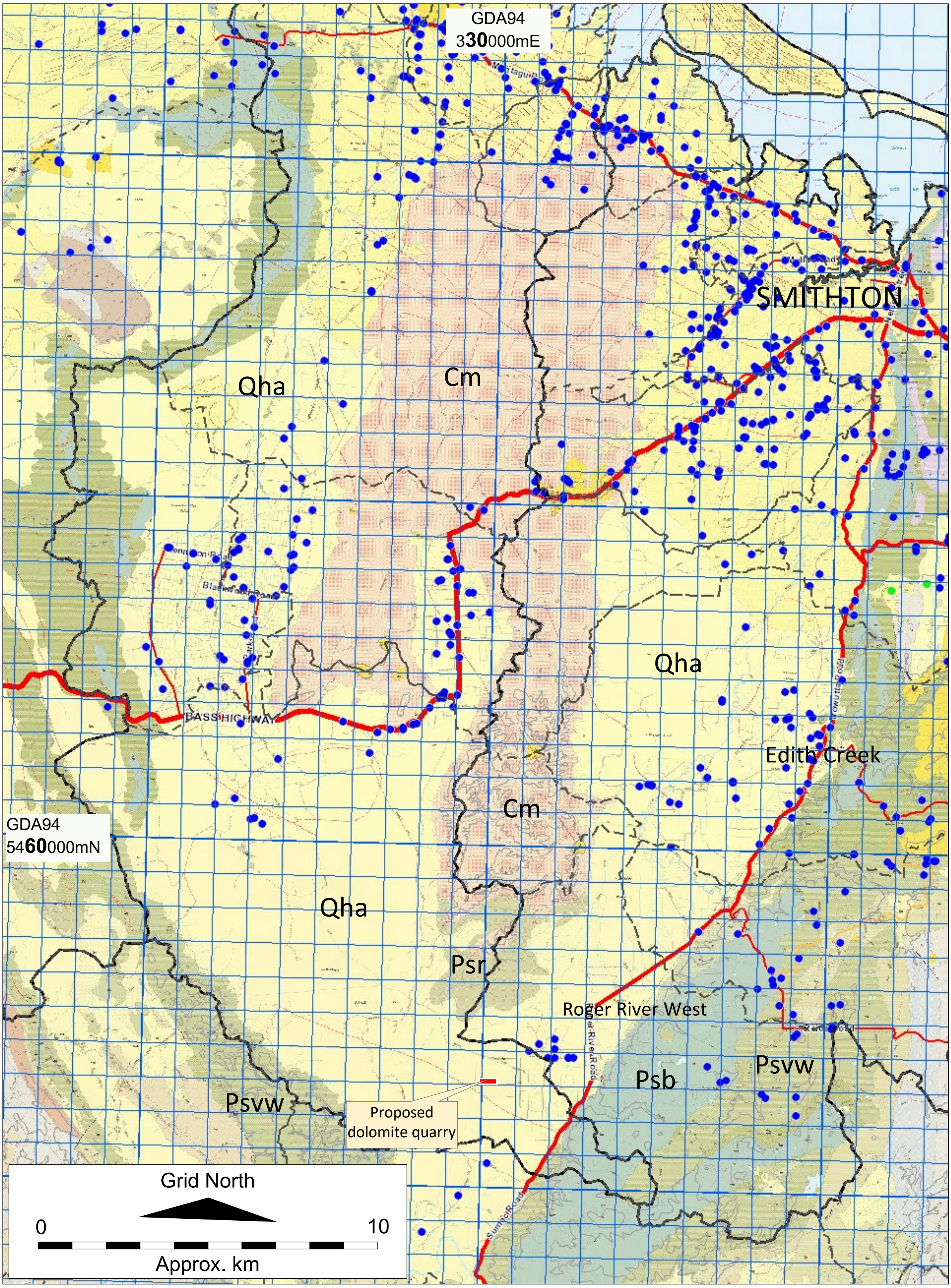


Figure 12. Groundwater bores (blue dots) in the Smithton Basin. About 800 bores are recorded on the DPIPWE Groundwater Access Information Portal.
Source of base map: www.thelist.tas.gov.au Geological rock symbols are the same as in Figure 8.

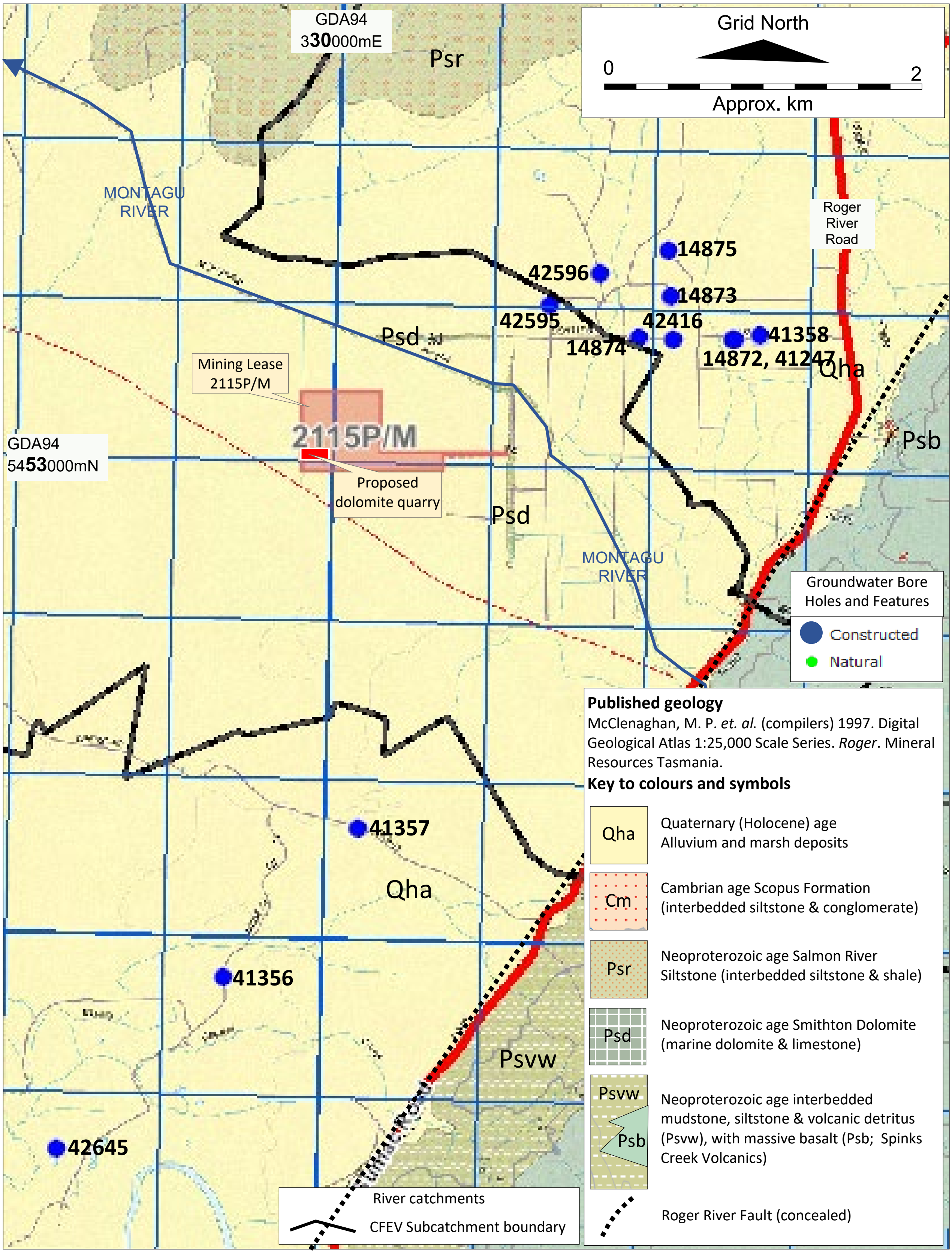


Figure 13. Locations of water bores drilled in the vicinity of mining lease 2115P/M. Bore numbers correspond to those in Table 2. Source: DPIPWE https://wrt.tas.gov.au/groundwater-info/

Table 2. Summary of published results of drilling for water in the vicinity of the Cresswells site. Bore numbers correspond to those in Figure 13. Depth is m, Initial yield is L/s, SWL = standing water level (m), TDS = total dissolved solids (mg/L). Source: DPIPWE https://wrt.tas.gov.au/groundwater-info/

Feature id	Feature type	Locality name	Easting	Northing	Datum	Coordinate accuracy (m)	Drilled date	Drilling company	Depth	Initial yield	SWL list	Last SWL date	Final TDS	Main aquifer geology	Last operating status	Last operating status date
14872	Bore	Roger River	332513	5453831	GDA94	10	30/11/1990	Gerald Spaulding Drillers Pty Ltd	24.40	1.01	6.1	30/11/1990		Precambrian Dolomite	decommissioned	13/07/2022
14873	Bore	Roger River	332113	5454084	GDA94	2000	30/11/1990	Gerald Spaulding Drillers Pty Ltd	42.70					Precambrian Dolomite	abandoned	30/11/1990
14874	Bore	Roger River	331915	5453820	GDA94	5	30/11/1990	Gerald Spaulding Drillers Pty Ltd	51.80	5.05	8	09/03/2010		Precambrian Dolomite		
14875	Bore	Roger River	332094	5454372	GDA94	2	30/11/1990	Gerald Spaulding Drillers Pty Ltd	42.00	1.45	6.1	30/11/1990		Precambrian Dolomite		
41247	Bore	Roger River	332512	5453832	GDA94	10	30/06/2008	Trevor Laycock Drilling	18.00	3.79				Precambrian Dolomite	decommissioned	13/07/2022
41356	Bore	Roger River	329384	5449748	GDA94	2	07/09/2011	Gerald Spaulding Drillers Pty Ltd	60.00	44.62	4.18;6.22;7.74;3.37	18/09/2018	233	Precambrian Dolomite		
41357	Bore	Roger River	330207	5450701	GDA94	2	08/09/2011	Gerald Spaulding Drillers Pty Ltd	60.00	19.25			340	Precambrian Dolomite		
42415	Bore	Roger River	332678	5453852	GDA94	10	26/02/2021	Gerald Spaulding Drillers Pty Ltd	54.00	20.00	9	26/02/2021	330	Precambrian Dolomite		
42416	Bore	Roger River	332126	5453822	GDA94	10	24/02/2021	Gerald Spaulding Drillers Pty Ltd	52.00	20.00	15	24/02/2021	270	Precambrian Dolomite	capped	27/06/2022
42595	Bore	Roger River	331353	5454013	GDA94	10	07/07/2022	Gerald Spaulding Drillers Pty Ltd	48.00	3.50			350	Precambrian Dolomite	abandoned	07/07/2022
42596	Bore	Roger River	331659	5454219	GDA94	10	13/07/2022	Gerald Spaulding Drillers Pty Ltd	66.00	22.00	7	13/07/2022	300	Precambrian Dolomite	capped	13/07/2022
42645	Bore	Roger River	328353	5448647	GDA94	5	04/10/2022	Gerald Spaulding Drillers Pty Ltd	22.00	20.00	4	04/10/2022	720	Precambrian Dolomite	capped	04/10/2022

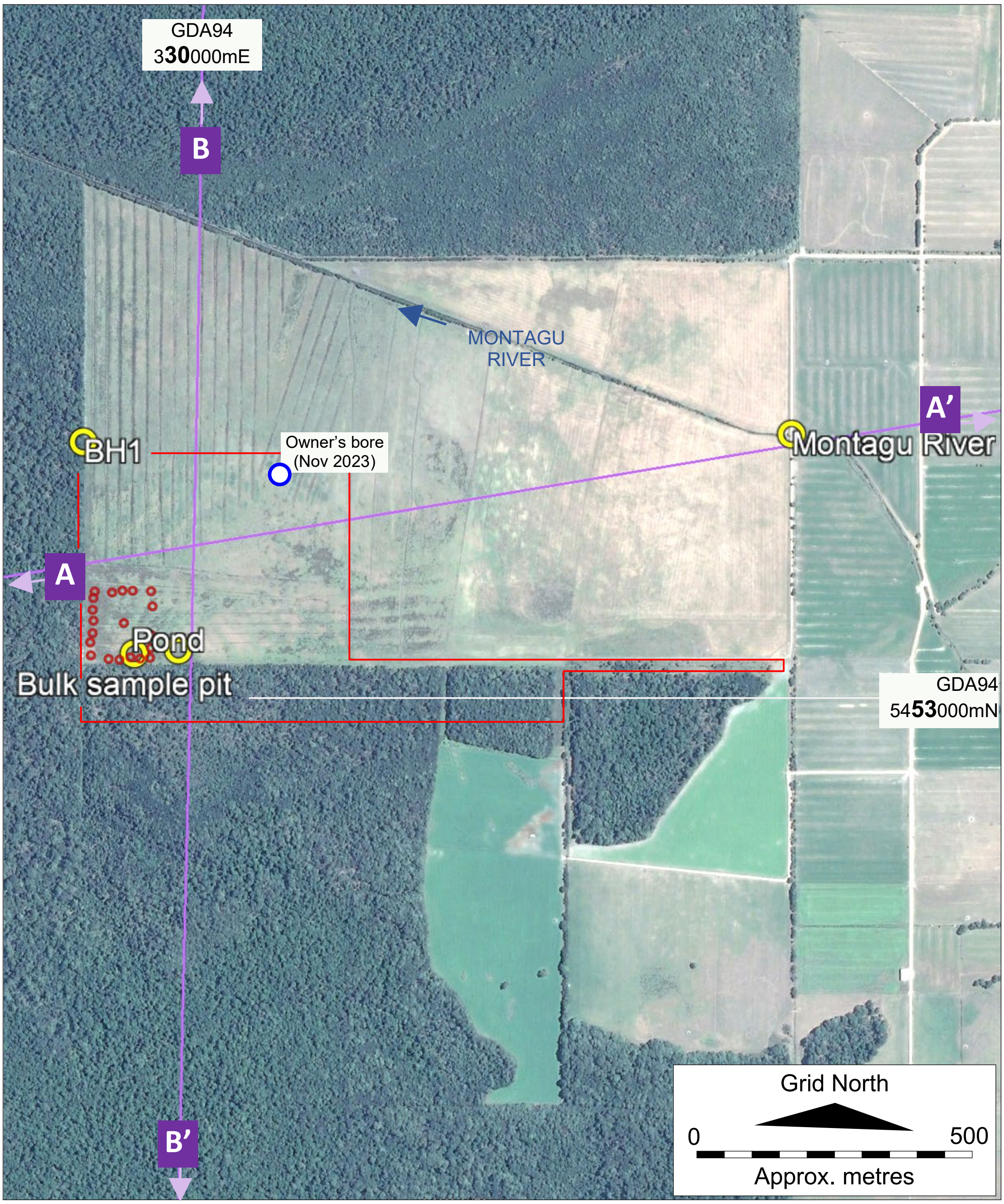


Figure 14. Water sample locations (yellow and white circles) during the site inspection of 1 May 2023 and (except for the Pond) the follow-up sampling event of 14 November 2023. Also shown are exploration rotary-percussion drill holes RR1 – RR20 (red circles) drilled February 2021 (Morrison, 2022). Mining lease 2115P/m is bordered in red.
Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map).
Source of base image: Google Earth (image date 30 December 2015)

2.3.3.3 Water in the bulk sampling pit

Approximately 2m depth of water was present in the bulk sampling pit during the site inspection on 1 May 2023, and the water level was 2.1m below ground (Plate 5). The water level was at the ground surface in mid-November 2023 (Plate 6). It is not clear whether these levels represent a fluctuating water table, or whether the water is all or part groundwater because the pit had been subject to rain runoff before the visits.

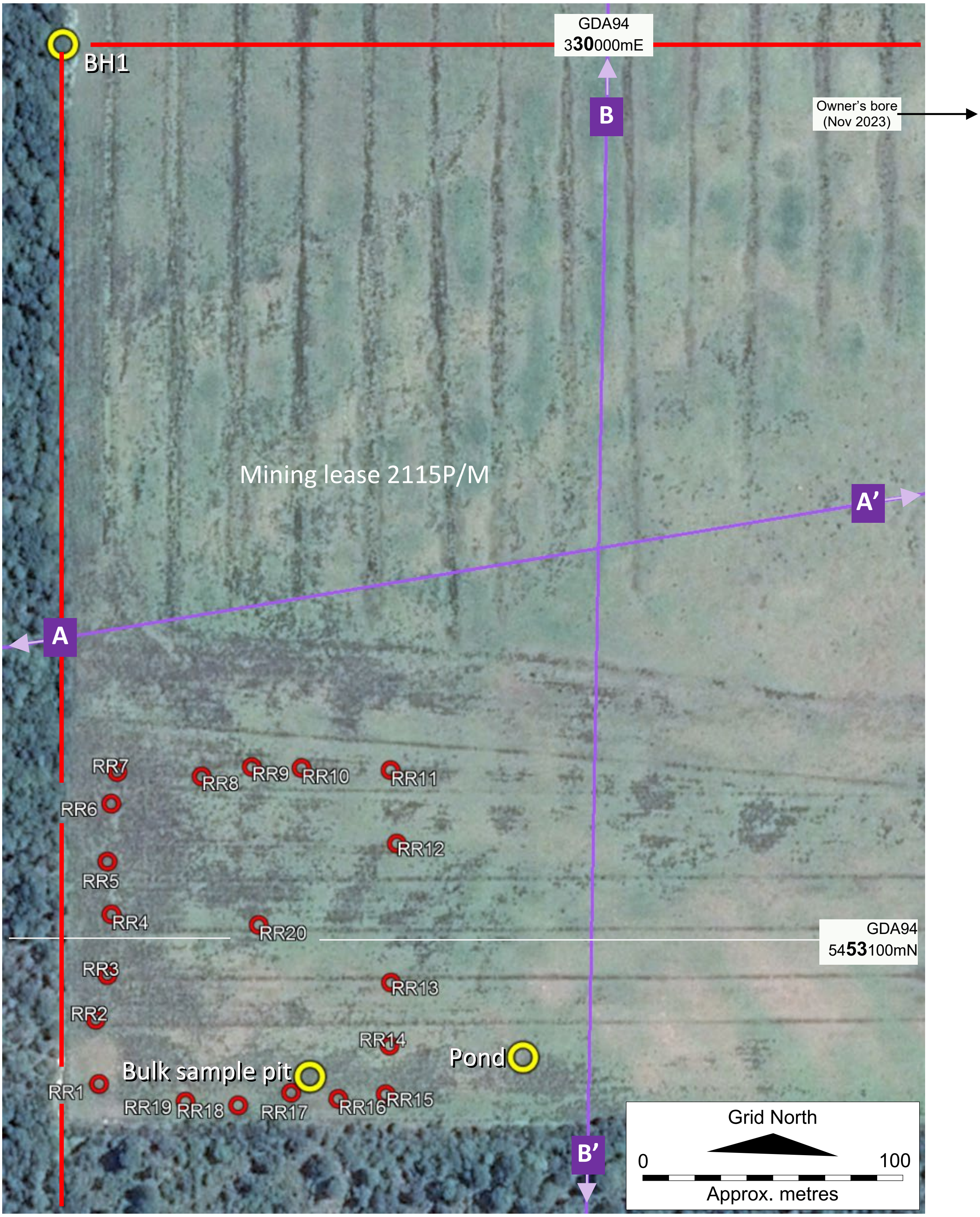


Figure 15. Water sample locations (yellow circles) during the site inspection of 1 May 2023, and exploration rotary-percussion drill holes RR1 – RR20 (red circles) drilled February 2021 (Morrison, 2022). The red line is the border to 2115P/M.

Lines A – A' and B – B' are cross section lines for the conceptual hydrogeological models in Section 3.3 (note the lines extend off the map). Source of base image: Google Earth (image date 30 December 2015)

2.3.3.4 Water in the Owner's bore

The standing water level in the Owner's bore was 4m below ground an unspecified time after drilling was completed on 14 November 2023[12]. This level is at the top of the 4 – 5m depth interval described as a gravelly cavity by the drillers, and which was dry during drilling. This in turn suggests that parts of the dolomite mass are impermeable, and are locally confining of groundwater which rises to the piezometric surface when drilling penetrates water-bearing zones and creates a pathway to higher levels.

2.3.4 Water sampling at and near the Cresswells site, May/Nov 2023

2.3.4.1 Water sampling events

On 1 May 2023, four opportunistic water samples were collected at the Cresswells site (Figures 14 and 15) for laboratory analysis: groundwater from BH1 ("BH1"), surface water from the Montagu River ("Montagu River"), water from the bulk sampling pit ("Pit Water"), and ponded surface water ("Pond").

On 14 November 2023, consultants ES&D (commissioned by Cresswells) re-sampled BH1, Montagu River and Pit Water, and also the nearby "Owner's bore" being drilled by *Spaulding Drillers* the same day. The Pond was not re-sampled in November.

Photographs of the sample sites (with the exception of the Owner's bore) and water field parameters for May and November 2023 are shown in Figure 16.

On both occasions, samples were submitted to Australian Laboratory Services (ALS) in Springvale, Melbourne for analysis. Laboratory results are presented in Attachments 1 and 2, and are compared in Table 3 and the variation diagrams of selected analytes in Figure 17.

Observations from the field parameters, Table 3 and Figure 17 are summarised below (some results are rounded).

2.3.4.2 BH1 (groundwater, May and November 2023)

The laboratory pH's for both events are similar at about 6.8 (the low field pH of 4.0 in May was anomalous). The laboratory EC's are very different: 904µS/cm in May and half that in November. The field Redox reduced forty-fold, from 395mV to 9mV.

Sulfate decreased 10-fold (234mg/L to 26mg/L) from May to November, and although ammonia increased five-fold to 0.51mg/L, nitrate decreased five-fold (0.65mg/L to 0.11mg/L) and total phosphorus more than halved to 0.22mg/L.

Detectable trace dissolved metals remained relatively constant, except for arsenic, zinc and iron, all three of which more than halved over the six months between sampling events.

BH1 (and the Owner's bore) returned detectable hydrocarbons. In BH1, TPH/TRH (TPH 470µg/L C10-C36, TRH 610µg/L >C10-C40) halved and decreased by about two thirds respectively between May and November. The hydrocarbons are probably related to lubricants added during drilling.

[12] Text message to William C Cromer Pty Ltd from Spaulding Drillers, 21 November 2023.

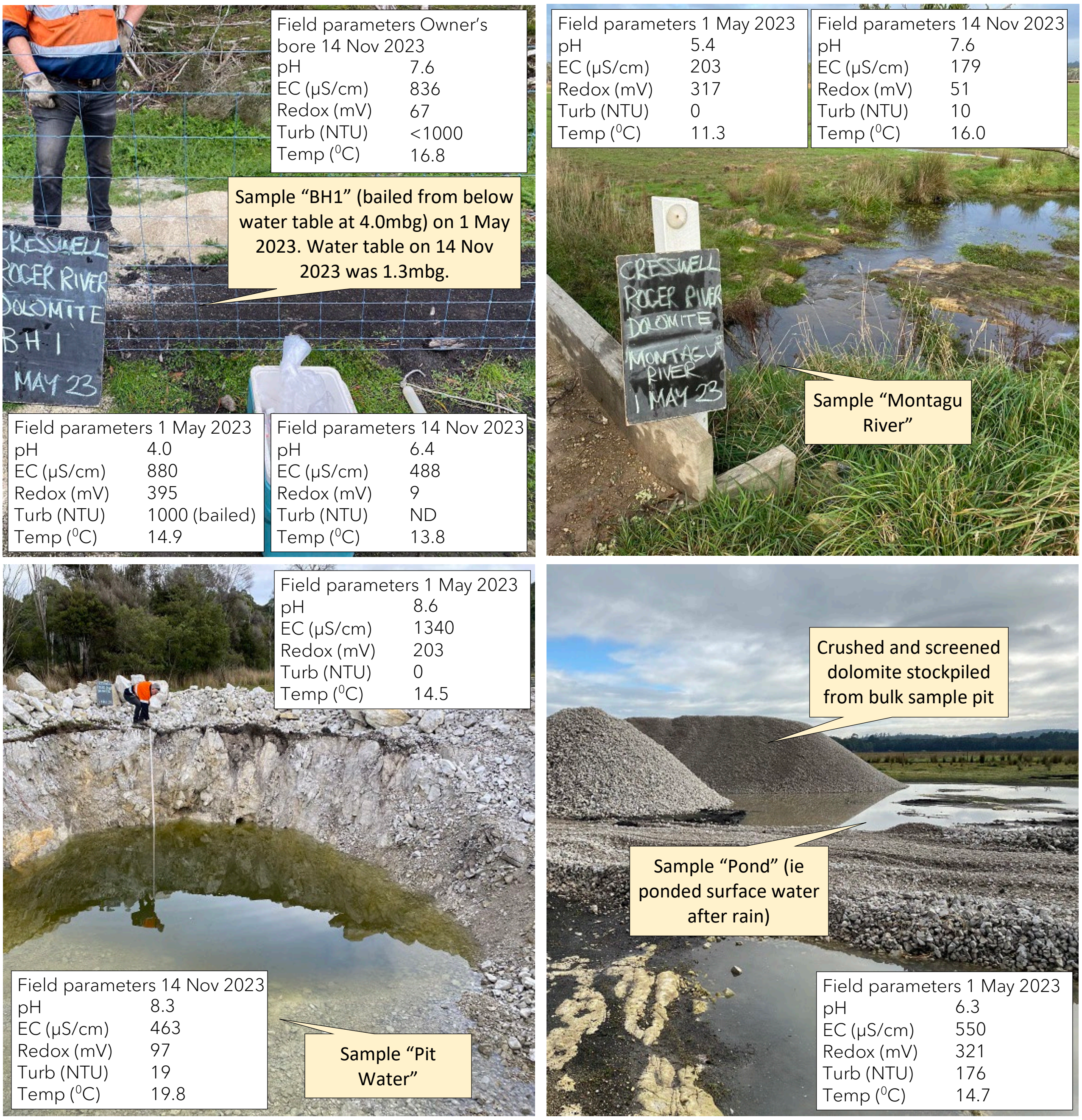


Figure 16. Photographs of water sample locations of the site inspection of 1 May 2023, and field parameters for 1 May and 14 November 2023 sampling events.

2.3.4.3 Montagu River (surface water, May and November 2023)

The Montagu River water quality remained largely unchanged between the two sampling events. pH and EC were 6.4 and 6.5, and 194µS/cm and 154µS/cm respectively.

The largest differences were a halving of sulfate (10mg/L to 4mg/L), but increases in dissolved metals (six-fold for aluminium to 0.06mg/L, and three-fold for iron to 0.17mg/L) and total metals (three-fold for aluminium to 0.34mg/L, and a doubling for iron to 0.64mg/L)

2.3.4.4 Pit Water (surface and groundwater, May and November 2023)

There were large differences in a range of analytes in the Pit Water between May and November. Most concentrations decreased, which may be because the flooded pit (Plate 6) contained mostly surface runoff from rain events.

The most notable difference were:

- a halving of EC from about 1,300µS/cm to 400µS/cm,
- a ten-fold decrease in sulfate from 188mg/L to 18mg/L,
- a thousand-fold decrease in ammonia from 18mg/L to 0.02mg/L,
- a ten-fold decrease in nitrate from 26mg/L to 2mg/L, and
- a twenty-fold decrease in both total Kjeldahl nitrogen and total nitrogen, from 20mg/L to 1mg/L and 47mg/L to 3mg/L respectively.

2.3.4.5 Pond (surface water, May 2023)

The May 2023 Pond water analysis is interpreted as reflecting water derived from rain and surface runoff in contact with crushed dolomite near the stockpiles.

Compared to the Montagu River sample, it had elevated (neutral) pH, elevated but the second-lowest EC of 537µS/cm, and elevated nutrients.

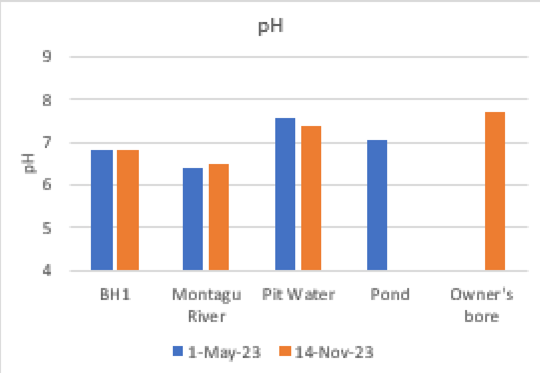
2.3.4.6 Owner's bore (groundwater, November 2023)

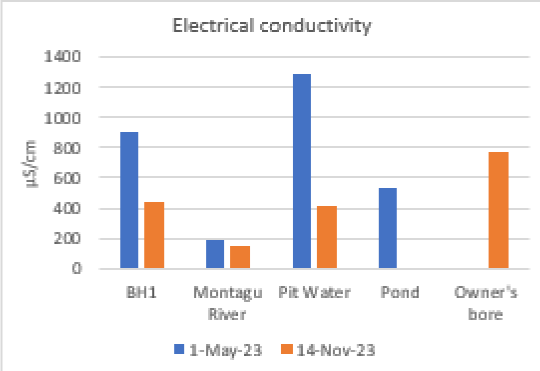
In November 2023, the Owner's bore was the most elevated of all samples in pH (7.7), EC (778µS/cm), ammonia (1.3mg/L), total phosphorus (1.5mg/L)sulphate (63mg/L), chloride (45mg/L), and a range of total (but not dissolved) metals. The total metals are interpreted as originating from the finely-crushed dolomite generated during down-the-hole hammer drilling.

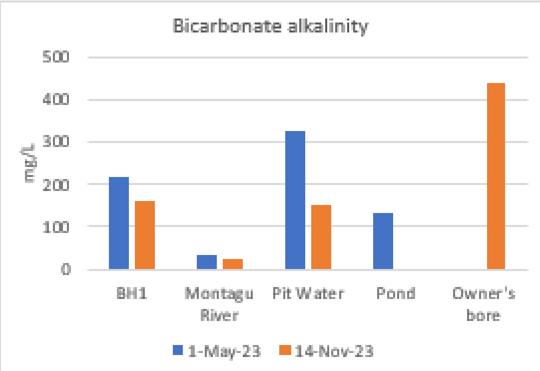
The groundwater sample returned detectable hydrocarbons: TPH/TRH (TPH 310µg/L C10-C36, TRH 420µg/L >C10-C40). Like the groundwater in BH1, the hydrocarbons are probably related to lubricants added during drilling.

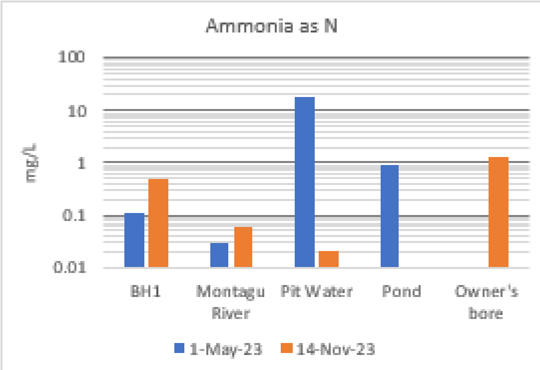
Table 3. Comparative summary of laboratory analyses of water collected from the vicinity of the Cresswells site on 1 May and 14 November 2023. The full laboratory reports are included in Attachments 1 and 2. Red-bordered cells enclose an analyte at a site which differ by more than about 100% between the two sampling events.

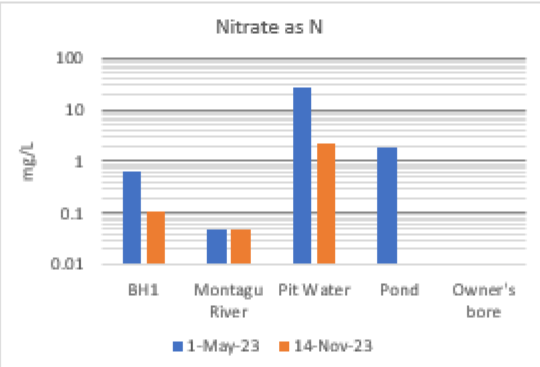
	Units	LOR	BH1		MONTAGU RIVER		PIT WATER		POND	OWNER'S BORE
			1-May-23	14-Nov-23	1-May-23	14-Nov-23	1-May-23	14-Nov-23	1-May-23	14-Nov-23
pH Value	pH Unit	0.01	6.83	6.82	6.4	6.5	7.59	7.38	7.04	7.74
Electrical Conductivity @ 25Â°C	ÂµS/cm	1	904	438	194	154	1290	413	537	778
Total Dissolved Solids (Calc.)	mg/L	1	588	285	126	100	838	268	349	506
Sodium Adsorption Ratio		0.01	0.48	0.72	1.27	1.44	0.51	0.59	0.67	0.76
Total Hardness as CaCO3	mg/L	1	441	208	42	33	574	196	223	406
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1	219	160	36	25	326	154	132	440
Total Alkalinity as CaCO3	mg/L	1	219	160	36	25	326	154	132	440
Major anions										
Sulfate as SO4	mg/L	1	234	26	10	4	188	18	58	63
Chloride	mg/L	1	31	36	30	29	66	33	52	45
Major Cations										
Calcium	mg/L	1	91	37	7	5	103	39	40	82
Magnesium	mg/L	1	52	28	6	5	77	24	30	49
Sodium	mg/L	1	23	24	19	19	28	19	23	35
Potassium	mg/L	1	1	2	1	1	2	3	3	1
Dissolved Metals										
Aluminium	mg/L	0.01	0.04	0.29	<0.01	0.06	<0.01	0.03	0.03	<0.01
Arsenic	mg/L	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.006	0.01	<0.001	<0.001	<0.001	<0.001	0.001	0.004
Copper	mg/L	0.001	0.012	0.012	<0.001	<0.001	0.017	0.004	0.008	0.007
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.001	0.025	0.024	0.001	<0.001	0.008	<0.001	0.001	0.022
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.023	0.009	<0.005	<0.005	0.009	<0.005	<0.005	<0.005
Iron	mg/L	0.05	0.13	1.55	0.06	0.17	<0.05	<0.05	<0.05	<0.05
Total Metals										
Aluminium	mg/L	0.01	12.1	13.4	0.13	0.34	0.1	0.06	6.18	24.2
Arsenic	mg/L	0.001	0.025	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	0.036
Cadmium	mg/L	0.0001	0.0002	>0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0017
Chromium	mg/L	0.001	0.06	0.056	<0.001	0.001	<0.001	<0.001	0.015	0.152
Copper	mg/L	0.001	0.076	0.037	0.002	0.002	0.02	0.004	0.014	0.248
Lead	mg/L	0.001	0.021	0.015	<0.001	<0.001	<0.001	<0.001	0.003	0.101
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.001	0.082	0.056	0.001	0.002	0.008	<0.001	0.008	0.505
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.182	0.04	<0.005	<0.005	0.008	<0.005	0.01	0.632
Iron	mg/L	0.05	75.3	11	0.28	0.64	0.1	<0.05	1.08	53.5
Fluoride	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nutrients										
Ammonia as N	mg/L	0.01	0.11	0.51	0.03	0.06	18.5	0.02	0.92	1.26
Nitrite as N	mg/L	0.01	0.09	>0.01	<0.01	<0.01	1.32	0.01	0.68	<0.01
Nitrate as N	mg/L	0.01	0.65	0.11	0.05	0.03	26.5	2.17	1.9	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.74	0.11	0.05	0.03	27.8	2.18	2.58	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	4.2	4.1	0.3	0.2	19.1	0.7	3.3	4.3
Total Nitrogen as N	mg/L	0.1	4.9	4.2	0.4	0.2	46.9	2.9	5.9	4.3
Total Phosphorus as P	mg/L	0.01	0.63	0.22	0.03	0.01	0.06	<0.01	0.17	1.47
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ionic Balance										
Total Anions	meq/L	0.01	10.1	4.5	1.77	1.4	12.3	4.38	5.31	11.4
Total Cations	meq/L	0.01	9.85	5.24	1.7	1.51	12.7	4.82	5.54	9.67
Ionic Balance	%	0.01	1.38	4.92	----	3.85	1.82	4.8	2.12	8.08
Chemical Oxygen Demand	mg/L	10	318	368	<10	117	37	368	132	282
TPH										
C6 - C9 Fraction	Âµg/L	20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction	Âµg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction	Âµg/L	100	150	110	<100	<100	<100	<100	<100	120
C29 - C36 Fraction	Âµg/L	50	320	120	<50	<50	<50	<50	<50	190
C10 - C36 Fraction (sum)	Âµg/L	50	470	230	<50	<50	<50	<50	<50	310
TRH										
C6 - C10 Fraction	Âµg/L	20	<20	<20	<20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX (F1)	Âµg/L	20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction	Âµg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction	Âµg/L	100	410	200	<100	<100	<100	<100	<100	260
>C34 - C40 Fraction	Âµg/L	100	200	<100	<100	<100	<100	<100	<100	160
>C10 - C40 Fraction (sum)	Âµg/L	100	610	200	<100	<100	<100	<100	<100	420
>C10 - C16 Fraction minus Naphthalene (F2)	Âµg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
BTEXN										
Benzene	Âµg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	Âµg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene	Âµg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	Âµg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	Âµg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	Âµg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX	Âµg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	Âµg/L	5	<5	<5	<5	<5	<5	<5	<5	<5

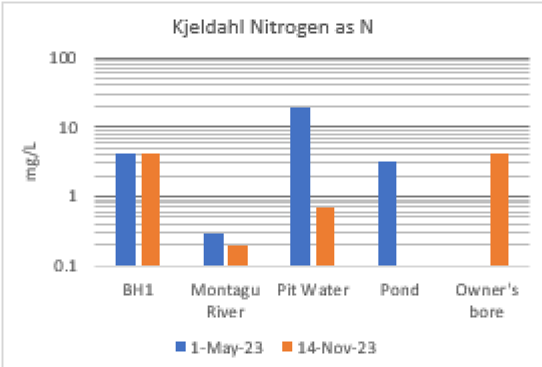

pH
9
8
7
6
5
4
pH
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23

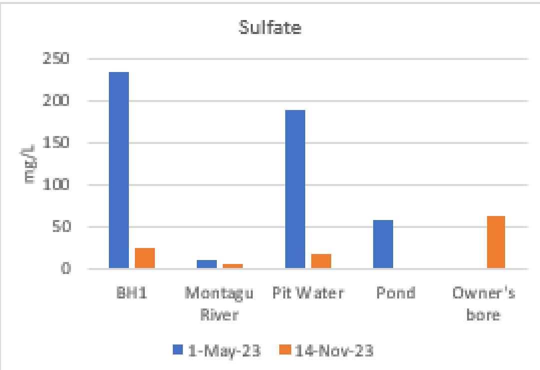

Electrical conductivity
1400
1200
1000
800
600
400
200
0
µS/cm
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23

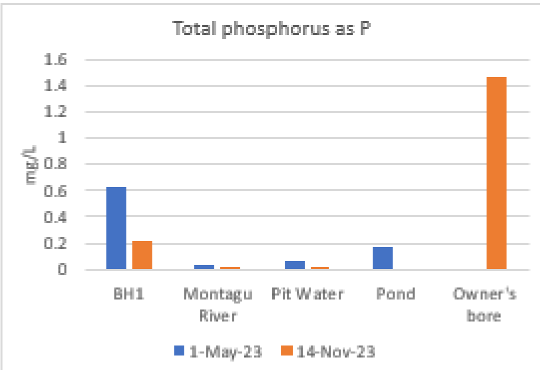

Bicarbonate alkalinity
500
400
300
200
100
0
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23

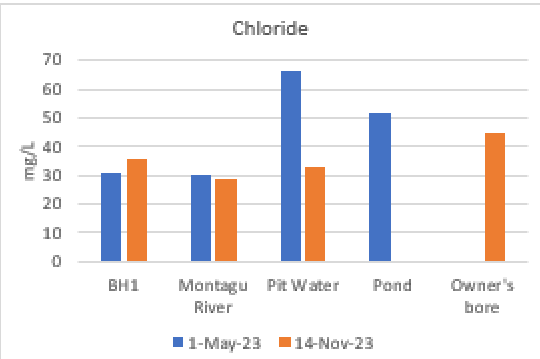

Ammonia as N
100
10
1
0.1
0.01
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23


Nitrate as N
100
10
1
0.1
0.01
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23


Kjeldahl Nitrogen as N
100
10
1
0.1
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23


Sulfate
250
200
150
100
50
0
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23


Total phosphorus as P
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23


Chloride
70
60
50
40
30
20
10
0
mg/L
BH1
Montagu River
Pit Water
Pond
Owner's bore
1-May-23
14-Nov-23

3 DISCUSSION

3.1 Groundwater fundamentals

3.1.1 Groundwater flow systems

Based on general hydrogeological principles, and records of drilled bores, at all scales the sedimentary and volcanogenic rocks of the Smithton Synclinorium are mostly fractured, hard-rock, unconfined aquifers. However, there are likely to be exceptions to this general comment:

- unconfined intergranular conditions will exist in the veneer of Quaternary surface alluvium and marsh deposits, and where bedrock is deeply weathered[13], and
- confined and probably localised conditions may exist where water in fractures is not in hydraulic continuity with adjacent groundwater with a water table under atmospheric conditions, because the bulk rock is impermeable (ie fractions in this part of the rock are either sealed, or absent).

In unconfined, fractured rock environments, Figure 18 illustrates different components of the land-based part of the hydrological cycle[14] at the scale of a single catchment or smaller. Effective rain (precipitation less evapotranspiration) flows overland to surface streams, or in recharge areas infiltrates (at a rate determined by soil and rock permeability) through the unsaturated zone to the water table. An important aspect of Figure 18 is the interconnectivity between surface water and groundwater.

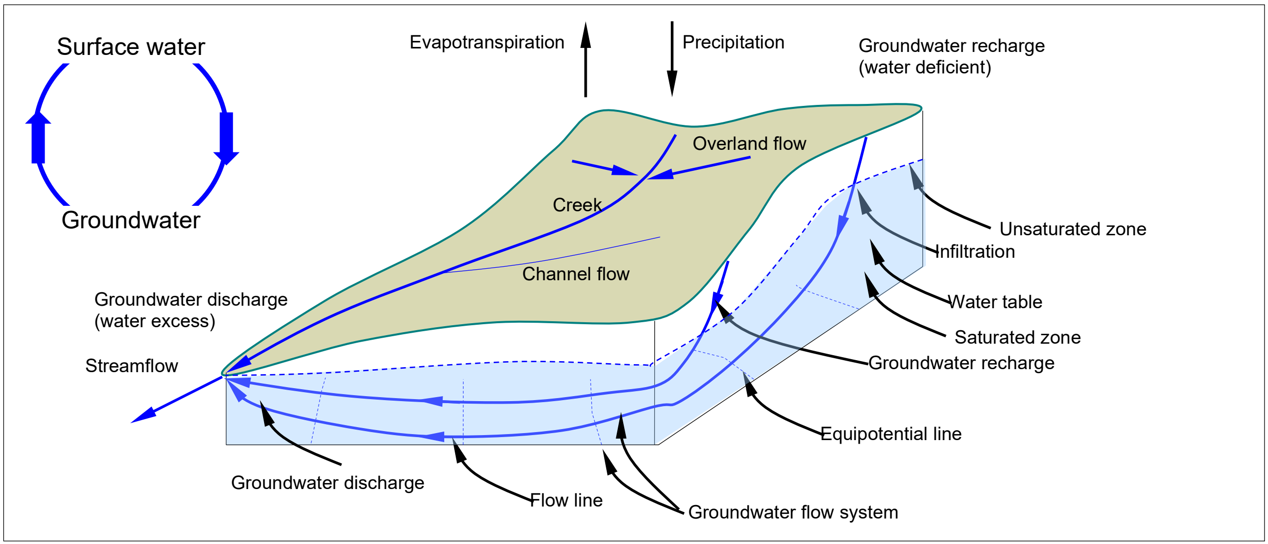


Figure 18. Aspects of the land-based hydrological cycle

[13] For example, the logs of exploration drillholes BU-001, BU-002 and BU-003 1.5 – 3km south of mining lease 2115P/M (Figure 5) show clayey materials to depths of about 23m. It is noted in Section 1.4.3 that the materials in all three holes were interpreted as basaltic, which is at odds with the dolomite reported to depths of up to 60m in nearby groundwater bores 41356, 41357 and 42645 (Table 2 and Figure 13).

[14] The *hydrological cycle* is the circulation of water in various phases through the atmosphere, over and under the earth, to the oceans, and back to the atmosphere. The cycle is solar-powered. Because water is a solvent it dissolves elements, and geochemistry is a fundamental part of the cycle, which is a flux for water, energy, and chemicals. Water enters the land-based cycle as precipitation; it leaves as surface streamflow (runoff) or evapotranspiration. The route which groundwater takes from a recharge point to a discharge point is a *flow path.*

The fundamentals of groundwater movement in an unconfined, gravity-driven groundwater flow system (GFS) are depicted schematically in Figure 19. Important points are:

- the hydraulic heads in recharge areas are relatively high and decrease with depth. In discharge areas, the energy and flow conditions are reversed; heads are low and increase with depth. In between, the throughflow is almost horizontal as shown by the steeply dipping equipotential lines.

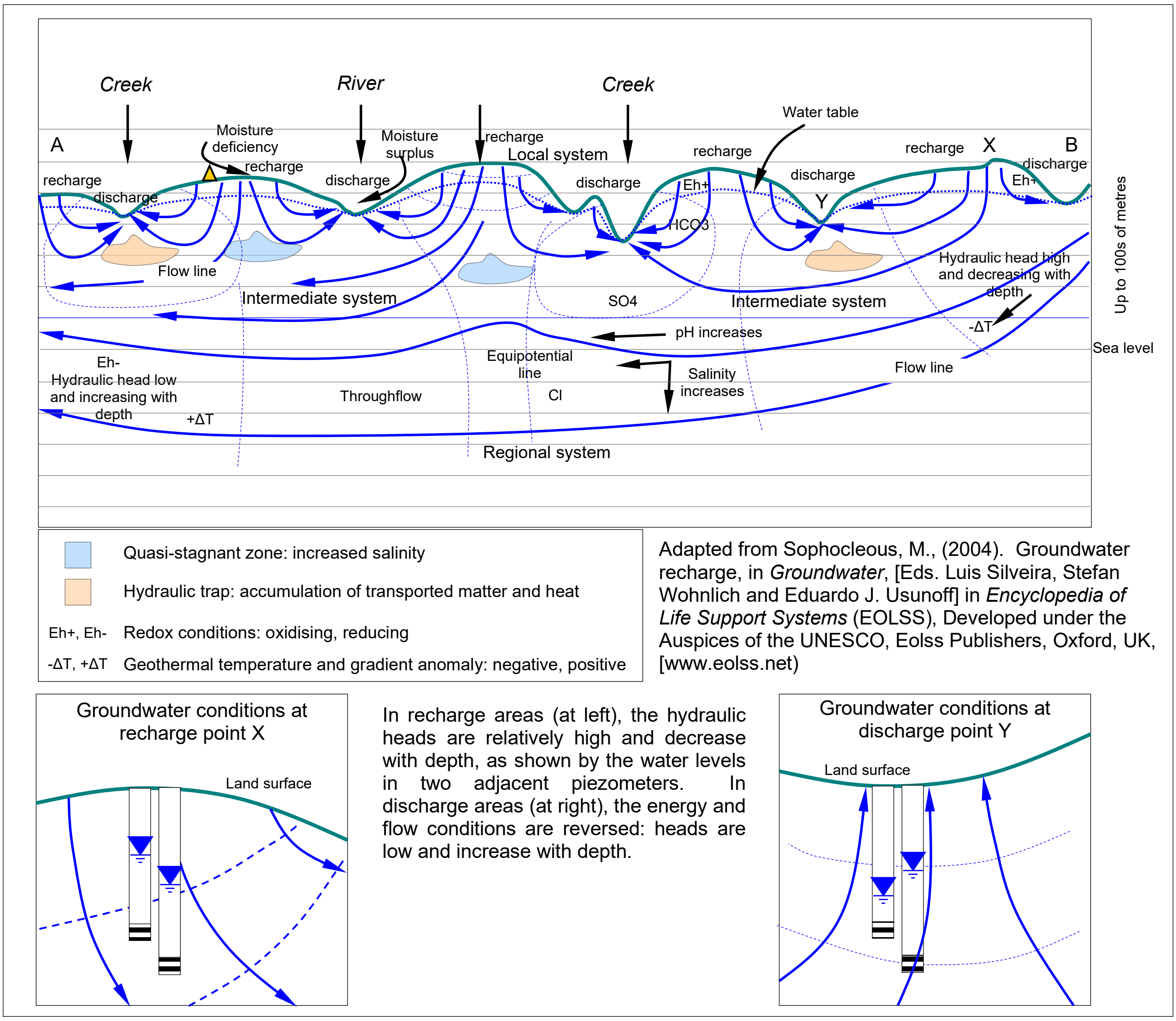


Figure 19. Fundamentals of groundwater hydrology in a gravity-driven groundwater system. Vertical exaggeration for the top section is about 5.

- the concept of a groundwater flow system (GFS[15]) is fundamental to understanding groundwater conditions in the vicinity of mining lease 2115P/M. Given the very low relief of the immediate area, and the higher relief of the surrounding hills, it can be expected that the near-surface dominant groundwater flows to depths of a few metres or so will be as <u>local</u> systems,

[15] Sophocleous (2004) cited in Figure 19 defines a GFS as "a set of groundwater flow paths with common recharge and discharge areas. Flow systems are dependent on the hydrogeologic properties of the soil/rock material, and landscape position. Areas of steep or undulating relief tend to have dominant lo*cal flow systems* (discharging to nearby topographic lows such as ponds and streams). Areas of gently sloping or nearly flat relief tend to have dominant *regional flow systems* (discharging at much greater distances than local systems in major topographic lows or oceans)." A three-dimensional closed groundwater flow system that contains all the flow paths is called the *groundwater basin*.

with almost horizontal flow lines. Groundwater gradients across these almost flat areas bordering the Montagu River will be very low, and since groundwater flow rate and volume (throughflow) are proportional to gradient, these will be very low as well. Depending on water table fluctuations, groundwater flow directions may also fluctuate, or be stationary.

- Recharge on more elevated areas will discharge to un-named minor streams. Some of the recharge will penetrate to depths of perhaps 10 – 50m or so, and will travel beneath the local-scale groundwater flow lines towards Montagu River and its larger tributary creeks. This scale of groundwater movement is regarded as intermediate.
- Still deeper groundwater infiltration results in regional systems discharging to the Arthur River, and west to the coast.

3.1.2 Scale of local, intermediate, and regional groundwater flow systems

The scale of GFSs depends on topography and geology, with local, intermediate and regional systems defined by the sizes of sub-subcatchments, subcatchments and catchments respectively of surface drainage systems.

A suggested scale of GFSs for the southern parts of the Smithton Basin (and probably elsewhere in Tasmania) is shown in Figure 20, together with adopted response times (travel times) for groundwater flow through each system. The indicative scale of local systems is nominally less than a kilometre or so, intermediate systems to 1 – 10km, and regional systems to >10km.

The response times (travel times) are similarly in proportion, but these are only conceptual since they depend on groundwater gradients and bulk rock permeability – both of which may change over orders of magnitude at all scales.

Response (travel) times for groundwater to move through a small local system may be measured in years to decades, through intermediate systems in decades to centuries; and through regional systems in centuries to millennia (Figures 20 and 21).

3.1.3 Groundwater independent ecosystems (GIEs)

Rain falls on an unconfined aquifer across its full areal extent. This situation applies throughout the district.

On unconfined aquifers, on relatively higher ground (interfluves) between adjacent watercourses, infiltrating rain moves vertically down through the soil profile towards the water table and downgradient away from the interfluve to join local, intermediate or regional GFS's. The water is entering the systems and "recharging" them.

Flora and fauna inhabiting the land and soil profile in interfluves receive intermittent water from direct rain, and from infiltrating rain which evaporates, evapotranspires, is temporarily stored in the unsaturated zone, and leaves the area as groundwater.

Such areas have a groundwater deficit and a relatively deep water table.

The flora and fauna may depend on the rain, but they do not depend on the groundwater.

Groundwater recharge zones host groundwater independent ecosystems (GIEs).

	Conceptual response (travel) times from recharge to discharge areas
Local GFS	Years to decades
Intermediate GFS	Decades to centuries
Regional GFS	Centuries to millenia

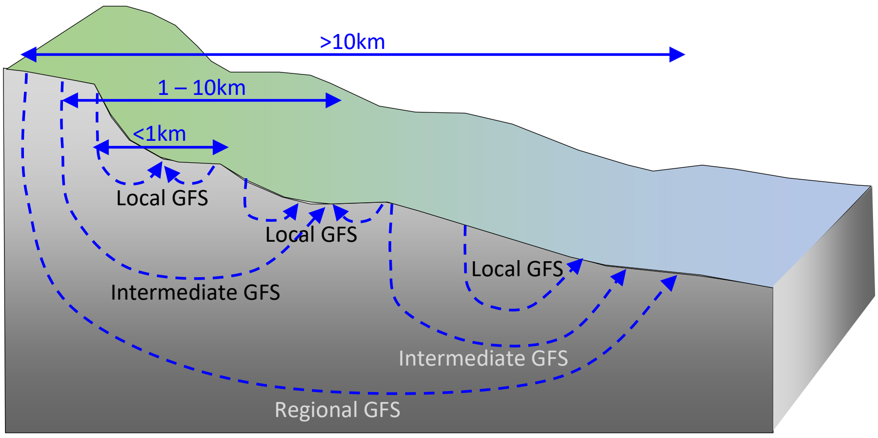


Figure 20. Conceptual sizes and response (travel) times for groundwater in Tasmanian local-, intermediate- and regional- GFS's. Blue dashed lines are some idealised groundwater flow lines. Adapted from Hocking *et. al.* (2015; Table 1 and Figure 15)

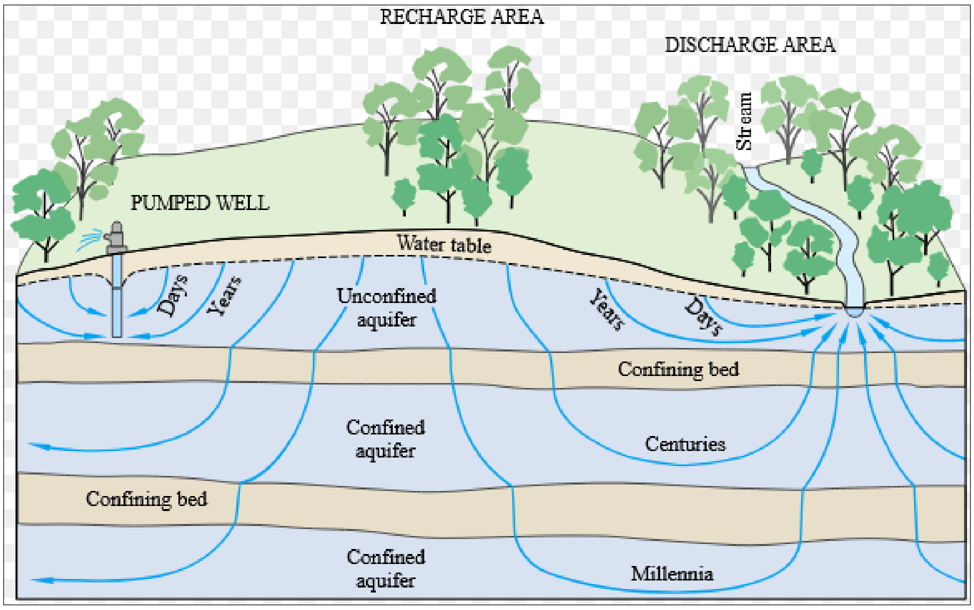


Figure 21. A schematic diagram showing that inferred travel times for groundwater flow (blue lines) in interbedded unconfined and confined conditions may range from days to millennia depending on the travel distance. Source: https://en.wikipedia.org/wiki/Groundwater

3.1.4 Groundwater dependent ecosystems (GDEs)

Groundwater from recharge areas has travelled via gravity through local, intermediate or regional GFS's towards lower-lying discharge areas, and if sufficient head is available the water moves upwards through the soil profile to evaporate and evapotranspire.

Such lower-lying areas have a groundwater excess and a relatively high water table. If upward flow rates exceed evaporation and evapotranspiration, the water table rises to or above the land surface where it forms wetlands, or contributes to creek and river flows.

Flora and fauna inhabiting the land surface and soil profile in lower-lying areas receive intermittent water from direct and infiltrating rain (the former evaporates or evapotranspires, and the latter leaves the area), but also from upwards moving groundwater.

The flora and fauna may depend on the rain, but they also depend on the groundwater.

Groundwater discharge zones host groundwater dependent ecosystems (GDEs).

Several types of GDEs are recognised in Australia (Table 4).

Table 4. Types of groundwater dependent ecosystems

GDE Type	Definition	Characteristics
Aquatic	Aquatic surface-based ecosystems relying on groundwater as a primary water source.	Water Source: groundwater discharging to freshwater or brackish water environments (rivers, streams, wetlands, springs, estuarine and near-shore marine environments); Fluctuations: seasonal or groundwater availability changes; Biodiversity: diverse aquatic plant and animal species; Sensitive Species: endemic or specialized species
Terrestrial	Terrestrial surface-based ecosystems dependent on groundwater as a vital water source.	Water source: groundwater; Vegetation: forests, woodlands, grasslands, shrublands; Root Systems: deep-rooted plants; Adaptations: drought tolerance, water storage mechanisms; Fauna Diversity: terrestrial animals; Varying groundwater availability supports different plant communities
Subterranean	Ecosystems existing below the surface, relying on groundwater.	Water source: groundwater in fractures, caves, caverns, solution channels etc; Dark environments, lack of sunlight; Alternative energy sources; Unique Fauna: specialized and adapted species (eg stygofauna) vulnerable to changes in groundwater availability and quality

In the district, the dominant surface GDE is mapped as aquatic in nature, and a Bureau of Meteorology (BOM) national-scale assessment (Figure 22) shows mining lease 2115P/M and parts of the surrounding district are of "High potential" for this type.

Terrestrial GDEs in the district are restricted to more elevated areas, and at a national-scale are also BOM-assessed as "High potential".

At a regional-scale study, the subcrop of the Smithton Dolomite is BOM-assessed as of "Unclassified potential" for subterranean GDEs.

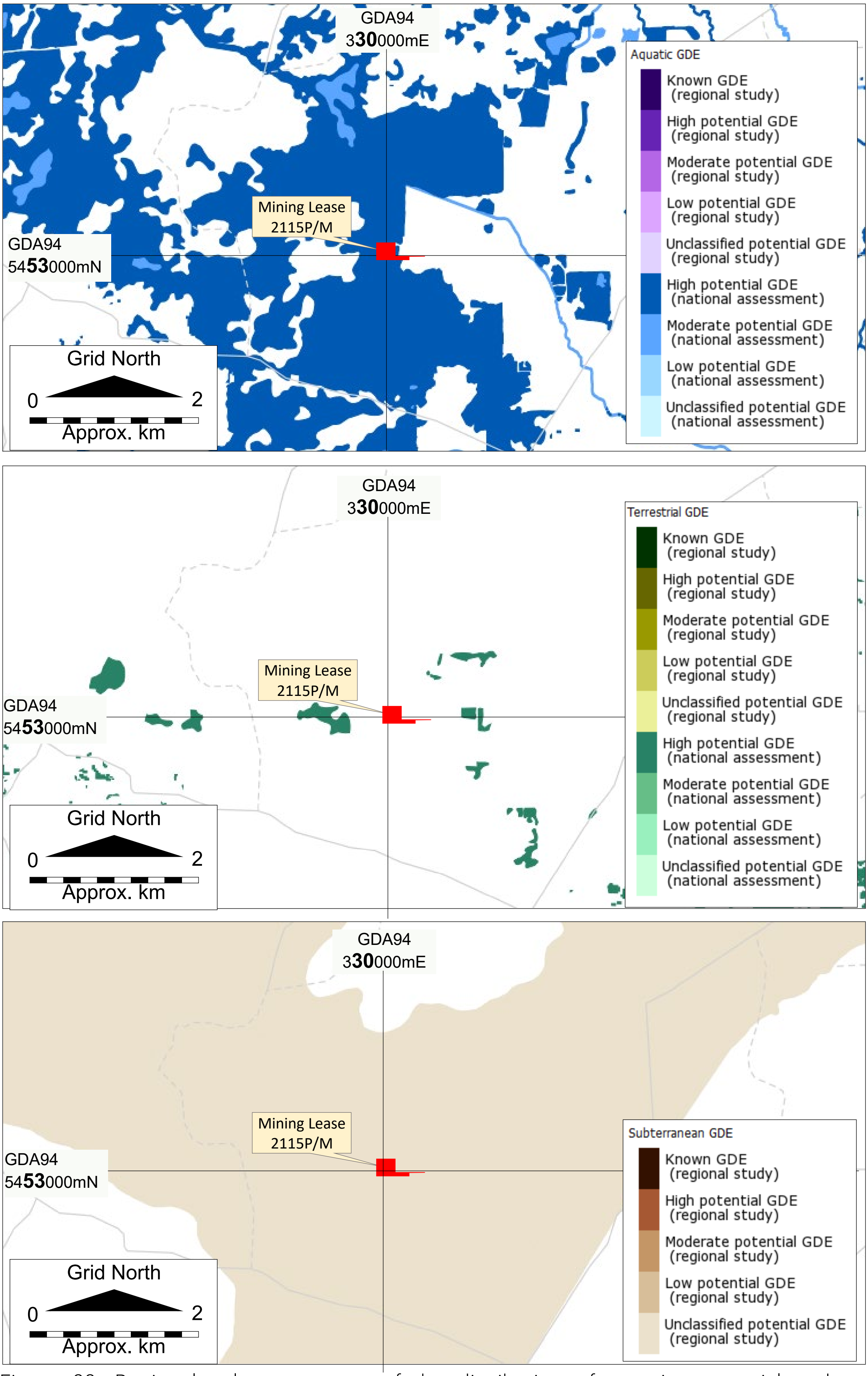


Figure 22. Regional-scale assessment of the distribution of aquatic, terrestrial and subterranean GDEs in the district. Source: GDE Atlas Map: Water Information: Bureau of Meteorology (bom.gov.au)

3.2 Local, intermediate and regional groundwater flow directions

3.2.1 General inferences and observations

Local-, intermediate- and regional-scale groundwater flow directions (Figure 23) in the southern part of the Smithton Basin (including mining lease 2115P/M) are inferred from topography, site observations, groundwater levels in bores, published surface subcatchments and sub-subcatchments from www.thelist.tas.gov.au, and groundwater fundamentals. In Figure 23:

- local-scale flow (thin red arrows; only some of hundreds are shown) is in all directions in sub-subcatchments of all sizes (Figure 5; discussed in Section 2.1.1.2) and towards the Montagu River and other major streams,
- intermediate flow (thicker red arrows) is similarly in all directions, and in the vicinity of mining lease 2115P/M, also towards the Montagu River and other major streams, and
- regional flow (thick, open red-bordered arrows) is mostly westwards towards the west coast.

3.2.2 Uncertainty of local-scale groundwater flow directions

3.2.2.1 Artificial drains

Within the almost flat areas surrounding the Montagu River and the adjacent Styx Creek system joining the Roger River (itself a tributary of the Duck River), surface flows and probably local groundwater systems have been heavily modified by artificial drains. (The purpose of the drains was to remove floodwaters from the low-lying areas to the major creeks and streams, to provide land for agriculture.)

One drain connects the Montagu River with Styx Creek, so two originally separate subcatchments are now joined (Figure 24).

3.2.2.2 Sub-subcatchment boundaries

The smaller sub-subcatchments depicted on Figure 23 are based on almost no topographic relief, and the location of their boundaries must be very approximate in some areas. In other areas – for example, in the intensively-drained former marshes at Togari 10km to the north northwest on the Montagu River – each set of artificial drainage drains defines a separate sub-subcatchment.

While drains define surface flow directions, the directions of flow of the immediately underlying local groundwater systems is uncertain. This uncertainty is indicated by the question marks in Figure 23.

3.2.2.3 Groundwater flow at and near the proposed quarry

Figure 23 indicates local (and intermediate) groundwater flow is northeasterly to the Montagu River. However, this is uncertain. In early May 2023, the water table in bore BH1 was estimated to be at least 3m lower than the water level in the Montagu River, and in the bulk sampling pit water level was perhaps a metre lower. In November 2023, the water table in BH1 was at a depth of 1.3m (Figure 16). The seasonal and longer variability in water table depth is unknown, but so long as the observed differences in water levels are maintained, shallow groundwater from mining lease 2115P/M cannot report to the Montagu River.

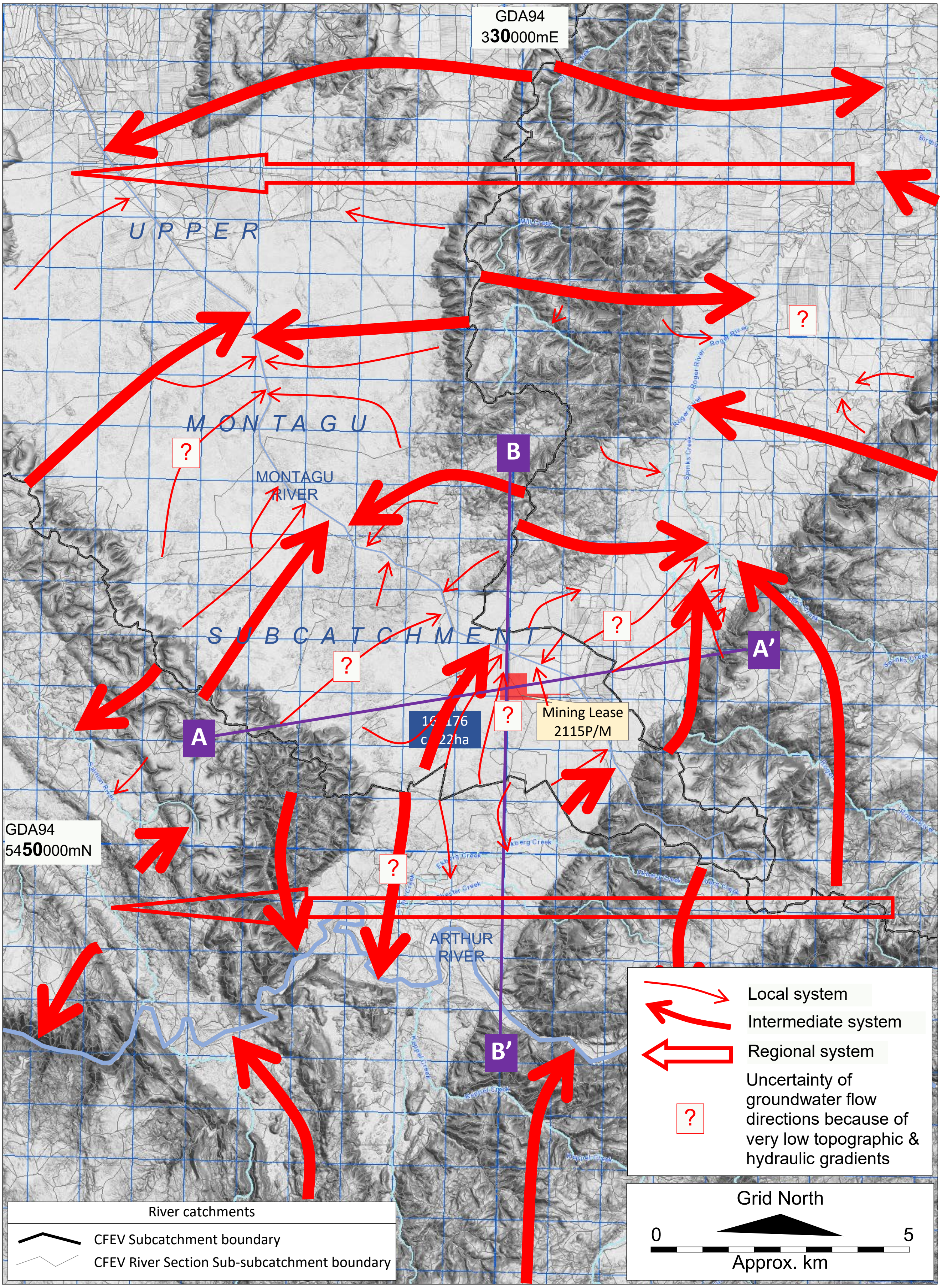


Figure 23. Inferred and approximate local, intermediate, and regional groundwater flow directions in the southern part of the Smithton Basin, including mining lease 2115P/M. Source for hillshading: www.thelsit.tas.gov.au.

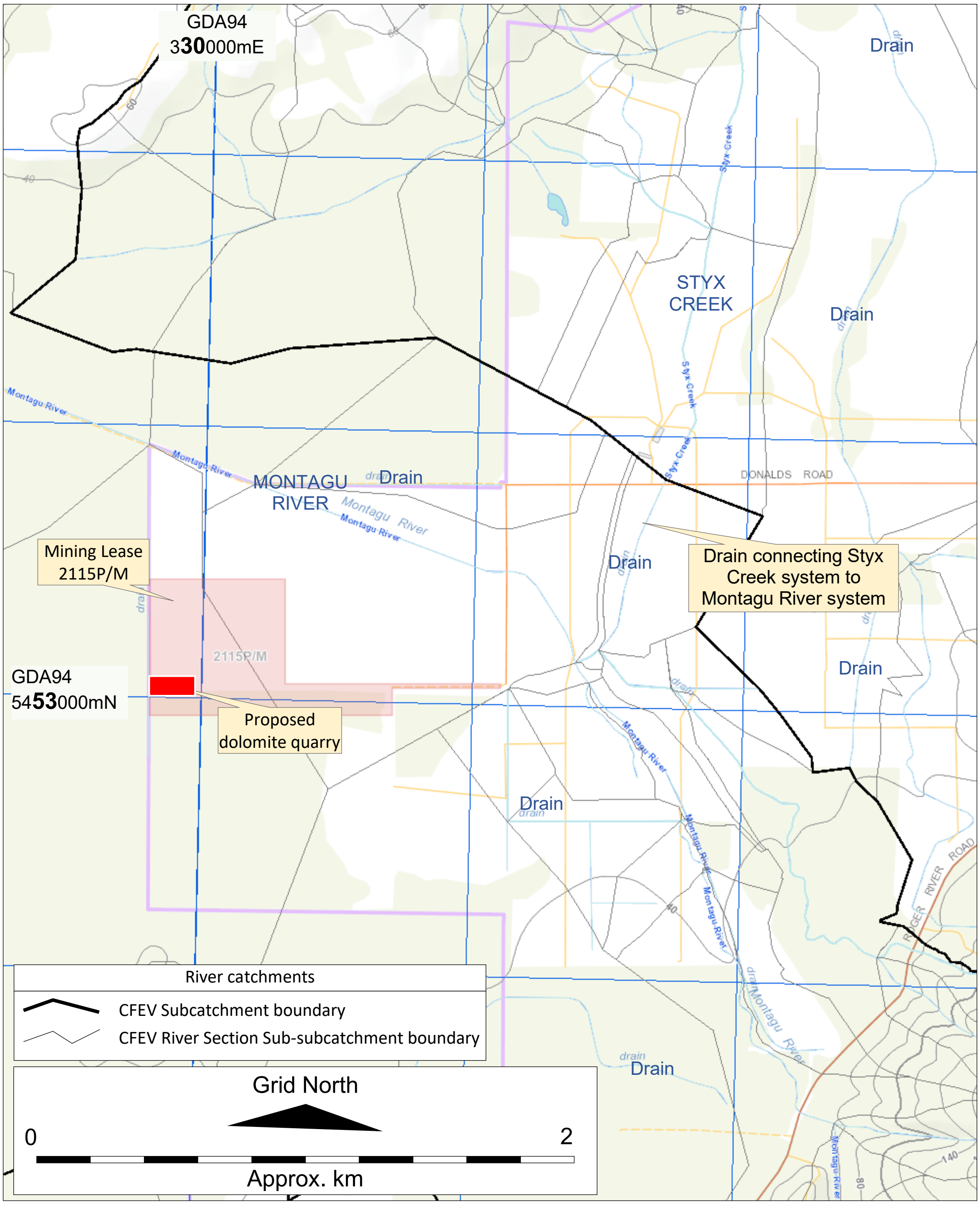


Figure 24. Artificial drains in the vicinity of mining lease 2115P/M.
Source for base map: www.thelsit.tas.gov.au.

It is also evident (Section 2.3.3, Table 2) that at a subregional and regional level groundwater occurs in fractures in the dolomite bedrock. But at the proposed quarry site, groundwater may occur locally only in pockets separated by almost-impermeable rock and not be connected laterally or vertically to other parts of the groundwater system. This inference is supported by:

- observations that surface fractures in bedrock are mostly sealed,
- the absence of any surface evidence of higher-conductivity karst features,
- the difference in water levels between the bulk sampling pit, BH1 and the Owner's bore, and
- the reported dry gravel-filled cavity between 4 – 5m in the Owner's bore (Section 2.3.3.4).

Adding further to the uncertainty of local-scale groundwater conditions is that if unusually high rain events raise the water table closer to the surface (as shown in Figure 11) the flat-lying areas would have almost no water table gradient. Under these conditions, irrespective of aquifer permeability, local-scale groundwater flow in any direction would almost not occur.

At and near the proposed dolomite quarry, the picture emerges of a complicated local-scale groundwater system which for much of the time might be effectively stationary.

3.2.4 Uncertainty of GDEs and GIEs at and near the proposed dolomite quarry

Usually, a river system like the Montagu surrounded by (slightly) elevated ground would receive upward-moving local-system groundwater flow and be classified as an aquatic GDE. The comments in Sections 3.2.2 and 3.2.3 indicate that while this might sometimes be the case, it is not clear whether it is always or even sometimes applicable. The river running past mining lease 2115P/M is straightened as a shallow (<0.5m deep) artificial drain (Plate 1), and massive dolomite is exposed along at least part of its length. When the river system is in flood, it is very likely that the neighbouring ground is also temporarily under water (despite the drainage systems) which then infiltrates the subsurface so that the area would technically become a GIE.

The Montagu River (and adjacent creeks and drains) may therefore alternately act as losing and gaining watercourses.

3.3 Conceptual hydrogeological models

Based on a consideration of Sections 3.1 and 3.2 (including Figures 22 and 23), conceptual hydrogeological cross sections have been drawn up along section lines A – A' and B – B'. These are presented in Attachment 2. The features of the cross sections include:

- bedrock in the district constitutes one or more unconfined hard-rock aquifers.
- In these aquifers, groundwater moves through secondary openings (mainly joints) between otherwise dry bulk rock,
- locally in the Smithton Dolomite secondary openings have become enlarged by solution to produce karst features including sinkholes and (presumably) underground caves and conduits,
- groundwater at local-scale typically comprises recharge and discharge areas between neighbouring sub-subcatchments, creeks and artificial drains; in flat-lying areas in the vicinity of mining lease 2115P/M, the very low water table gradients suggest groundwater may be stationary or fluctuating in flow direction some of the time,
- groundwater at intermediate-scale comprises recharge and discharge areas between neighbouring subcatchments and major creeks and rivulets (discharge zones),
- groundwater at regional-scale comprises recharge and discharge areas between neighbouring catchments and rivers (discharge zones),
- groundwater flow rates in most fractured rocks are judged to be very low (of the order of a few cm/day) and travel times are relatively long (from decades in local-scale systems, to millennia in regional-scale systems); these comments hold also for flow times in high permeability karstic features in the almost-flat parts of the district when hydraulic gradients are very low or approaching zero (zero gradient = zero rate of flow).

3.4 Surface water and groundwater quality

3.4.1 Background surface water quality

Water samples "Montagu River" (Section 2.3.4, and Table 3) are here taken to be reasonably representative of surface water in the river at the times of sampling (early May and mid-November).

The integrated environmental value of the river in this vicinity is "High" (Figure 5).

Table 5 presents the Default Guideline Values (DGVs) for the Montagu Catchment for High Ecological Value (HEV) and Slightly to Moderately Disturbed (SMD) situations for aquatic ecosystems on a seasonal and annual basis.

Table 6 compares the 1 May 2023 (Autumn) analysis of the river (Table 3) to those in Table 5. There is reasonably good agreement between the DGVs for HEV- and SMD-level ecosystems, and the 1 May and 14 November 2023 water analyses.

3.4.2 Background groundwater quality

No data are available for groundwater quality in the district, other than:

- the field-measured total dissolved solids (TDS; "salinity") reported in Section 2.3.2 for the bores listed in Table 2 [TDS values ranged from 233 – 720mg/L of Total Dissolved Solids (TDS), roughly equating to electrical conductivities (EC) in the 360 – 1,100µS/cm range],
- the regional-level summaries on the *Northwest Tasmania Groundwater Quality Map* (Matthews and Latinovic, 2006b), where the reported TDS range for dolomite is 250 – 3700mg/L, roughly equating to electrical conductivities (EC) in the 400 – 6,000µS/cm range], and
- at the Cresswell site, the May and November 2023 analyses of groundwater from BH1, and the November 2023 analysis of groundwater from the nearby Owner's bore, reported in Table 3 (selected analytes are graphically depicted in Figure 17). A difficult-to-explain observation is the large differences in some analytes (EC, sulfate, nutrients) in BH1 between the May and November 2023 sampling events. An explanation might lie in the difference in water table depths (4mbg and 1.2mbg) over the same period.

Omitting the TPH/TRH in BH1 and the Owner's bore as due to contamination introduced during drilling, and pending further possible sampling events, background groundwater quality for some analytes at the Cresswell site might reasonably be regarded as somewhere in the range exhibited by both bores: pH 6.5 – 8, EC 400 – 800µS/cm, Ammonia as N 0.5 – 1mg/L, Nitrate as N 0.01 – 0.1mg/L, Total phosphorus as P 0.2 – 1.4mg/L. Sulfate 20 – 60mg/L.

Table 5. DGVs summary for aquatic ecosystems in the Montagu River Catchment, seasonally and annually, for HEV and SMD ecosystems. Annual and Autumn values are here boxed in red.
Source: Appendix A of EPA (2021).

Physico-chemical indicators and water quality DGVs for Aquatic Ecosystems

HEV	DO (mg/L) lower	DO (mg/L) upper	DO (% sat)^ lower	DO (% sat)^ upper	Cond (µs/cm)	pH lower	pH upper	Turb NTU	Temp (°C) lower	Temp (°C) upper	TAN as N^ (mg/L)	NO_3 as N^ (mg/L)	NO_2 as N^ (mg/L)	Total N as N^ (mg/L)	DRP as P^ (mg/L)	Total P as P^ (mg/L)	TSS^ (1.5 µm) (mg/L)	TSS* (0.45 µm) (mg/L)
Annual	8.4	11.0	78.4	100.4	377.2	5.3	7.3	14.6	8.7	13.7	0.051	0.136	0.008	0.706	0.004	0.025	5.00	3.00
Summer	7.7	10.0	89.7	104.5	178.6	6.7	7.4	12.7	13.4	16.0	0.048~	0.172	0.007~	0.662	0.005~	0.024	5.00~	3.00
Autumn	6.8	10.6	64.2	101.3	488.0	6.3	7.3	9.7	9.0	13.1	0.070~	0.130	0.007~	0.643	0.004~	0.029	5.00~	5.00
Winter	9.3	11.4	77.0	95.3	367.0	4.7	7.1	14.7	7.3	9.8	0.055~	0.091~	0.008~	0.825	0.004~	0.065	5.00~	3.00
Spring	8.3	11.2	79.7	98.5	340.0	5.1	7.1	15.4	9.8	12.2	0.043~	0.087	0.009~	0.717	0.004~	0.018	5.00~	3.00

NB: DO (dissolved oxygen), Cond (electrical conductivity), Turb (turbidity), TAN (total ammonia nitrogen), DRP (dissolved reactive phosphorus), TSS (total suspended solids) filtered through, e.g., 1.5 µm. * State derived values, ^ Hydrological region values, ~ <95% confidence. Figures shown above are based on data from 2 HEV sites within the Montagu Catchment unless noted otherwise in the table.

Physico-chemical indicators and water quality DGVs for Aquatic Ecosystems

SMD	DO (mg/L) lower	DO (mg/L) upper	DO (% sat) lower	DO (% sat) upper	Cond (µs/cm)	pH lower	pH upper	Turb NTU	Temp (°C) lower	Temp (°C) upper	TAN as N (mg/L)	NO_3 as N (mg/L)	NO_2 as N (mg/L)	Total N as N (mg/L)	DRP as P (mg/L)	Total P as P (mg/L)	TSS^ (1.5 µm) (mg/L)	TSS* (0.45 µm) (mg/L)
Annual	8.8	11.1	88.5	105.2	206.2	6.3	7.3	10.9	10.3	15.8	0.052	0.032	0.001	0.349	0.006	0.018	5.00	11.00
Summer	8.6	11.2	93.0	115.6	202.8	6.9	7.5	8.9	13.6	22.2	0.041~	0.026~	0.001~	0.490~	0.005~	0.012~	5.00	15.20
Autumn	9.8	11.4	90.3	114.2	204.6	7.0	7.4	11.3	11.0	16.0	0.073~	0.020~	0.001~	0.264~	0.005~	0.015~	5.00~	12.00
Winter	8.8	11.2	85.7	100.2	208.4	6.0	6.9	11.2	9.0	10.8	0.015~	0.039~	0.001~	0.191~	0.006~	0.013~	8.00	7.00
Spring	8.7	10.5	88.4	99.8	200.9	6.1	6.7	11.2	11.0	14.7	0.067~	0.037~	0.001~	0.309~	0.007~	0.038~	11.20~	8.20

NB: DO (dissolved oxygen), Cond (electrical conductivity), Turb (turbidity), TAN (total ammonia nitrogen), DRP (dissolved reactive phosphorus), TSS (total suspended solids) filtered through, e.g., 1.5 µm. * State derived values, ^ Hydrological region values, ~ <95% confidence. Figures shown above are based on data from 3 SMEV sites within the Montagu Catchment unless noted otherwise in the table.

Table 6. DGVs for HEV- and SMD-level ecosystem guidelines, and selected analytes from the 1 May and 14 Nov 2023 water analyses, for the Montagu Catchment near mining lease 2115P/M.

	pH	EC (µS/cm)	TN (mg/L)	TP (mg/L)
Autumn HEV DGVs	6.3 – 7.3	488	0.64	0.03
Annual HEV DGVs	5.3 – 7.3	377	0.71	0.03
Autumn SMD DGVs	7.0 – 7.4	205	0.26	0.02
Annual SMD DGVs	6.3 – 7.3	206	0.35	0.02
1 May 2023 (this report)	6.4	194	0.4	0.03
14 Nov 2023 (this report)	6.5	154	0.2	0.01

DGVs = Default Guideline Values; from EPA (2021)
Some numbers are rounded
HEV = High Ecological Value
SMD = Slightly to Moderately Disturbed
EC = Electrical conductivity
TN = Total Nitrogen as N
TP = Total Phosphorus as P

3.4.3 Water quality in the bulk sampling pit

3.4.3.1 Water quality in May 2023

As discussed in Section 2.3.4, of the four water samples collected on 1 May 2023, the water in the pit had the highest field pH (8.6), the highest EC (1340µS/cm field, 1290µS/cm lab), the highest alkalinity (326mg/L), the second highest sulfate (188mg/L), the highest calcium, magnesium and sodium (103, 77 and 28mg/L respectively), detectable trace dissolved metals copper, nickel, zinc and iron), the highest total nitrogen (46.9mg/L) and the second lowest total phosphorus (0.06mg/L).

The high total nitrogen is interpreted as being mostly due to the ANCO explosive[16] used in drillholes to blast the bedrock for excavation. Nitrogenous fertilisers may also be a source.

The elevated field pH, EC, calcium and magnesium are interpreted as due to the mixed groundwater - surface water being in contact with finely-fractured and pulverised dolomite in the pit.

Water in (and if pumped from) the proposed quarry may be similarly affected by blasting, but this inference needs to be followed up by further sampling and analysis of pit water during initial quarrying operations (see Section 3.4.3.2 below).

3.4.3.2 Water quality in November 2023

As discussed in Section 2.3.4.4, there were large differences in a range of analytes in the Pit Water between May and November 2023. Most concentrations decreased, which may be because the flooded pit (Plate 6) contained mostly surface runoff from rain events.

This in turn suggests that if and when the working pit is flooded between summer mining operations, total nitrogen (and other analytes) levels will be similar to, or lower than those measured in November 2023. It is also expected that in contrast to the initial blasting conditions posed by the solid undisturbed

[16] ANFO = Ammonium Nitrate Fuel Oil, approx. 94% NH_4O_3; 6% hydrocarbons (diesel, etc). Also present as minor constituents may be anti-caking agents (eg $CaCO_3$, $MgCO_3$), sensitizers (eg powdered aluminium, coating agents (eg paraffin wax), stabilisers (eg $CaSO_4$).

ground when the trial pit was opened up, blasting during operations will be adjacent to open pit faces. This allows more efficient blasting patterns, and less explosives.

3.5 Effect of proposed quarrying on groundwater and GDEs

Quarrying is proposed to depths of about 5m below current ground level, and operations will reportedly occur mostly in summer months. It is likely but not certain that excavation to these depths will encounter groundwater. The uncertainty arises because:

- the water level in the bulk sampling pit on 1 May 2023 may not be representative of the water table at the time if (as reported) surface runoff from rain had entered the excavation, and
- the depth to groundwater in BH1 was 4mbg on 1 May 2023, and 1.2mbg on 14 November 2023; also in November 2023, the water table in the Owner's bore (at a very similar elevation to BH1 and about 300m to the east) was 4mbg. This almost 3m difference in water table depths indicates that the groundwater in both bores is not directly connected, and suggests similar conditions might pertain during mining. In further discussion in this report, it is assumed that the water table fluctuates between 1mbg and 4mbg.

Accordingly, if (as is likely) mining excavations extend below the water table, the rate of groundwater ingress may be variable. Blasting will fracture the bulk rock in the immediate vicinity, and may cause any contained groundwater to enter the pit, but if fractures (secondary openings) are tight or absent outside the artificially fractured zone, inflow during quarrying may be short-lived, low or absent. On the other hand, if karstic features (enlarged secondary openings) are encountered, groundwater inflow rates immediately on exposure may be high. Depending on the size of the karst feature and its connectivity with other such features, the inflows might be significant and maintained, or they might be short-lived as the local water table difference quickly reduces to zero and flow stops.

Notwithstanding these comments, and for the purpose of site management, it is conservatively assumed (mostly from the hydrogeological cross sections in Attachment 2) that:

- groundwater is present everywhere over the footprint proposed for quarrying and is in limited hydraulic conductivity with surface water in the Montagu River,
- the Montagu River in the vicinity has a *High* integrated conservation value, and a *Very High* classification for its immediate and potential *Conservation Management Priority,*
- the low lying area including the proposed quarry and the Montagu River is an aquatic groundwater dependent ecosystem of *High* potential,
- the groundwater gradient between the proposed quarry footprint and the Montagu River is essentially zero most of the time, and because of this low gradient, (and irrespective of dolomite bulk permeability) groundwater flow to the river is mostly non-existent or extremely slow (ie quasi- stagnant groundwater conditions; Figure 18) ,or reversible if water table levels fluctuate,
- blasting will produce highly-fractured and partly-pulverised dolomite with high exposed surface areas; below the water table, there may be an increase in groundwater pH, electrical conductivity, calcium and magnesium levels, and sulfate. Blasting will also introduce elevated levels of soluble nitrogen species to groundwater in the immediate vicinity,
- the water table will be intersected during quarrying, and groundwater will need to be pumped from the quarry so that operations can proceed,

- pumping will lower the water table inside and around the quarry, drawing it down ("drawdown") to produce a zone of influence within which local groundwater flow will be towards the quarry; outside the zone of influence, groundwater flow directions will not be significantly altered,
- the rate of pumping required to dewater the quarry is unknown and may vary as operations progressively enlarge the pit.

These observations and inferences are schematically depicted in Figure 25, showing current and inferred operational groundwater conditions towards the end of quarry life.

3.6 Groundwater and surface water risk assessment of proposed quarry

Arising from the present report, and from a risk assessment perspective, the proposed quarrying operations:

1. will possibly affect local groundwater quality if blasting and quarrying remain above the seasonally-high water table,
2. will almost certainly affect local groundwater quality if blasting and quarrying occur below the seasonally-high water table (Issue 2a); this situation is very likely to require dewatering so that groundwater flow directions in the immediate vicinity of the excavation will almost certainly be modified (Issue 2b), and if quality-affected groundwater is pumped from the quarry and allowed to discharge to the Montagu River it would likely affect water quality in the river (Issue 2c),
3. may possibly damage karstic structures and any accompanying biota (Issue 3),
4. are likely to contaminate groundwater if fuel spillages occur in the quarry (Issue 4), and
5. are unlikely to affect the groundwater dependent ecosystem (assuming it exists) in the vicinity (Issue 5)

The likelihood, consequences and risks associated with Issues 1 – 5 are listed in Table 7, before and after treatment[17]. Before treatment, the highest perceived risks are to localised groundwater contamination from explosives, and to effects on water quality in the Montagu River. After appropriate treatment, these higher risks reduce to Moderate in both cases.

3.7 Groundwater and surface water monitoring plan

The hydrogeological model (Attachment 2) for this site is summarised in Table 7 as: "a dolomite quarry up to about 5m deep covering between 2 and 4 ha (at end of life) on flat ground 500m from a high conservation level river. The water table fluctuates between 1mbg and 4mbg, and its hydraulic gradient presumably towards the river is less than 1:1000. The area is an aquatic groundwater dependent ecosystem of high potential. Subsurface karst features may be present and the subterranean GDE is of low potential. ANFO explosives will be used in quarrying."

On this basis, Table 7 includes suggested treatment options to mitigate perceived risks. These constitute a *Groundwater and Surface Water Management Plan* for operations, and are summarised in Table 8. A karst management plan has been compiled from Table 7, and is presented in Table 9.

[17] It is recognised that risk assessment including likelihood and consequences is a subjective process, and different practitioners may assess each differently .

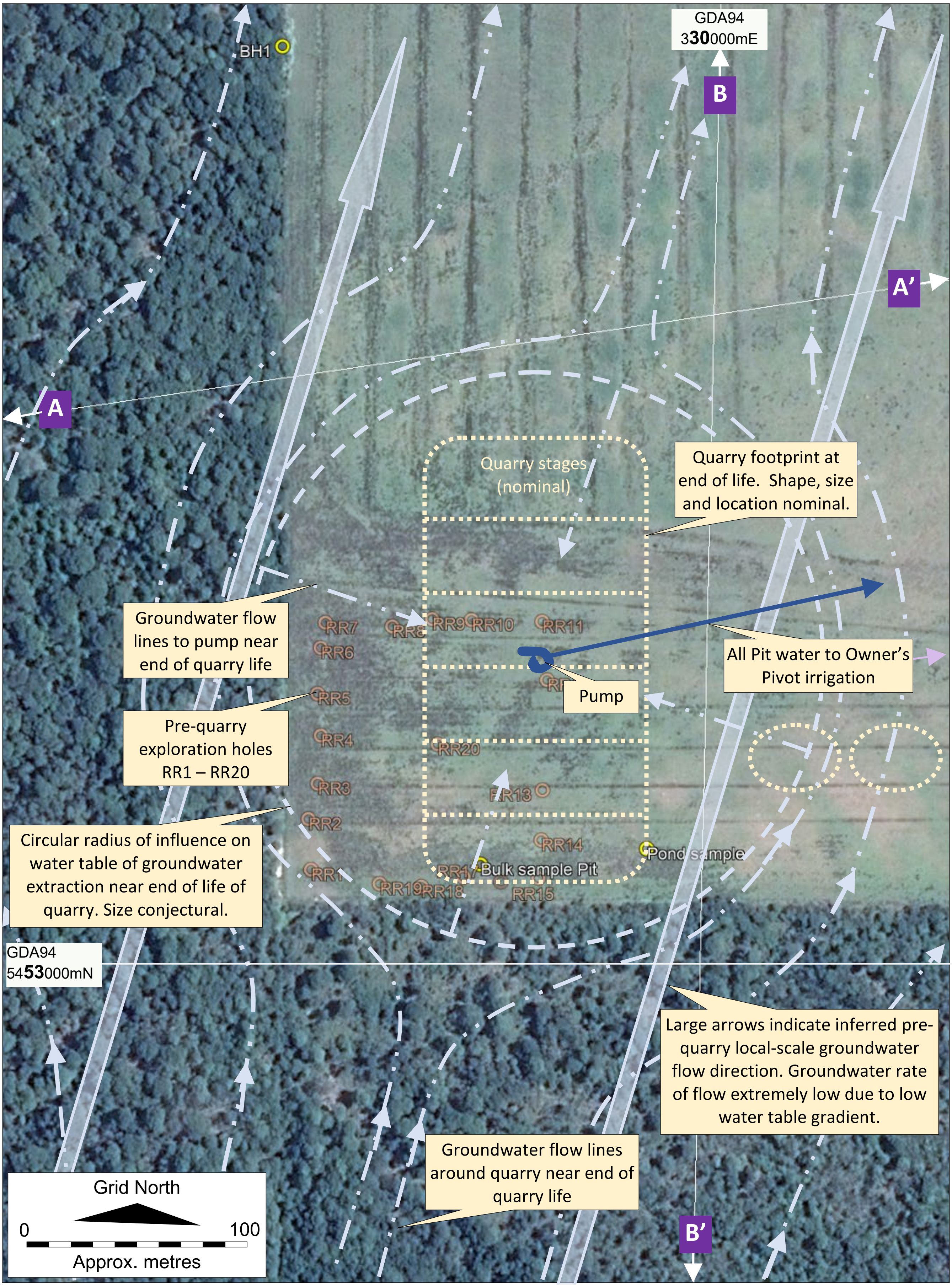


Figure 25. Conceptual interpretation of effect on groundwater conditions of groundwater extraction from the quarry near the end of quarry life, assuming a 5m deep excavation over the footprint, and the need to dewater the pit.

Table 7. Risks to groundwater and the Montagu River arising from the proposed quarrying operations, before and after suggested treatment (management). The colour-coded likelihood – consequence – risk terminology is explained in the matrix beneath.

		Before treatment				After treatment		
	1	2	3	4		2	3	4
	Issues	**Likelihood of occurrence**	**Consequence of occurrence**	**Level of risk of occurrence**	**Suggested risk treatments**	**Likelihood of occurrence**	**Consequence of occurrence**	**Level of risk of occurrence**
	Elements at risk = local scale groundwater in fractured hard rocks beneath the site, and the Montagu River							
1	Blasting and quarrying remain above the seasonally-high water table	Groundwater contamination Possible	ANFO explosives will introduce nitrogen to groundwater, and fragmentation of bulk rock will increase groundwater pH, EC, Ca, Mg, SO4. At and external to the quarrying operations, consequences will be Minor to Insignificant (natural groundwater flow direction is towards the Montagu River, but in dolomite (even with potential high permeability karstic features) its rate of flow is very slow due to very low water table gradient.	Very Low to Moderate	Consider modifying quarry depth because of fluctuating water table. To better establish water table gradient, flow direction and background quality, install two monitoring bores: one on southern side of proposed quarry, and another (additional to BH1) between quarry and Montagu River. (Note: BH1 and the Owner's bore will provide useful groundwater data, but they have not been constructed to minimium Australian standards for monitoring bores, so additional bores must be installed). Minimise ANFO explosive use, particularly near the water table by implementing strict blast design practices (eg techniques such as pre-splitting, line blasting, timing and delay patterns). Consider monitoring blast vibrations and their effect on the water table, and consider adjusting blast design or locations if excessive impact is observed. Regularly monitor groundwater quality (include nitrogen species).	Groundwater contamination Possible	Unchanged	Very Low to Moderate

The hydrogeological model (Attachment 2) for this site is: a dolomite quarry up to about 5m deep covering between 2 and 4 ha (at end of life) on flat ground 500m from a high conservation level river. The water table fluctuates between 1mbg and 4mbg, and its hydraulic gradient presumably towards the river is less than 1:1000. The area is an aquatic groundwater dependent ecosystem of high potential. Subsurface karst features may be present and the subterranean GDE is of low potential. ANFO explosives will be used in quarrying.

Colour-coded risk levels for Likelihood – Consequence pairs

	Consequence				
Likelihood	Catastrophic	Major	Medium	Minor	Insignificant
Almost Certain	Very High	Very High	Very High	High	Mod or Low
Likely	Very High	Very High	High	Moderate	Low
Possible	Very High	High	Moderate	Moderate	Very Low
Unlikely	High	Moderate	Low	Low	Very Low
Rare	Moderate	Low	Low	Very Low	Very Low
Barely Credible	Low	Very Low	Very Low	Very Low	Very Low

Table 7 (continued). Risks to groundwater and the Montagu River arising from the proposed quarrying operations, before and after suggested treatment (management).

		Before treatment (management)				After treatment (management)		
	1	2	3	4		2	3	4
	Issues	Likelihood of occurrence	Consequence of occurrence	Level of risk of occurrence	Suggested risk treatments	Likelihood of occurrence	Consequence of occurrence	Level of risk of occurrence
	Elements at risk = local scale groundwater in fractured hard rocks beneath the site, and the Montagu River							
2a	Blasting and quarrying occur below the seasonally-high water table; dewatering occurs. **Effect on groundwater quality**	Groundwater contamination Almost Certain but only in immediate vicinity of quarry	Minor. See also comments in 1 above re cause and effect.	High	As for Issue 1	Groundwater contamination Likely but only in immediate vicinity of quarry	Minor	Moderate
2b	Blasting and quarrying occur below the seasonally-high water table; dewatering occurs. **Effect on groundwater flow directions**	Modified flow directions Almost Certain, but only in immediate vicinity of quarry	Insignificant	Low	Monitor groundwater levels in the two new monitoring bores proposed for Issue 1 (and in BH1 and the Owner's bore)	Modified flow directions Almost Certain, but only in immediate vicinity of quarry	Insignificant	
2c	Blasting and quarrying occur below the seasonally-high water table; dewatering occurs and groundwater is discharged to surface near quarry. **Effect on water quality in Montagu River**	Effect on river water quality Likely	Medium to Major depending on river flow	High to Very High	As for Issue 1. Also, throughout mining, pump all water from the operating pit to *Pivot* irrigation on the Owner's land, under an existing agreement. (No pit water discharges directly from the pit overland to the Montagu River)	Rare	Medium to Major depending on river flow	Low

The hydrogeological model (Attachment 2) for this site is: a dolomite quarry up to about 5m deep covering between 2 and 4 ha (at end of life) on flat ground 500m from a high conservation level river. The water table fluctuates between 1mbg and 4mbg, and its hydraulic gradient presumably towards the river is less than 1:1000. The area is an aquatic groundwater dependent ecosystem of high potential. Subsurface karst features may be present and the subterranean GDE is of low potential. ANFO explosives will be used in quarrying.

Table 7 (continued). Risks to groundwater and the Montagu River arising from the proposed quarrying operations, before and after suggested treatment (management).

		Before treatment				After treatment		
	1	2	3	4		2	3	4
	Issues	Likelihood of occurrence	Consequence of occurrence	Level of risk of occurrence	Suggested risk treatments	Likelihood of occurrence	Consequence of occurrence	Level of risk of occurrence
	Elements at risk = local scale groundwater in fractured hard rocks beneath the site, and the Montagu River							
3	Blasting and quarrying occur below the seasonally-high water table; dewatering occurs and groundwater is discharged to surface near quarry. **Effect on karst features and accompanying biota**	Possible	Minor to Major	Moderate to High	As for Issue 2c. Operate quarry with the accompanying Karst Management Plan.	Unlikely	Minor	Low
4	Blasting and quarrying occur below the seasonally-high water table; dewatering occurs and groundwater is discharged to surface near quarry. **Effect of fuel spillages on groundwater**	Likely	Minor	Moderate	As for Issue 2c. Develop and operate with Spill Management Plan. Include daily visual inspection of quarry floor, regular maintenance of plant and equipment, use proper fuel transfer procedures, have spill response kits and containment materials on site, use adequate fuel storages (in vehicles only); train staff adequately; adopt proper waste disposal techniques; include emergency contact numbers	Possible	Minor	Low

The hydrogeological model (Attachment 2) for this site is: a dolomite quarry up to about 5m deep covering between 2 and 4 ha (at end of life) on flat ground 500m from a high conservation level river. The water table fluctuates between 1mbg and 4mbg, and its hydraulic gradient presumably towards the river is less than 1:1000. The area is an aquatic groundwater dependent ecosystem of high potential. Subsurface karst features may be present and the subterranean GDE is of low potential. ANFO explosives will be used in quarrying.

Table 7 (continued). Risks to groundwater and the Montagu River arising from the proposed quarrying operations, before and after suggested treatment (management).

		Before treatment				**After treatment**		
	1	2	3	4		2	3	4
	Issues	Likelihood of occurrence	Consequence of occurrence	Level of risk of occurrence	Suggested risk treatments	Likelihood of occurrence	Consequence of occurrence	Level of risk of occurrence
	Elements at risk = local scale groundwater in fractured hard rocks beneath the site, and the Montagu River							
5	Blasting and quarrying occur below the seasonally-high water table; dewatering occurs and groundwater is discharged to surface near quarry. **Effect on groundwater dependent ecosystem.**	Unlikely. This is because groundwater contamination will be restricted to the immediate vicinity of the quarry (Issue 2a)	Minor	Low	Instigate all treatment suggestions in Issues 1 – 4.	Unlikely	Minor	Low

The hydrogeological model (Attachment 2) for this site is: a dolomite quarry up to about 5m deep covering between 2 and 4 ha (at end of life) on flat ground 500m from a high conservation level river. The water table fluctuates between 1mbg and 4mbg, and its hydraulic gradient presumably towards the river is less than 1:1000. The area is an aquatic groundwater dependent ecosystem of high potential. Subsurface karst features may be present and the subterranean GDE is of low potential. ANFO explosives will be used in quarrying.

Table 8. Groundwater and surface water management plan for the proposed dolomite quarry

	Item	**Comments**
Groundwater Management	Water table levels and groundwater flow direction	Install one "upgradient" and one "downgradient" groundwater monitoring bore at nominal locations (GDA94 329800mE, 5453000mN) and GDA94 330100mE, 54353600mN) in accord with national guidelines (NDULC, 2020). During operational periods, record groundwater levels monthly in both bores. Also record monthly water table levels in existing uncased bores BH1 and the Owner's bore.
	Quality	Prior to, and immediately after, each operational period, sample groundwater in both monitoring bores (using low flow, not *hydrasleeve* -type methods) and any water in the quarry, for pH, EC, Ca, Mg, SO4 and nutrients.
	Extraction	Record volume of surface/groundwater pumped from the quarry to landowner irrigation after pit dewatering prior to summer quarrying.
Montagu River	Water sampling	On the same dates as the groundwater sampling, sample Montagu River water upstream and downstream of quarrying operations

Table 9. Karst management plan for the proposed dolomite quarry

	Action	Comment
1	**Stop Quarrying Operations**	As soon as a karst feature (any sized opening in bedrock thought not to be caused by blasting or excavation) is discovered, quarrying operations in the immediate vicinity should be stopped to prevent further damage to the feature and ensure the safety of personnel. Isolate the feature; if appropriate and safe to do so, continue quarrying elsewhere in the excavation while the karst feature is assessed.
2	**Consult Experts**	Engage experts to evaluate the karst feature and recommend appropriate mitigation measures. Expert investigations might include visual inspections, geological mapping, and geotechnical, and/or geophysical investigations. Geotechnical techniques might include Ground Penetrating Radar, Resistivity, etc. Expert reports may be generated, and authorities notified.
3	**Develop a Mitigation Plan**	Based on expert recommendations, develop a mitigation plan considering the stability of the karst feature, the potential impacts on quarrying operations and (following expert advice) the significance and management of any contained biota.
4	**Implement Protective Measures**	Subject to expert advice, protect and stabilize the karst feature. This may involve (but not necessarily be restricted to) techniques such as: a. physical barriers such as fencing or barricades, to prevent accidental intrusion or damage to the karst feature. b. reinforcement: stabilization techniques such as grouting or injection of stabilizing materials, to reinforce the structure of the karst feature and prevent further deterioration. c. redesigning the quarry layout: modify the quarry layout and excavation plans to avoid or minimize direct interaction with the karst feature. Consider adjusting the blasting patterns, excavation boundaries, or quarry footprint. d. monitoring: based on expert advice, consider installing monitoring equipment, such as inclinometers, piezometers, or strain gauges, to continuously monitor the stability of the karst feature and detect any changes or movements.
5	**Regular Monitoring and Evaluation**	Subject to expert advice, conduct regular monitoring of the karst feature and its surroundings to ensure that the implemented mitigation measures are effective and that no further damage or instability is occurring. Monitoring data should be regularly reviewed and analyzed by experts to assess the ongoing stability of the feature.
6	**Adapt and Modify**	If monitoring indicates any unexpected changes or potential risks, modify subject to expert advice this karst management plan and implement additional measures as needed to address any emerging issues.

4 CONCLUSIONS

This hydrogeological assessment for the proposed dolomite quarry concludes:

- the quarry site within mining lease 2115P/M is on almost-flat ground about 0.5km south of the Montagu River,
- the river integrated conservation value of the Montagu River passing mining lease 2115P/M is *High* and it has a *Very High* classification for its immediate and potential *Conservation Management Priority,*
- this section of the river is an artificial drain about 5m wide and less than 0.5m deep, with dolomite exposed in parts of its floor,
- dolomite is patchily exposed at the quarry site, and shallowly buried under less than 0.5m of dark-coloured high organic content soil,
- the dolomite exposed at the surface is high-strength, with sealed fractures; it is unclear whether sealed fractures continue at depth
- there is no surface evidence of karst features (eg sinkholes) at and near the quarry site (this contrasts with areas near the Rapid River Road – Donalds Road intersection several kilometres to the east, where sinkholes are common),
- evidence of a karst feature closer to the Cresswell site is the dry gravel-filled cavity at a depth of 4 – 5mbg in the Owner's bore drilled in November 2023 about 300m northeast of the existing trial pit; it would be judicious to assume that karstic features occur at the quarry site,
- measured water table depths in the immediate area were 4mbg and 1.2mbg in bore BH1 on 1 May and 14 November 2023 respectively, and 4mbg in the Owner's bore on 14 November 2023; these depths are below the level of water in the Montagu River, so local-scale groundwater flow towards the river was not occurring on those two dates, and may occur only rarely or not at all,
- the almost-3m difference in water table depth between BH1 and the Owner's bore on 14 November 2023 suggests no direct hydraulic connection between them, which in turn supports the inference that sections of the bedrock are impermeable and act as local confining zones,
- short-term, seasonal and annual water table variability in the immediate vicinity of the Cresswell site is unknown (it may be several metres), and the water table depth elsewhere has not been established, and,
- local-scale groundwater flow directions in the vicinity of the proposed quarry and Montagu River are uncertain, and may fluctuate with changing water table conditions;
- the area has been assigned as an aquatic surface-based groundwater dependent ecosystem of high potential, but the assessment by the Bureau of Meteorology was done at national level; local groundwater conditions remain unclear and do not necessarily support this assessment
- with a reported nominal depth of five metres, excavation in the quarry is likely to extend below the seasonally-high water table,
- explosives will be used to facilitate excavation,

- ANFO has been used for blasting in a recent 1000t bulk sample excavation at the site; after blasting and bulk sampling, surface water possibly combined with groundwater accumulated in the pit, and when sampled on 1 May 2023 and subsequently laboratory-tested, showed elevated ammonia and nitrate, pH, electrical conductivity, calcium, magnesium and sulfate; these analytes were at considerably reduced levels when resampled in November 2023 when the pit was full of rain runoff/groundwater

- quarrying will be confined to November to April, and it is likely the pit will contain pre-mining accumulated groundwater and probably surface runoff which will need to be removed before operations start,

- during operations the rate of groundwater inflow to the quarry will be variable and unpredictable, and depending on inflow rates, dewatering may be required, and

- Cresswells Transport Pty Ltd and the landowner have entered into a Compensation Agreement enforceable under ML2115P/M whereby for the duration of mining the landowner has agreed to take all water from the pit for his irrigation system.

A groundwater management plan is recommended to mitigate the risks to groundwater and the Montagu River.

A karst management plan is recommended to mitigate the risks to karstic features which might be affected by quarrying.

5 RECOMMENDATION

From a hydrogeological perspective, the proposed dolomite quarry should proceed subject to the recommended groundwater and karst management plans..

6 REFERENCES

EPA (2022). *Extractive Industry Environmental Effects Report Guidelines Cresswells Transport Pty Ltd Donalds Road Quarry, Roger River.* Environment Protection Authority, Tasmania, November 2022.

Everard, J. L., Seymour, D. B., Reed, A. R., McClenaghan, M. P., Green, D. C. and Calver, C. R. (2007). *Regional geology of the Southern Smithton Synclinorium. Explanatory Report for the Roger, Sumac and Dempster 1:25,000 scale geological map sheets, far northwestern Tasmania.* 1:25 000 Scale Digital Geological Map Series – Explanatory Report 2 – Mineral Resources Tasmania

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Hocking, M., Bastick, C., Hardie, M, Dyson, P and Lynch, S. (2005). *Understanding Groundwater Flow Systems and processes causing salinity in the Southern Midlands and Clarence Municipalities.* NRM South and North and National Action Plan for Salinity and Water Quality Tasmania Report, published by Southern Midlands Council, 2005.

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Attachment 1

(11 pages including this page)

May 2023 surface water and groundwater laboratory reports

Australian Laboratory Services (ALS) Report EM2307758
Sample Receipt Notification (3 pages)
Certificate of Analysis (COA; 7 pages)

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EM2307758**		
Client	: **WILLIAM C CROMER PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BILL CROMER	Contact	: Shirley LeCornu
Address	: 74A CHANNEL HIGHWAY TAROONA TASMANIA 7053	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: billcromer@bigpond.com	E-mail	: shirley.lecornu@Alsglobal.com
Telephone	: 03 6227 8970	Telephone	: +6138549 9630
Facsimile	: ----	Facsimile	: +61-3-8549 9626
Project	: CRESSWELL	Page	: 1 of 3
Order number	: CRESSWELL (EVENT 20230501)	Quote number	: EM2017WILCRO0001 (EN/222)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: WC		

Dates

Date Samples Received	: 04-May-2023 11:20	Issue Date	: 04-May-2023
Client Requested Due Date	: 11-May-2023	Scheduled Reporting Date	: **11-May-2023**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 7.5°C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 5 / 5

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please direct any queries related to sample condition / numbering / breakages to Client Services.**
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **Analytical work for this work order will be conducted at ALS Springvale.**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The laboratory will process these samples unless instructions are received from you indicating you do not wish to proceed. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.

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Issue Date	:	04-May-2023
Page	:	2 of 3
Work Order	:	EM2307758 Amendment 0
Client	:	WILLIAM C CROMER PTY LTD

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method *Sample ID*	Sample Container Received	Preferred Sample Container for Analysis
Dissolved Mercury by FIMS : EG035F		
BH1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
MONTAGU RIVER	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
PIT WATER	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
POND	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite A : EG020A-F		
BH1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
MONTAGU RIVER	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
PIT WATER	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
POND	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
Major Cations - Dissolved : ED093F		
BH1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
MONTAGU RIVER	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
PIT WATER	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
POND	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EN67-B02 Field Tests (performed by external sampler)	WATER - EP026SP Chemical Oxygen Demand (COD)	WATER - NT-14 Extended Water Suite B	WATER - W-04 TRH/BTEXN	WATER - W-18 TRH(C6 - C9)/BTEXN	WATER - W-30 11 Metals	WATER - W-30T 11 Metals (Total)
EM2307758-001	01-May-2023 11:40	BH1	✓	✓	✓	✓		✓	✓
EM2307758-002	01-May-2023 09:10	MONTAGU RIVER	✓	✓	✓	✓		✓	✓
EM2307758-003	01-May-2023 10:20	PIT WATER	✓	✓	✓	✓		✓	✓
EM2307758-004	01-May-2023 10:30	POND	✓	✓	✓	✓		✓	✓
EM2307758-005	01-May-2023 00:00	Trip Blank					✓		

Issue Date : 04-May-2023
Page : 3 of 3
Work Order : EM2307758 Amendment 0
Client : WILLIAM C CROMER PTY LTD

MONTAGU RIVER	Clear Plastic Bottle - Natural	----	01-May-2023	04-May-2023	✘	----	----
PIT WATER	Clear Plastic Bottle - Natural	----	01-May-2023	04-May-2023	✘	----	----
POND	Clear Plastic Bottle - Natural	----	01-May-2023	04-May-2023	✘	----	----
EK057G: Nitrite as N by Discrete Analyser							
BH1	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
MONTAGU RIVER	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
PIT WATER	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
POND	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
EK071G: Reactive Phosphorus as P-By Discrete Analyser							
BH1	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
MONTAGU RIVER	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
PIT WATER	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----
POND	Clear Plastic Bottle - Natural	----	03-May-2023	04-May-2023	✘	----	----

Requested Deliverables

BILL CROMER

- *AU Certificate of Analysis - NATA (COA)	Email	billcromer@bigpond.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	billcromer@bigpond.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	billcromer@bigpond.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	billcromer@bigpond.com
- A4 - AU Tax Invoice (INV)	Email	billcromer@bigpond.com
- Chain of Custody (CoC) (COC)	Email	billcromer@bigpond.com
- EDI Format - ENMRG (ENMRG)	Email	billcromer@bigpond.com

CERTIFICATE OF ANALYSIS

Work Order	: **EM2307758**	Page	: 1 of 7
Client	: **WILLIAM C CROMER PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BILL CROMER	Contact	: Shirley LeCornu
Address	: 74A CHANNEL HIGHWAY TAROONA TASMANIA 7053	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: 03 6227 8970	Telephone	: +6138549 9630
Project	: CRESSWELL	Date Samples Received	: 04-May-2023 11:20
Order number	: CRESSWELL (EVENT 20230501)	Date Analysis Commenced	: 04-May-2023
C-O-C number	: ----	Issue Date	: 09-May-2023 21:14
Sampler	: WC		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Arenie Vijayaratnam	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Dilani Fernando	Laboratory Coordinator	Melbourne Inorganics, Springvale, VIC
Eric Chau	Metals Team Leader	Melbourne Inorganics, Springvale, VIC
Jarwis Nheu	Non-Metals Team Leader	Melbourne Inorganics, Springvale, VIC
Nancy Wang	2IC Organic Chemist	Melbourne Organics, Springvale, VIC

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General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- As per QWI – EN55-3 Data Interpreting Procedures, Ionic balances are typically calculated using Major Anions - Chloride, Alkalinity and Sulfate; and Major Cations - Calcium, Magnesium, Potassium and Sodium. Where applicable and dependent upon sample matrix, the Ionic Balance may also include the additional contribution of Ammonia, Dissolved Metals by ICPMS and H+ to the Cations and Nitrate, SiO_2 and Fluoride to the Anions.
- It is recognised that total metals is less than dissolved metals for samples EM2307758 #3 However, the difference is within experimental variation of the methods.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Page : 3 of 7
Work Order : EM2307758
Client : WILLIAM C CROMER PTY LTD
Project : CRESSWELL

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	BH1	MONTAGU RIVER	PIT WATER	POND	Trip Blank
			Sampling date / time	01-May-2023 11:40	01-May-2023 09:10	01-May-2023 10:20	01-May-2023 10:30	01-May-2023 00:00
			Sample ID	EM2307758-001	EM2307758-002	EM2307758-003	EM2307758-004	EM2307758-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.83	6.40	7.59	7.04	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	0.48	1.27	0.51	0.67	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	904	194	1290	537	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	588	126	838	349	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	441	42	574	223	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	219	36	326	132	----
Total Alkalinity as CaCO3	----	1	mg/L	219	36	326	132	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	234	10	188	58	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	31	30	66	52	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	91	7	103	40	----
Magnesium	7439-95-4	1	mg/L	52	6	77	30	----
Sodium	7440-23-5	1	mg/L	23	19	28	23	----
Potassium	7440-09-7	1	mg/L	1	1	2	3	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.04	<0.01	<0.01	0.03	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L	0.006	<0.001	<0.001	0.001	----
Copper	7440-50-8	0.001	mg/L	0.012	<0.001	0.017	0.008	----
Nickel	7440-02-0	0.001	mg/L	0.025	0.001	0.008	0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L	0.023	<0.005	0.009	<0.005	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH1	MONTAGU RIVER	PIT WATER	POND	Trip Blank
			Sampling date / time	01-May-2023 11:40	01-May-2023 09:10	01-May-2023 10:20	01-May-2023 10:30	01-May-2023 00:00
Compound	CAS Number	LOR	Unit	EM2307758-001	EM2307758-002	EM2307758-003	EM2307758-004	EM2307758-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	0.13	0.06	<0.05	<0.05	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	12.1	0.13	0.10	6.18	----
Arsenic	7440-38-2	0.001	mg/L	0.025	<0.001	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	<0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L	0.060	<0.001	<0.001	0.015	----
Copper	7440-50-8	0.001	mg/L	0.076	0.002	0.020	0.014	----
Nickel	7440-02-0	0.001	mg/L	0.082	0.001	0.008	0.008	----
Lead	7439-92-1	0.001	mg/L	0.021	<0.001	<0.001	0.003	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L	0.182	<0.005	0.008	0.010	----
Iron	7439-89-6	0.05	mg/L	75.3	0.28	0.10	1.08	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.11	0.03	18.5	0.92	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	0.09	<0.01	1.32	0.68	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	0.65	0.05	26.5	1.90	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	0.74	0.05	27.8	2.58	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	4.2	0.3	19.1	3.3	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	4.9	0.4	46.9	5.9	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.63	0.03	0.06	0.17	----
EK071G: Reactive Phosphorus as P by discrete analyser								

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	BH1	MONTAGU RIVER	PIT WATER	POND	Trip Blank
			Sampling date / time	01-May-2023 11:40	01-May-2023 09:10	01-May-2023 10:20	01-May-2023 10:30	01-May-2023 00:00
			Sample ID	EM2307758-001	EM2307758-002	EM2307758-003	EM2307758-004	EM2307758-005
				Result	Result	Result	Result	Result
EK071G: Reactive Phosphorus as P by discrete analyser - Continued								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**10.1**	**1.77**	**12.3**	**5.31**	----
ø Total Cations	----	0.01	meq/L	**9.85**	**1.70**	**12.7**	**5.54**	----
ø Ionic Balance	----	0.01	%	**1.38**	----	**1.82**	**2.12**	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)								
Chemical Oxygen Demand	----	10	mg/L	**318**	<10	**37**	**132**	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	----
C15 - C28 Fraction	----	100	µg/L	**150**	<100	<100	<100	----
C29 - C36 Fraction	----	50	µg/L	**320**	<50	<50	<50	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	**470**	<50	<50	<50	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	----
>C16 - C34 Fraction	----	100	µg/L	**410**	<100	<100	<100	----
>C34 - C40 Fraction	----	100	µg/L	**200**	<100	<100	<100	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	**610**	<100	<100	<100	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**105**	**106**	**105**	**106**	**109**

Page : 6 of 7
Work Order : EM2307758
Client : WILLIAM C CROMER PTY LTD
Project : CRESSWELL

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH1	MONTAGU RIVER	PIT WATER	POND	Trip Blank
			Sampling date / time	01-May-2023 11:40	01-May-2023 09:10	01-May-2023 10:20	01-May-2023 10:30	01-May-2023 00:00
Compound	CAS Number	LOR	Unit	EM2307758-001	EM2307758-002	EM2307758-003	EM2307758-004	EM2307758-005
				Result	Result	Result	Result	Result
EP080S: TPH(V)/BTEX Surrogates - Continued								
Toluene-D8	2037-26-5	2	%	**99.1**	**97.0**	**99.8**	**101**	**102**
4-Bromofluorobenzene	460-00-4	2	%	**100**	**99.1**	**103**	**101**	**104**

Work Order : EM2307758
Client : WILLIAM C CROMER PTY LTD
Project : CRESSWELL

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	*CAS Number*	*Recovery Limits (%)* Low	*Recovery Limits (%)* High
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	73	129
Toluene-D8	2037-26-5	70	125
4-Bromofluorobenzene	460-00-4	71	129

Attachment 2

(11 pages including this page)

November 2023 surface water and groundwater laboratory reports

Australian Laboratory Services (ALS) Report EM2320557
Sample Receipt Notification (3 pages)
Certificate of Analysis (COA; 7 pages)

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EM2320557**		
Client	: **WILLIAM C CROMER PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BILL CROMER	Contact	: Shirley LeCornu
Address	: 74A CHANNEL HIGHWAY TAROONA TASMANIA 7053	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: billcromer@bigpond.com	E-mail	: shirley.lecornu@Alsglobal.com
Telephone	: 03 6227 8970	Telephone	: +6138549 9630
Facsimile	: ----	Facsimile	: +61-3-8549 9626
Project	: CRESSWELL	Page	: 1 of 3
Order number	: CRESSWELL#2 (EVENT 20231114)	Quote number	: EM2017WILCRO0001 (EN/222)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: ES&D (Maja)		

Dates

Date Samples Received	: 17-Nov-2023 11:17	Issue Date	: 18-Nov-2023
Client Requested Due Date	: 24-Nov-2023	Scheduled Reporting Date	: **24-Nov-2023**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 7.0°C - Ice Bricks present
Receipt Detail	:	No. of samples received / analysed	: 5 / 4

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please direct any queries related to sample condition / numbering / breakages to Client Services.**
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **Analytical work for this work order will be conducted at ALS Springvale.**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The laboratory will process these samples unless instructions are received from you indicating you do not wish to proceed. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.

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Issue Date	: 18-Nov-2023
Page	: 2 of 3
Work Order	: EM2320557 Amendment 0
Client	: WILLIAM C CROMER PTY LTD

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method *Sample ID*	Sample Container Received	Preferred Sample Container for Analysis
Dissolved Mercury by FIMS : EG035F		
Monitoring Bore	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
BH1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite A : EG020A-F		
Monitoring Bore	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
BH1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
Major Cations - Dissolved : ED093F		
Monitoring Bore	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
BH1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
Total Mercury by FIMS : EG035T		
Monitoring Bore	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Unfiltered
Total Metals by ICP-MS - Suite A : EG020A-T		
Monitoring Bore	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Unfiltered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	(On Hold) WATER No analysis requested	WATER - EP026SP Chemical Oxygen Demand (COD)	WATER - NT-14 Extended Water Suite B	WATER - W-04 TRH/BTEXN	WATER - W-30 11 Metals	WATER - W-30T 11 Metals (Total)
EM2320557-001	14-Nov-2023 13:00	Monitoring Bore		✓	✓	✓	✓	✓
EM2320557-002	14-Nov-2023 16:00	Montagu River		✓	✓	✓	✓	✓
EM2320557-003	14-Nov-2023 13:30	Bulk Sample Pit		✓	✓	✓	✓	✓
EM2320557-004	14-Nov-2023 15:00	BH1		✓	✓	✓	✓	✓
EM2320557-005	14-Nov-2023 16:00	FD2	✓					

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Client Sample ID(s)	Container	Due for extraction	Due for analysis	Samples Received Date	Samples Received Evaluation	Instructions Received Date	Instructions Received Evaluation
EA005-P: pH by Auto Titrator							
BH1	Clear Plastic Bottle - Natural	----	14-Nov-2023	17-Nov-2023	×	----	----
Bulk Sample Pit	Clear Plastic Bottle - Natural	----	14-Nov-2023	17-Nov-2023	×	----	----
Monitoring Bore	Clear Plastic Bottle - Natural	----	14-Nov-2023	17-Nov-2023	×	----	----
Montagu River	Clear Plastic Bottle - Natural	----	14-Nov-2023	17-Nov-2023	×	----	----
EK057G: Nitrite as N by Discrete Analyser							
BH1	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	×	----	----
Bulk Sample Pit	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	×	----	----

Issue Date : 18-Nov-2023
Page : 3 of 3
Work Order : EM2320557 Amendment 0
Client : WILLIAM C CROMER PTY LTD

Monitoring Bore	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	✘	----	----
Montagu River	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	✘	----	----
EK071G: Reactive Phosphorus as P-By Discrete Analyser							
BH1	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	✘	----	----
Bulk Sample Pit	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	✘	----	----
Monitoring Bore	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	✘	----	----
Montagu River	Clear Plastic Bottle - Natural	----	16-Nov-2023	17-Nov-2023	✘	----	----

Requested Deliverables

BILL CROMER

- *AU Certificate of Analysis - NATA (COA)	Email	billcromer@bigpond.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	billcromer@bigpond.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	billcromer@bigpond.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	billcromer@bigpond.com
- A4 - AU Tax Invoice (INV)	Email	billcromer@bigpond.com
- Chain of Custody (CoC) (COC)	Email	billcromer@bigpond.com
- EDI Format - ENMRG (ENMRG)	Email	billcromer@bigpond.com

CERTIFICATE OF ANALYSIS

Work Order	: **EM2320557**	Page	: 1 of 7
Client	: **WILLIAM C CROMER PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR BILL CROMER	Contact	: Shirley LeCornu
Address	: 74A CHANNEL HIGHWAY TAROONA TASMANIA 7053	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: 03 6227 8970	Telephone	: +6138549 9630
Project	: CRESSWELL	Date Samples Received	: 17-Nov-2023 11:17
Order number	: CRESSWELL#2 (EVENT 20231114)	Date Analysis Commenced	: 20-Nov-2023
C-O-C number	: ----	Issue Date	: 26-Nov-2023 23:19
Sampler	: ES&D (Maja)		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 5		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Laboratory Coordinator	Melbourne Inorganics, Springvale, VIC
Jarwis Nheu	Non-Metals Team Leader	Melbourne Inorganics, Springvale, VIC
Nancy Wang	2IC Organic Chemist	Melbourne Organics, Springvale, VIC
Xing Lin	Senior Organic Chemist	Melbourne Organics, Springvale, VIC

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General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- As per QWI – EN55-3 Data Interpreting Procedures, Ionic balances are typically calculated using Major Anions - Chloride, Alkalinity and Sulfate; and Major Cations - Calcium, Magnesium, Potassium and Sodium. Where applicable and dependent upon sample matrix, the Ionic Balance may also include the additional contribution of Ammonia, Dissolved Metals by ICPMS and H+ to the Cations and Nitrate, SiO2 and Fluoride to the Anions.
- EG020F: EM2320237#1 Poor matrix spike recovery for metals due to sample matrix. Confirmed by re-extraction and re-analysis.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.

Page : 3 of 7
Work Order : EM2320557
Client : WILLIAM C CROMER PTY LTD
Project : CRESSWELL

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	Monitoring Bore	Montagu River	Bulk Sample Pit	BH1	----
			Sampling date / time	14-Nov-2023 13:00	14-Nov-2023 16:00	14-Nov-2023 13:30	14-Nov-2023 15:00	----
Compound	CAS Number	LOR	Unit	EM2320557-001	EM2320557-002	EM2320557-003	EM2320557-004	----
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.74	6.49	7.38	6.82	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	0.76	1.44	0.59	0.72	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	778	154	413	438	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	506	100	268	285	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	406	33	196	208	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	440	25	154	160	----
Total Alkalinity as CaCO3	----	1	mg/L	440	25	154	160	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	63	4	18	26	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	45	29	33	36	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	82	5	39	37	----
Magnesium	7439-95-4	1	mg/L	49	5	24	28	----
Sodium	7440-23-5	1	mg/L	35	19	19	24	----
Potassium	7440-09-7	1	mg/L	1	1	3	2	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.06	0.03	0.29	----
Arsenic	7440-38-2	0.001	mg/L	0.005	<0.001	<0.001	0.002	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L	0.004	<0.001	<0.001	0.010	----

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	Monitoring Bore	Montagu River	Bulk Sample Pit	BH1	----
			Sampling date / time	14-Nov-2023 13:00	14-Nov-2023 16:00	14-Nov-2023 13:30	14-Nov-2023 15:00	----
			Sample ID	EM2320557-001	EM2320557-002	EM2320557-003	EM2320557-004	-----
				Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	0.007	<0.001	0.004	0.012	----
Nickel	7440-02-0	0.001	mg/L	0.022	<0.001	<0.001	0.024	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	0.009	----
Iron	7439-89-6	0.05	mg/L	<0.05	0.17	<0.05	1.55	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	24.2	0.34	0.06	13.4	----
Arsenic	7440-38-2	0.001	mg/L	0.036	<0.001	<0.001	0.006	----
Cadmium	7440-43-9	0.0001	mg/L	0.0017	<0.0001	<0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L	0.152	0.001	<0.001	0.056	----
Copper	7440-50-8	0.001	mg/L	0.248	0.002	0.004	0.037	----
Nickel	7440-02-0	0.001	mg/L	0.505	0.002	<0.001	0.056	----
Lead	7439-92-1	0.001	mg/L	0.101	<0.001	<0.001	0.015	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L	0.632	<0.005	<0.005	0.040	----
Iron	7439-89-6	0.05	mg/L	53.5	0.64	<0.05	11.0	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	1.26	0.06	0.02	0.51	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.01	<0.01	----

Page : 5 of 7
Work Order : EM2320557
Client : WILLIAM C CROMER PTY LTD
Project : CRESSWELL

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	Monitoring Bore	Montagu River	Bulk Sample Pit	BH1	----
			Sampling date / time	14-Nov-2023 13:00	14-Nov-2023 16:00	14-Nov-2023 13:30	14-Nov-2023 15:00	----
				EM2320557-001	EM2320557-002	EM2320557-003	EM2320557-004	-----
				Result	Result	Result	Result	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.03	2.17	0.11	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.03	2.18	0.11	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	4.3	0.2	0.7	4.1	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	4.3	0.2	2.9	4.2	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	1.47	0.01	<0.01	0.22	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	11.4	1.40	4.38	4.75	----
ø Total Cations	----	0.01	meq/L	9.67	1.51	4.82	5.24	----
ø Ionic Balance	----	0.01	%	8.08	3.85	4.80	4.92	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)								
Chemical Oxygen Demand	----	10	mg/L	282	117	39	368	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	----
C15 - C28 Fraction	----	100	µg/L	120	<100	<100	110	----
C29 - C36 Fraction	----	50	µg/L	190	<50	<50	120	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	310	<50	<50	230	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	----

Page : 6 of 7
Work Order : EM2320557
Client : WILLIAM C CROMER PTY LTD
Project : CRESSWELL

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	Monitoring Bore	Montagu River	Bulk Sample Pit	BH1	----
			Sampling date / time	14-Nov-2023 13:00	14-Nov-2023 16:00	14-Nov-2023 13:30	14-Nov-2023 15:00	----
Compound	CAS Number	LOR	Unit	EM2320557-001	EM2320557-002	EM2320557-003	EM2320557-004	----
				Result	Result	Result	Result	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
>C16 - C34 Fraction	----	100	µg/L	**260**	<100	<100	**200**	----
>C34 - C40 Fraction	----	100	µg/L	**160**	<100	<100	<100	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	**420**	<100	<100	**200**	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**111**	**109**	**110**	**112**	----
Toluene-D8	2037-26-5	2	%	**104**	**106**	**102**	**103**	----
4-Bromofluorobenzene	460-00-4	2	%	**106**	**109**	**105**	**105**	----

Surrogate Control Limits

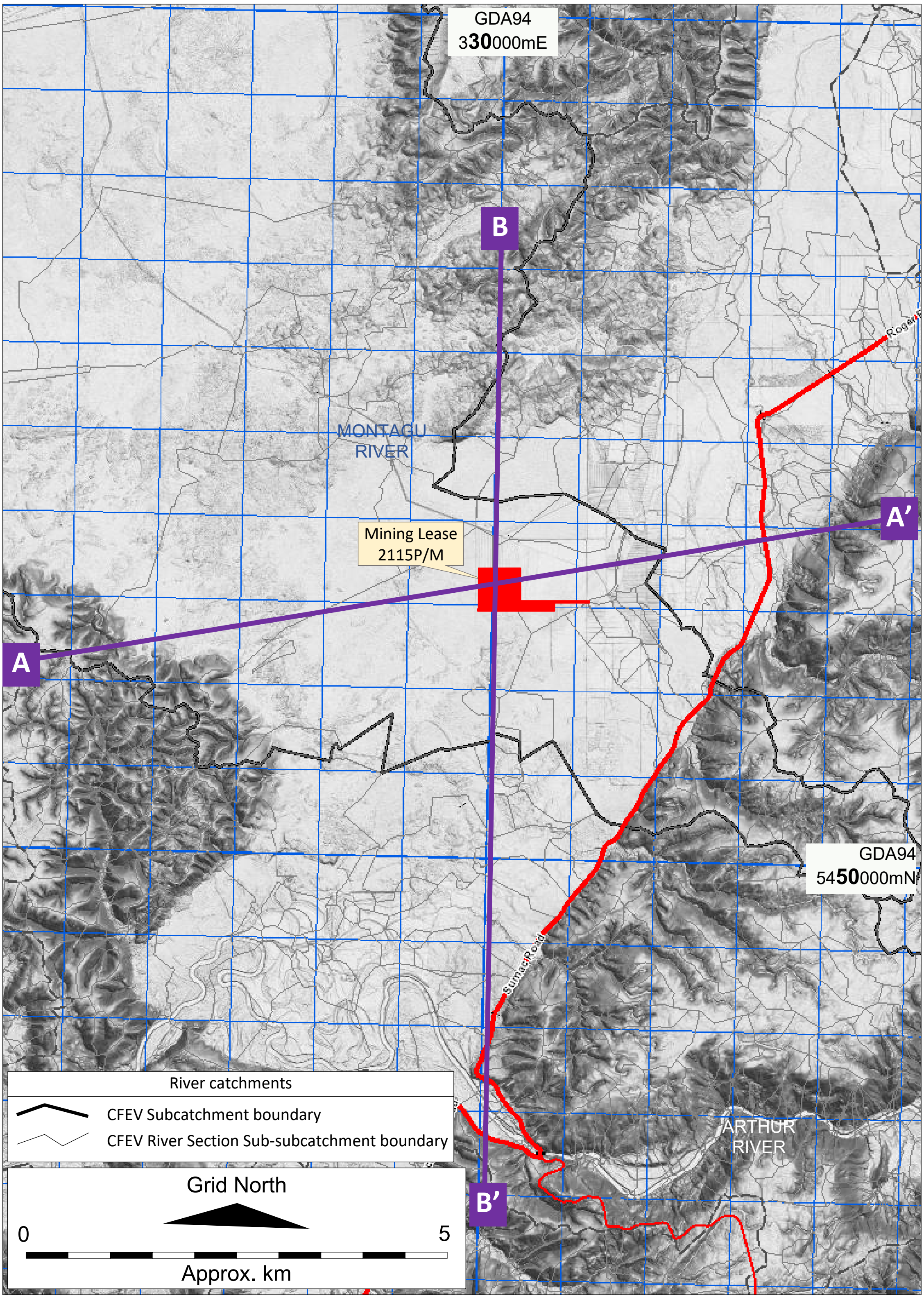
Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	73	129
Toluene-D8	2037-26-5	70	125
4-Bromofluorobenzene	460-00-4	71	129

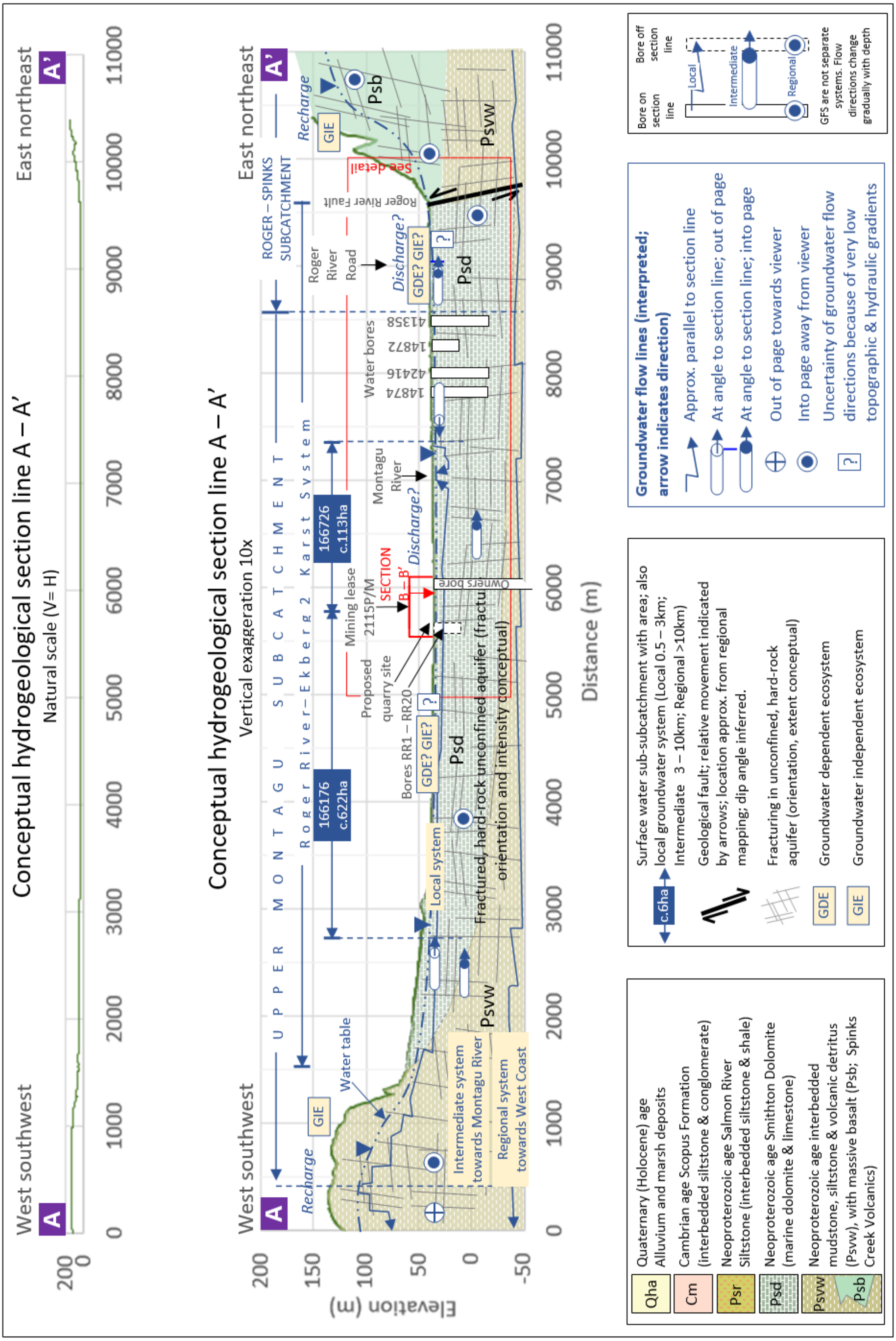
Attachment 3

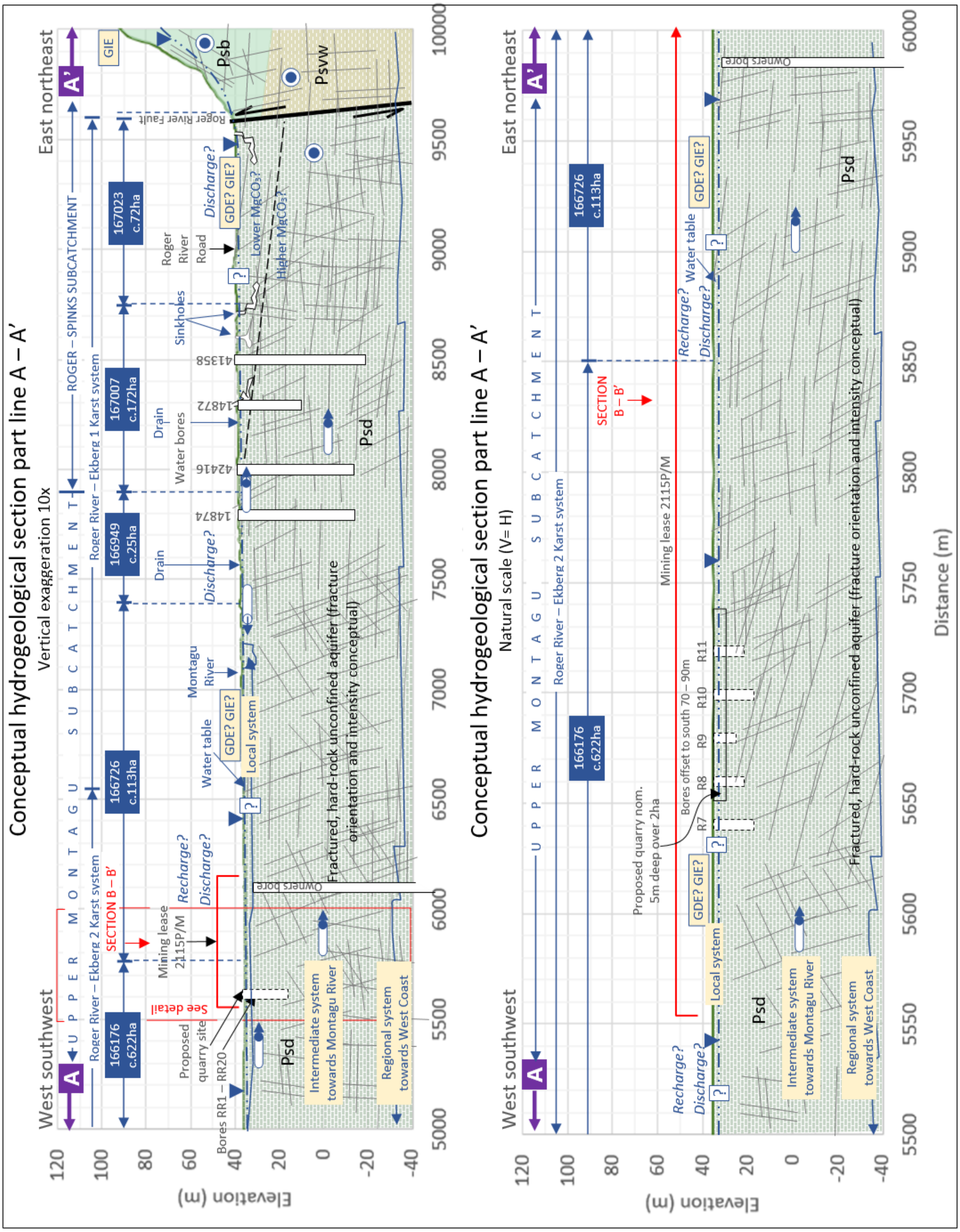
(6 pages including this page)

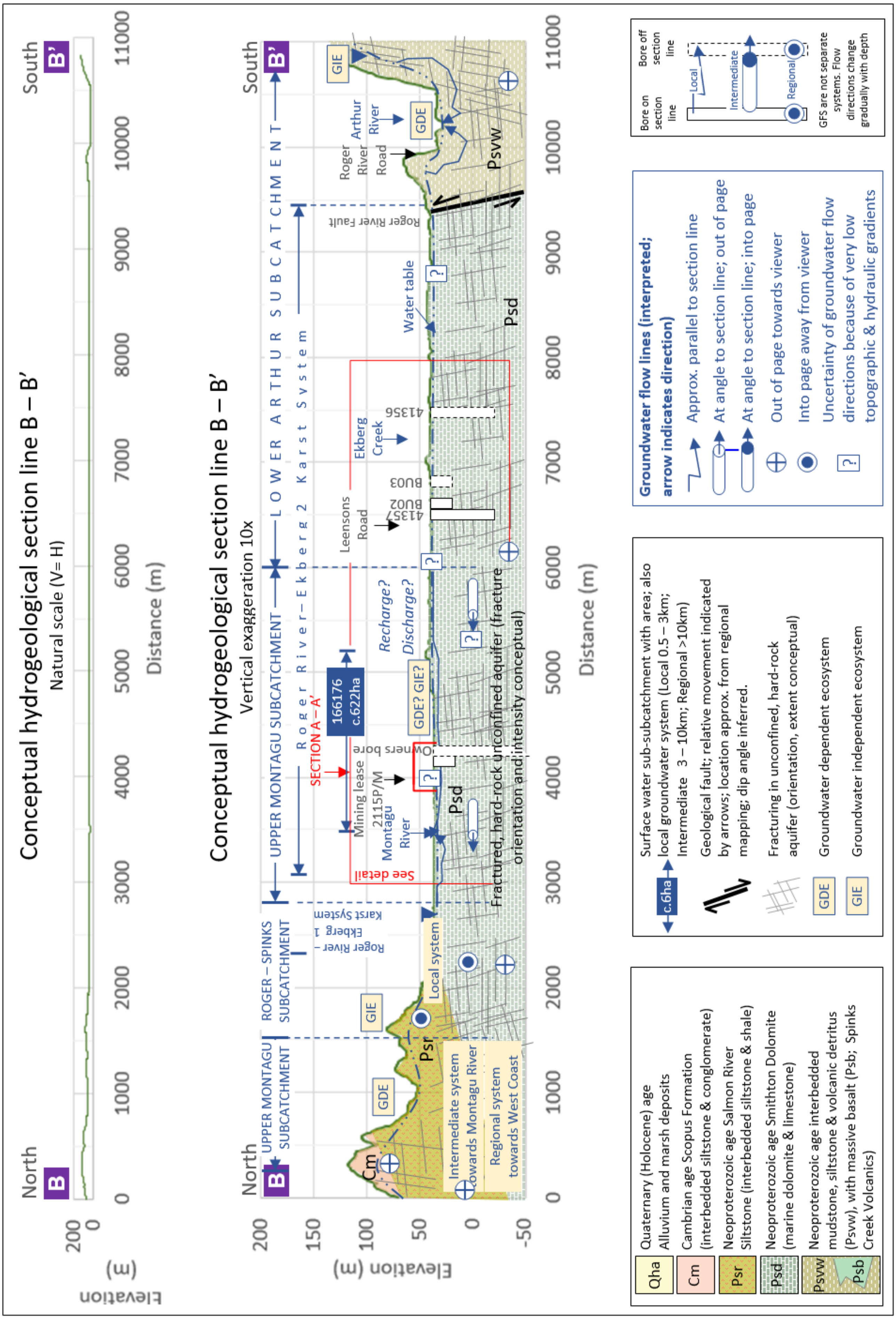
Conceptual hydrogeological models (cross sections A – A' and B – B')

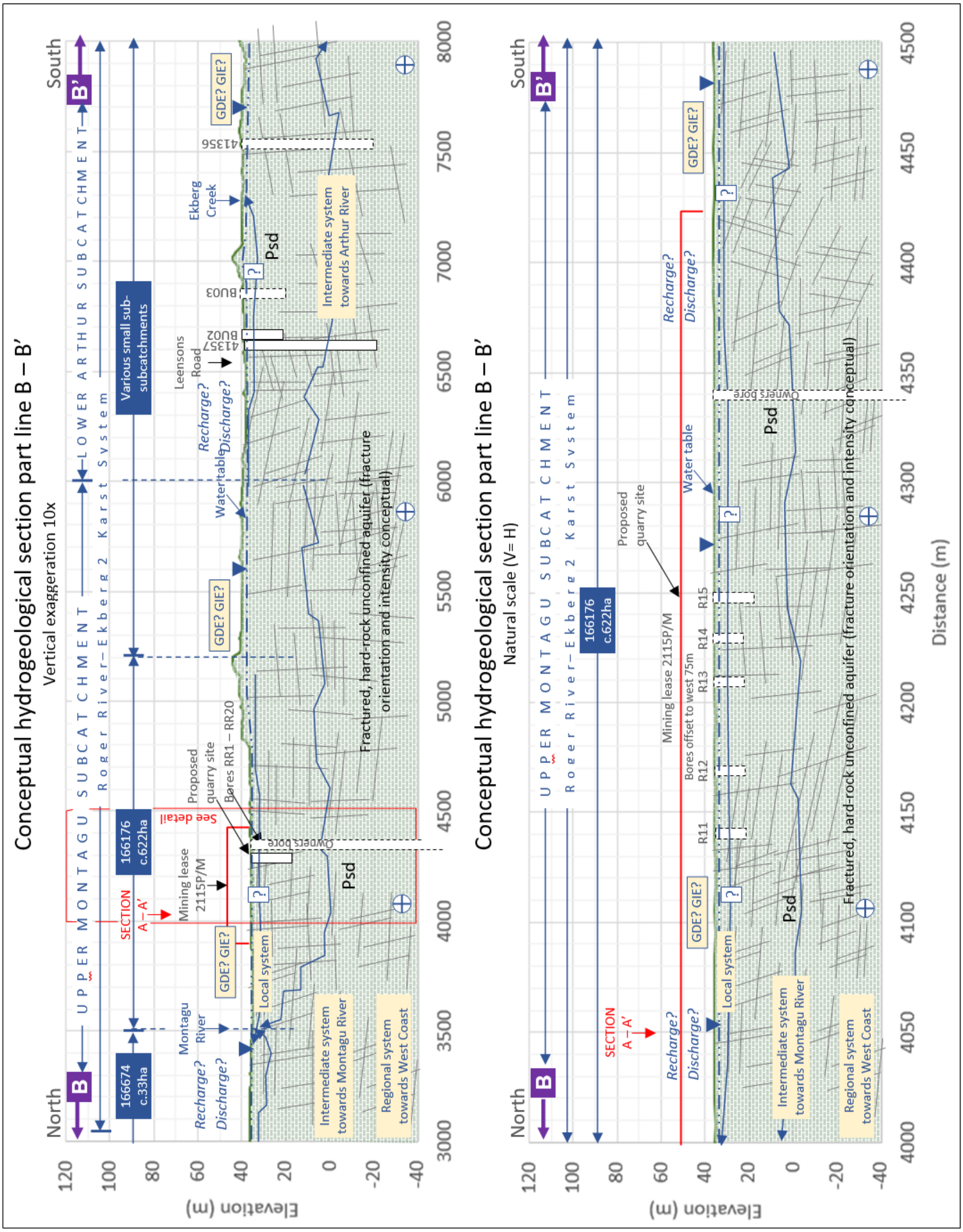
The locations of the two section lines are shown on the hillshade image on the following page, and also on various other maps in the report. Section line A – A' is aligned WSW – ENE (not west-east and not orthogonal to line B – B') to include elevated ground at both ends within a 10km length, and also karst features in the Smithton Dolomite near the Roger River Road-Donalds Road intersection.


GDA94
330000mE
B
MONTAGU
RIVER
Mining Lease
2115P/M
A'
A
GDA94
5450000mN
Sumac Road
River catchments
CFEV Subcatchment boundary
CFEV River Section Sub-subcatchment boundary
ARTHUR
RIVER
B'
Grid North
0
5
Approx. km


Conceptual hydrogeological section line A – A'
Natural scale (V= H)
West southwest
East northeast
A
A'
Conceptual hydrogeological section line A – A'
Vertical exaggeration 10x
Elevation (m)
Distance (m)
U P P E R M O N T A G U S U B C A T C H M E N T
Roger River – Ekberg 2 Karst System
ROGER – SPINKS SUBCATCHMENT
Recharge
GIE
Water table
166176 c.622ha
166726 c.113ha
Local system
Intermediate system towards Montagu River
Regional system towards West Coast
Fractured, hard-rock unconfined aquifer (fracture orientation and intensity conceptual)
GDE? GIE?
Bores RR1 – RR20
Proposed quarry site
Mining lease 2115P/M
SECTION B – B'
Owners bore
Discharge?
Montagu River
Water bores
14874
42416
14872
41358
Roger River Road
Roger River Fault
See detail
Psd
Psvw
Psb
Quaternary (Holocene) age Alluvium and marsh deposits
Cambrian age Scopus Formation (interbedded siltstone & conglomerate)
Neoproterozoic age Salmon River Siltstone (interbedded siltstone & shale)
Neoproterozoic age Smithton Dolomite (marine dolomite & limestone)
Neoproterozoic age interbedded mudstone, siltstone & volcanic detritus (Psvw), with massive basalt (Psb; Spinks Creek Volcanics)
Qha
Cm
Psr
c.6ha
Surface water sub-subcatchment with area; also local groundwater system (Local 0.5 – 3km; Intermediate 3 – 10km; Regional >10km)
Geological fault; relative movement indicated by arrows; location approx. from regional mapping; dip angle inferred.
Fracturing in unconfined, hard-rock aquifer (orientation, extent conceptual)
GDE
Groundwater dependent ecosystem
Groundwater independent ecosystem
Groundwater flow lines (interpreted; arrow indicates direction)
Approx. parallel to section line
At angle to section line; out of page
At angle to section line; into page
Out of page towards viewer
Into page away from viewer
Uncertainty of groundwater flow directions because of very low topographic & hydraulic gradients
Bore on section line
Bore off section line
Local
Intermediate
Regional
GFS are not separate systems. Flow directions change gradually with depth


Conceptual hydrogeological section part line A – A'
Vertical exaggeration 10x
West southwest
East northeast
UPPER MONTAGU SUBCATCHMENT
ROGER – SPINKS SUBCATCHMENT
Roger River – Ekberg 2 Karst system
Roger River – Ekberg 1 Karst system
166176 c.622ha
166726 c.113ha
166949 c.25ha
167007 c.172ha
167023 c.72ha
SECTION B – B'
Mining lease 2115P/M
See detail
Proposed quarry site
Bores RR1 – RR20
Recharge?
Discharge?
Water table
GDE? GIE?
Local system
Montagu River
Drain
Water bores
Sinkholes
Roger River Road
Lower MgCO₃?
Higher MgCO₃?
Roger River Fault
GIE
Psb
Psvw
Psd
Owners bore
14874
42416
14872
41358
Fractured, hard-rock unconfined aquifer (fracture orientation and intensity conceptual)
Intermediate system towards Montagu River
Regional system towards West Coast
Elevation (m)
Conceptual hydrogeological section part line A – A'
Natural scale (V= H)
Proposed quarry nom. 5m deep over 2ha
Bores offset to south 70 – 90m
R7
R8
R9
R10
R11
Mining lease 2115P/M
Distance (m)


Conceptual hydrogeological section line B – B'
Natural scale (V= H)
North
South
B
B'
Elevation (m)
Distance (m)
Conceptual hydrogeological section line B – B'
Vertical exaggeration 10x
UPPER MONTAGU SUBCATCHMENT
ROGER – SPINKS SUBCATCHMENT
UPPER MONTAGU SUBCATCHMENT
LOWER ARTHUR SUBCATCHMENT
Roger River – Ekberg 1 Karst System
Roger River – Ekberg 2 Karst System
SECTION A – A'
166176 c.622ha
Mining lease 2115P/M
Montagu River
See detail
Owners bore
Recharge?
Discharge?
GDE? GIE?
Leensons Road
41357
BU02
BU03
Ekberg Creek
41356
Water table
Roger River Fault
Roger River Road
Arthur River
GDE
GIE
Psr
Cm
Psd
Psvw
Local system
Intermediate system towards Montagu River
Regional system towards West Coast
Fractured, hard-rock unconfined aquifer (fracture orientation and intensity conceptual)
Qha
Quaternary (Holocene) age Alluvium and marsh deposits
Cm
Cambrian age Scopus Formation (interbedded siltstone & conglomerate)
Psr
Neoproterozoic age Salmon River Siltstone (interbedded siltstone & shale)
Psd
Neoproterozoic age Smithton Dolomite (marine dolomite & limestone)
Psvw
Psb
Neoproterozoic age interbedded mudstone, siltstone & volcanic detritus (Psvw), with massive basalt (Psb; Spinks Creek Volcanics)
c.6ha
Surface water sub-subcatchment with area; also local groundwater system (Local 0.5 – 3km; Intermediate 3 – 10km; Regional >10km)
Geological fault; relative movement indicated by arrows; location approx. from regional mapping; dip angle inferred.
Fracturing in unconfined, hard-rock aquifer (orientation, extent conceptual)
Groundwater dependent ecosystem
Groundwater independent ecosystem
Groundwater flow lines (interpreted; arrow indicates direction)
Approx. parallel to section line
At angle to section line; out of page
At angle to section line; into page
Out of page towards viewer
Into page away from viewer
Uncertainty of groundwater flow directions because of very low topographic & hydraulic gradients
Bore on section line
Bore off section line
Local
Intermediate
Regional
GFS are not separate systems. Flow directions change gradually with depth


Conceptual hydrogeological section part line B – B'
Vertical exaggeration 10x
North
South
B
B'
UPPER MONTAGU SUBCATCHMENT
LOWER ARTHUR SUBCATCHMENT
Roger River – Ekberg 2 Karst System
166674 c.33ha
166176 c.622ha
Various small sub-subcatchments
SECTION A – A'
Mining lease 2115P/M
Proposed quarry site
Bores RR1 – RR20
See detail
Owners bore
Montagu River
Leensons Road
Ekberg Creek
BU02
BU03
41357
41356
Recharge?
Discharge?
Water table
GDE? GIE?
Local system
Psd
Intermediate system towards Montagu River
Intermediate system towards Arthur River
Regional system towards West Coast
Fractured, hard-rock unconfined aquifer (fracture orientation and intensity conceptual)
Elevation (m)
Conceptual hydrogeological section part line B – B'
Natural scale (V= H)
Bores offset to west 75m
R11
R12
R13
R14
R15
Distance (m)