Hydrogeological Assessment

350 Rowlands Creek Road

Prepared for
Jim Glazebrook & Associates Pty Ltd

May 2018

DOCUMENT TRACKING

Item	Detail
Project Name	Rowlands Creek Hydrogeological Assessment
Project Number	9023
Project Manager	Thomas Neame
Prepared by	Lauren Stephens / Corneli van der Merwe
Reviewed by	Thomas Neame
Approved by	Johan du Plooy
Status	FINAL
Version Number	4
Last saved on	4 May 2018

This report should be cited as 'Eco Logical Australia (2018). *Rowlands Creek Hydrogeological Assessment*. Issued to Jim Glazebrook & Associates Pty Ltd on behalf of Jack Hallam.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Jim Glazebrook & Associates Pty Ltd, and Jack Hallam.

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Template 29/9/2015

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1 Introduction

Eco Logical Australia (ELA) was engaged by Jim Glazebrook & Associates Pty Ltd (JGA) to undertake a desktop study and hydrogeological assessment to assess the potential impacts associated with undertaking bulk groundwater production at Rowlands Creek, NSW, to supply water for commercial bottling. This includes potential impacts on the natural groundwater and surface water systems within the region, as well as existing groundwater users and receptors (including groundwater dependent ecosystems; GDEs). The assessment is required to support a Development Application, in addition to satisfying Clause 7.15 of the *Tweed Local Environmental Plan* (LEP) (2014), in regard to water bottling facilities.

Groundwater production is proposed from one groundwater bore (GW304537) located at Lot 3, DP815475 (No. 350) Rowlands Creek road, NSW, for commercial bottling of the produced water which will be undertaken offsite. The bore has a licenced annual extraction limit of 25 megalitres (ML), for both irrigation and industrial purposes. However, it is envisaged that a maximum of 24 ML of water will be extracted and bottled annually.

This report presents a summary of the findings from the desktop study of existing, publicly-available groundwater data within the region, the potential impacts identified and a preliminary risk assessment to identify the likelihood and consequence of the potential impacts occurring due to groundwater extraction. These findings have been assessed against the *NSW Aquifer Interference Policy* (AIP) (2012) and the *Water Management Act* 2000. The study also includes a field inspection and assessment of the proposed production bore and immediate area to support and confirm the information collated during the desktop study.

1.1 Background

1.1.1 Site area

The site (350 Rowlands Creek road, Lot 3 / DP815475) is located at the junction of Rowlands Creek road and Chowan Creek road, approximately 3.3 km south-east of Kyogle road at the village of Uki. The site is 4.65 ha in size, with approximately 150 m frontage along Rowlands Creek road and 240 m of frontage towards Chowan Creek road. The surrounding land use is predominantly rural, and used for cattle grazing and associated residences (JGA, 2017).

The site comprises two sheds (Shed 1 and Shed 2) located towards the north-eastern corner of the site boundary, an existing concrete slab south of Shed 1, a truck turn-around area and an existing dwelling located 100m to the south of Rowlands Creek road. **Figure 1-1** and **Figure 1-2** present a locality map and the site layout respectively.

1.1.2 Production bore

The proposed production bore (GW304537) is located at Shed 1 and currently supplies groundwater for stock and domestic use. The licenced maximum annual extraction volume is 25 ML/year, which was granted by the NSW Office of Water during 2009. The licence has since undergone conversion under the *Water Management Act* 2000 on 1 July 2016, and now exists under water access licence (WAL) 30AL314314 and combined approval number 30CA314315 (JGA, 2017).

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1.1.3 Proposed water extraction

An annual extraction volume of 24 ML/year is proposed from GW304537 to supply water for bottling offsite. Produced water will be acquired using an electric submersible pump installed within the bore and stored within two 39,000 L water tanks. The water tanks are proposed to be installed at the existing concrete slab (**Figure 1-2**) and within the vicinity of the existing production bore. Produced water will be transported offsite to the bottling facility via water tanker trucks (maximum capacity of 28,500 L per truck), which will enter the site via the driveway and existing truck turn-around area, collect the produced water from the onsite water tanks via an electric pump, and exit the property. A maximum of three tanker truck loads per day (for 6 days per week, over 50 weeks) have been proposed, with only one truck onsite at any given time (JGA, 2017).

1.2 Report objectives

The following presents the objectives of this report:

1. Due to the close proximity of the production bore to Rowlands Creek, identify whether the groundwater system is connected to the surface water system, hence whether produced water is likely to be sourced directly from the groundwater or by leakage from Rowlands Creek.
    - Identification of a hydraulic connection between the groundwater and surface water system is also required to enable assessment of whether groundwater extraction may potentially cause negative impacts to the surface water system.
2. Satisfy the requirements of the Development Application and the Tweed LEP (2014) under the relevant NSW legislation and policy (NSW Water Management Act 2000 and the NSW AIP, 2012), to demonstrate that groundwater extraction of 24 ML/year will not cause impacts to the local and/or regional surface water and/or groundwater environments.

1.3 Scope

The scope of the report is as follows:

- A review of all available hydrogeological data and information from the proposed production bore and registered bores within the local region to gain an understanding of the site hydrogeological conceptualisation;
- A site inspection to assess the production bore and local area. This includes field measurement of groundwater level within the production bore and collation of additional anecdotal information;
- A review of the NSW legislation and regulation including the relevant Water Sharing Plans for the groundwater source and region, and the NSW AIP (2012);
- A description of the existing water environment including surface water features, existing groundwater users and GDEs within the vicinity of the project area; and
- Identification of any potential impacts due to the groundwater extraction at the proposed bore.

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Figure 1-1: Locality map

Legend

- Site area (Lot 3/ DP 815475)
- Existing bore GW304537 (approx. location)

0 5 10 20
Metres
Datum/Projection:
GDA 1994 MGA Zone 56

N

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Figure 1-2: Site area

2 Methodology

2.1 Desktop study

2.1.1 Data sources

The following data sources were consulted during the desktop review:

- Available registered groundwater bore data, geological and hydrogeological information from the NSW Office of Water (NOW, 2017) PINNEENA Groundwater (online) database and the Bureau of Meteorology (BoM, 2017) Australian Groundwater Explorer database;
- BoM (2017) National GDE Atlas;
- Current bore licensing details sourced from the NOW Water Register (online) database;
- Geoscience Australia Elevation Information System (ELVIS) online database;
- Brunker et al. (1972) Tweed Heads 1:250,000 Geological Sheet SH/56-03, 1st edition, Geological Survey of NSW, Sydney;
- JGA (2016). Statement of Environmental Effects – Proposed Bulk Loading & Delivery of Extracted Water at Lot 3, DP815475 (No. 350) Rowlands Creek Road, Rowlands Creek, prepared by Jim Glazebrook & Associates Pty Ltd, December 2016;
- JGA (2017). Planning Committee advice report, submitted by Development Assessment and Compliance, November 2017; and
- Data obtained during site visit, including:
    - bore Certificate of Title; and
    - groundwater quality data from previous sampling and laboratory analysis conducted during 2005.

2.2 Site visit

A site visit was undertaken on 18 December 2017 to collect field measurements from the GW304537 production bore (standing water level) and additional anecdotal information and local references to inform the hydrogeological conceptualisation and support this report.

2.3 Impact assessment

An impact assessment was undertaken to assess the potential impacts from the groundwater extraction on other existing water users and GDEs. The assessment was undertaken in accordance with the requirements of the NSW AIP (2012) and the relevant water sharing plans.

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3 Legislation

The following presents a review of the legislative and statutory requirements relevant to the Rowlands Creek road hydrogeological assessment.

3.1 Water Management Act 2000

The objective of the NSW *Water Management Act 2000* is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The Act recognises the need to allocate and provide water for the environmental health of the State's rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The main tool within the Act for managing the State's water resources are Water Sharing Plans (WSPs), which protect the health of rivers and groundwater while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water.

The following WSP has been identified as relevant to the groundwater environment within the Project area:

- The *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Source* (2016), specifically the New England Fold Belt Coast Groundwater Source within this WSP.

3.1.1 Aquifer Interference Policy 2012

The Aquifer Interference Policy (AIP) was established to define the assessment process for development applications in terms of their potential impacts on aquifers, to clarify the requirements for obtaining water licences for aquifer interference activities, and to define the considerations for assessing potential impacts on key water-dependent assets. The policy focuses on activities that remove water from aquifers for non-water supply purposes.

The *Water Management Act 2000* defines an aquifer interference activity as that which involves any of the following:

- The penetration of an aquifer.
- The interference with water in an aquifer.
- The obstruction of the flow of water in an aquifer.
- The taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.
- The disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

Aquifer interference activities may take water from the source in which they exist as well as connected groundwater and surface water sources. The AIP clarifies water licensing requirements and details how these potential interference activities will be assessed under relevant planning and approvals processes. The policy provides 'minimal impact considerations' to evaluate potential impacts on groundwater levels, pressures, and quality for different categories of groundwater sources. The policy also includes provisions for water take from a source following the cessation of the aquifer interference activity.

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According to the AIP, the assessment of impacts on water sources and groundwater dependent ecosystems (GDEs) is based on the project proponents' ability to demonstrate:

1. The capacity to obtain the necessary licences to account for the take of water from a given source, or if licences are unavailable, that the Project has been designed to prevent the take of water;
2. That adequate arrangements will be in place to meet the 'minimal impact considerations' defined in the policy; and,
3. Proposed remedial actions for impacts greater than those that were predicted as part of the relevant approval.

The 'minimal impact considerations' provided in the AIP are defined for 'highly productive' and 'less productive' groundwater sources, both of which are further grouped into categories according to aquifer type (e.g. alluvial, coastal sands, fractured rock, etc.). Two levels of 'minimal impact considerations' are provided, and if the predicted impacts are less than the Level 1 impact considerations, then the impacts from the project would be considered acceptable. If the predicted impacts are greater than the Level 1 considerations, studies would be required to fully assess these impacts.

For the purposes of this study, a desk-top assessment of the potential impact of the Project on the North Coast fractured rock groundwater (forms part of the North Coast Fractured and Porous Rock Groundwater Source WSP) has been undertaken based on the criteria described in the AIP and re-produced in **Table 3-1**. Our assessment conservatively considers:

- The fractured rock aquifer of the Neranleigh-Fernvale Group falls within the Level 1 considerations for the highly productive fractured rock water sources, based on anecdotal information and information provided in the North Coast Fractured Rock Groundwater Source WSP (very low TDS and often highly productive bore).

It would be beneficial to the long term sustainability of the water production activities to validate the findings of this desk study against hydraulic testing.

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Table 3-1: Minimal Impact Considerations (1) for Aquifer Interference Activities (Level 1)

Aquifer	Water table	Water pressure	Water quality
Fractured Rock Water Sources	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: (a) High priority groundwater dependent ecosystem; or (b) High priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2m decline cumulatively at any water supply work.	A cumulative pressure head decline of not more than a 2m decline, at any water supply work. If the predicted pressure head decline is greater than the requirement above then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.

NOTES:
(1) All predicted volumes and aquifer impacts are to be determined using data and modelling as described in section 3.2.3 of (AIP, 2012);
(2) "post-water sharing plan" – refers to the period after the commencement of the first water sharing plan in the water source, including the highest pressure head (allowing for typical climatic variations) within the first year after commencement of the first water sharing plan;
(3) "Highly connected" surface water sources are identified in the Regulations and will be based those determined during the water sharing planning process;
(4) "Reliable water supply" is as defined in the SRLUP

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4 Desktop study

4.1 Physical setting

4.1.1 Topography and drainage

The site is located within the NSW region of the New England Fold Belt, and is situated along the Rowlands Creek drainage line, in the valley formed by the creek within the mountain ranges north of the Mt Jerusalem National Park. Available information suggest that Rowlands Creek is perennial (personal communication with landowner), and a tributary to the Tweed River (located north-west of the site towards Uki). The local catchment drains to the north via this creek line and discharges to the Tweed River (JGA, 2016).

Topography data sourced from the Geoscience Australia Elevation Information System (ELVIS) suggests the ground elevation at the site is approximately 38 metres above Australian Height Datum (mAHD). The ground surface at the site and immediate area can be described as generally flat to moderately sloping (JGA, 2016); however, outside of this area (on a regional scale) ground elevation increases sharply to approximately 120 mAHD approximately 400 metres to the south-west and south-east of the site, and to ~200 mAHD in the north-east (approximately 900 m from the site; **Figure 4-2**).

4.1.2 Geology

The Tweed Heads 1:250,000 Geological Map (Brunker et al. 1972) indicates the regional geology at the site area consists of greywacke, slate and phyllite quartzite rock of the Palaeozoic Neranleigh – Fernvale Group. Greywackes consist of argillaceous sandstones, which contain a significant amount of silt or clay originating from volcanic rocks such as basalt. Both greywacke and basalt have been identified in drillers logs for bores in the vicinity of the site; however, greywacke can easily be misidentified as basalt.

Within the valley, the Neranleigh – Fernvale Group is locally, sporadically overlain by alluvial deposits associated with Rowlands Creek. Colluvial clay deposits are also likely to be present amongst the alluvium, overlying the Neranleigh-Fernvale Group interface (ELA, 2016).

The geology to the north of the site consists of the Cainozoic (Tertiary) Mount Warning Central Complex (peralkaline granite and microgranites). The Triassic age Chillingham Volcanics (rhyolite, rhyolitic tuff and claystone materials derived from the Neranleigh – Fernvale Beds) exist to the south of the site (Brunker et al. 1972).

Figure 4-3 presents a map of the regional geology.

4.1.3 Hydrogeology

No detailed hydrogeological studies have been undertaken within or in the vicinity of the site area. Based on the lack of detailed hydrogeological information, the hydrogeological setting for the site area has been based on the hydrogeological information from the JGA (2016) Statement of Environmental Effects (SEE), data from the NSW Office of Water's (NOW) PINNEENA Groundwater database (NOW, 2017) and the Bureau of Meteorology (BoM) Groundwater Explorer database.

The fractured rock aquifer of the Neranleigh-Fernvale Group has been identified as the most significant groundwater resource within the site and surrounding area; however, groundwater is also likely to be present within any alluvial and colluvial deposits associated with Rowlands Creek. The phyllite aquifer is

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typically low yielding; however, higher yields are common where the phyllite rock is pervasively fractured. Groundwater from this aquifer is also typically reported as 'good quality' due to rainfall recharge and minimal mineral leaching processes (DPI Water, 2016).

Interrogation of the NOW (2017) PINNEENA Groundwater database and the BoM (2017) Groundwater Explorer database identified six registered groundwater bores within 1 km radial distance from the site, and located along the Rowlands Creek drainage line. **Table 4-1** presents a summary of the registered bore information used in this study, with the bores listed in order of upstream to downstream along Rowlands Creek. All bores listed are registered for stock / domestic use, hence fall under 'Basic Landholder Rights' activities and do not require an access licence for groundwater extraction under the *Water Management Act* 2000. This was confirmed through interrogation of each bore within the NOW Water Register online database.

The registered bore GW304537 was identified as the production bore assessed in this study, however no hydrogeological records were available for this bore (includes drilling or bore construction details, standing water level etc.). During a review of this study ELA was made aware of an additional 5 bores located in the vicinity of the site (30WA307328, 30WA321492, 30WA313158. 30WA306780 and 30WA308141), but no information could be obtained on any of these bores or water use licenses on the registered on-line databases.

Figure 4-1 shows the locations of all registered bores in relation to the site.

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Table 4-1: Registered bore details

Bore ID	Drilled year	Depth (m)	Easting (m) Z56	Northing (m) Z56	Licence	Status	Purpose	Slotted interval (m)	Hydrostratigraphy[1]	SWL[2] (m)	Salinity (mg/L)	Yield (L/s)
GW303884	2003	12	533697	6854023	30BL180847	Cancelled	Domestic	4.5 – 7.5	Alluvium gravel	--	--	1.2
GW300644	1996	15	533619	6854381	30BL177397	Converted	Stock / Domestic	12 - 15	Fractured rock with quartz seams	--	“Good”	2.9
GW300530	1996	20	533179	6854442	30BL177537	Active	Stock / Domestic	14 - 20	Clay & rocks	--	“Good”	--
GW301314	1995	33	533033	6854482	30BL176970	Active	Domestic	Open hole[3]	Basalt	--	“Good”	--
GW070304	1992	36	533056	6854873	30BL150853	Active	Domestic	12 - 36	Shale (weathered)	--	--	0.4
GW301388	1995	28	532877	6854905	30BL177026	Active	Domestic	22 - 28	Shale	15	“Good”	0.4

NOTES:

1. Drillers log records.
2. SWL = standing water level.
3. Water bearing zone recorded at 21 – 22 metres below ground level.

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Figure 4-1: Registered bore locations

4.1.4 Neranleigh-Fernvale Group

The Neranleigh-Fernvale group forms part of the southern coastal section of a folded and fractured aquifer known as the New England Fold Belt Coast Groundwater Source, which extends from Port Stephens in the south to the NSW – QLD border in the north, and east of Moree in the west. This is a fractured rock aquifer with groundwater predominantly contained within, and transmitted through, fractures in the rock, that are typically present due to tectonic stress. Groundwater yields are typically low (~ 1L/s), however yields up to 10 L/s may be obtained from highly fractured fault systems. Groundwater is typically recharged by direct rainfall infiltration. This combined with the minimal degree of mineral leaching that has occurred over time, generally results in good quality water (DPI Water, 2016; ELA, 2016).

It is considered likely that the production bore that is being assessed within this study sources groundwater from the fractured rock aquifer.

4.1.5 Weathered rock

As indicated on the borehole log for GW300644 (150m west of the production bore) a weathered layer exists at the top of the fractured phyllite rock aquifer, as observed within the available drillers bore logs for the bores identified in **Table 4-1**. The weathered layer consists of clay and weathered phyllite and shales, and is likely to be of low permeability and limit hydraulic connectivity between the fractured rock, the alluvial aquifer (where present) and surface water system to some extent.

4.1.6 Alluvium

The alluvium forms part of the Tweed River alluvium, and is typically shallow and discontinuous within the site area. Brunker et al. (1972) indicates the Quaternary alluvium (comprised of sand, silt, clay and gravel, with some residual colluvial deposits) is present along the Tweed River and Smiths Creek (> 2 km to the north of the site) and within a small area approximately 500 m south of the site (**Figure 4-3**). Information from the available bore drilling logs also shows shallow gravel materials recorded in only one bore log, located 200 m south of the site, hence it is inferred that the alluvial sediments are predominantly located along Rowlands Creek and to a lesser extent within the surrounding area.

The Tweed River alluvium comprises the following alluvial aquifer types:

- Shallow ‘upriver’ alluvial aquifers, which generally consist of coarser materials such as sand and gravels; and
- the coastal floodplain alluvial aquifers, which consist of relatively fine materials and are often found amongst silt and clay layers (NOW, 2010).

Based on the available geological information for the site area, it is inferred that the alluvial deposits at the Tweed River, and where present within the vicinity of the site, consist of materials characteristic of the shallow ‘upriver’ alluvium. These aquifers are generally classed as ‘highly connected’ to their parent stream, with a significant level of connectivity between the shallow alluvial groundwater and surface water systems (NOW, 2010).

The low permeability weathered phyllite layer observed overlying the fractured rock aquifer is considered to have the ability to limit connection between the alluvial aquifer and deeper fractured rock to some extent, hence groundwater extraction from the fractured rock aquifer as part the project is unlikely to impact groundwater within the alluvial aquifer and associated surface water systems.

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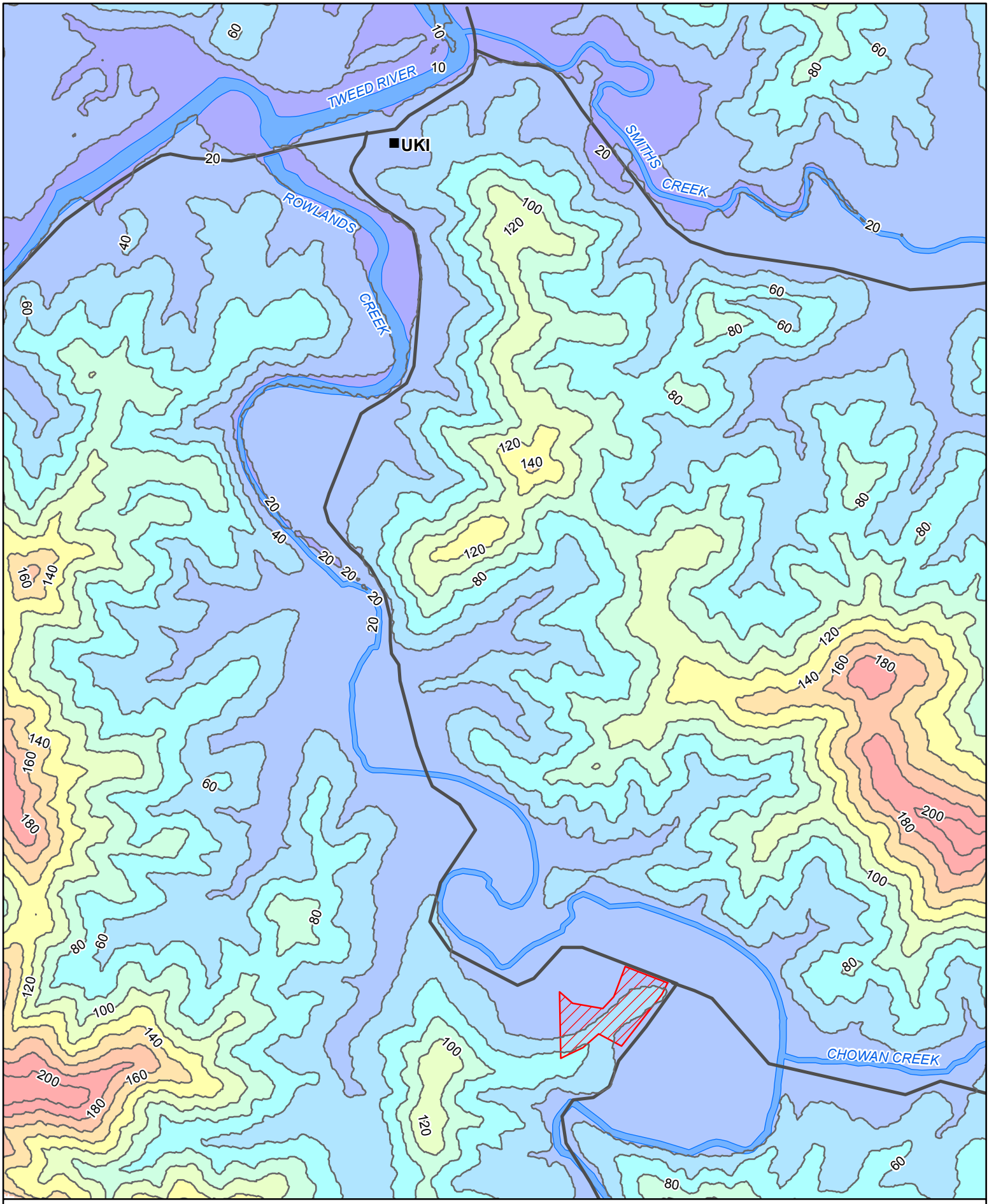
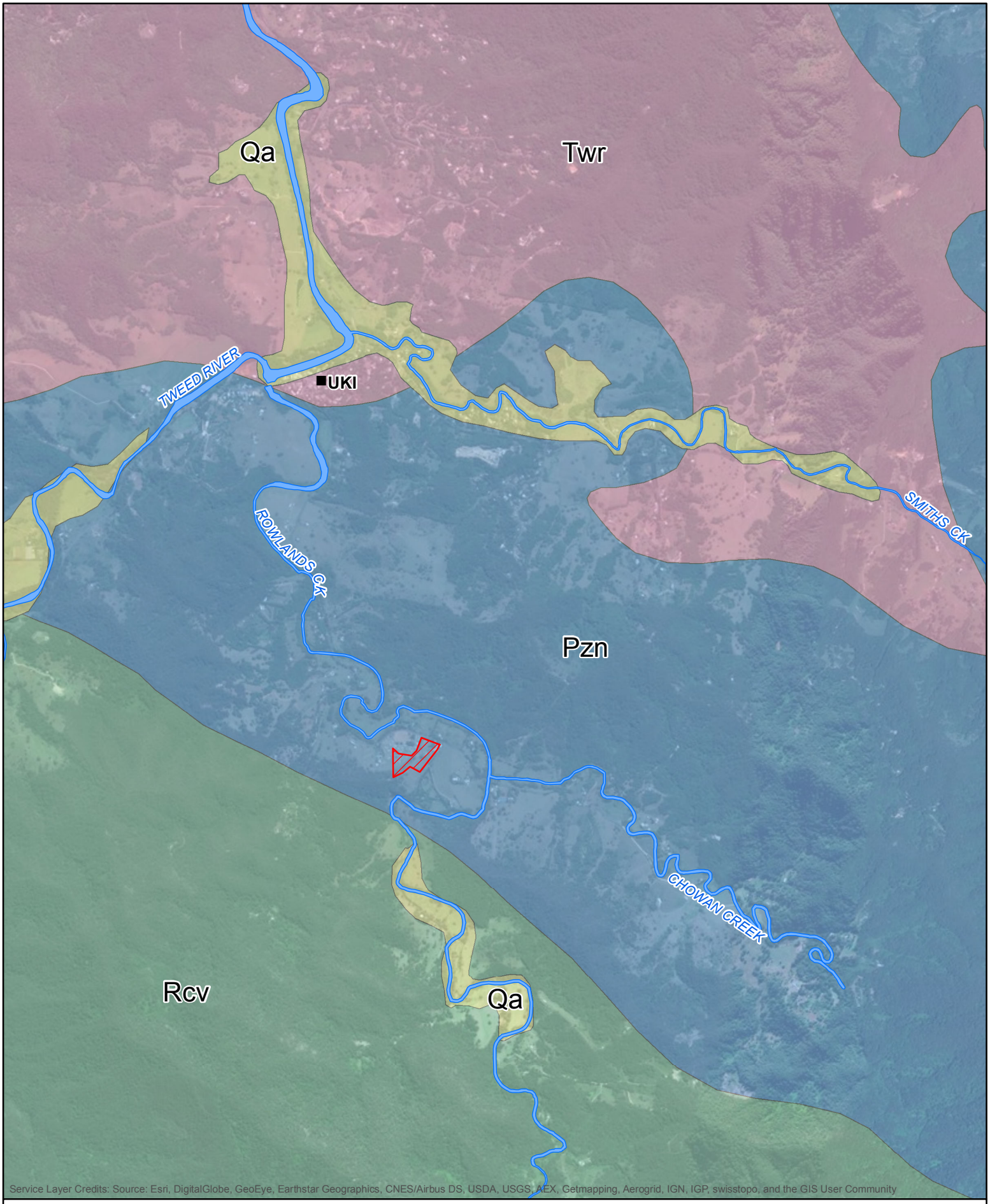


Figure 4-2: Regional topography



Site area (Lot 3/ DP 815475)
Rivers / Creeks
Locality

Geology

Quaternary sediments (Qa)
Neranleigh - Fernvale Group (Pzn)
Chillingham Volcanics (Rcv)
Mt Warning Complex (Twr)

0 235 470 940
Metres
Datum/Projection:
GDA 1994 MGA Zone 56

N

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Figure 4-3: Regional geology

4.1.7 Water quality

Groundwater quality data from 2005 was the only available data for GW304537 and was provided to ELA during the site inspection. The laboratory results as presented in **Table 4-2** have been reported against the National Health and Medical Research Council (NHMRC) Australian Drinking Water Guidelines 2011. No reported concentrations exceed these guidelines. A copy of the laboratory report received has been provided in Appendix A. Anecdotal information (including personal communication with landowner indicating a "good" water quality) suggests GW304537 receives direct recharge from rainfall infiltration and is of shallow depth (less than 20 m). A registered groundwater bore (GW300644) which exists approximately 150 m west of GW304537 (within Lot 5 / DP 629432) is 15 m deep and installed within the fractured phyllite aquifer of the Neranleigh – Fernvale Group. The available water quality data for this bore also reports the salinity as "Good".

No existing water quality information was identified for Rowlands Creek during the desktop review, to assist in assessing a potential hydraulic connection between the GW304537 bore (Neranleigh-Fernvale fractured rock aquifer) and surface water of Rowlands Creek. However, water quality data from groundwater samples collected from five groundwater bores (unrelated to this project), that are located approximately 30km north of the site and known to be installed within the Neranleigh-Fernvale Beds, were plotted against the GW304537 water quality sample in **Figure 4-4** as a Schoeller plot. This was done to assess the likelihood of the water from GW304537 being sourced from the same aquifer type.

The Schoeller plot suggests a similar water composition for the GW304537 sample and the bores known to access groundwater within the fractured rock aquifer. These results support the assumption that GW304537 accesses groundwater from the Neranleigh-Fernvale fractured phyllite aquifer, and not surface water from Rowlands Creek.

Table 4-2: Previous laboratory water quality analysis for GW304537 (sampled and analysed during 2005)

Analysis	Units	Value	NHMRC Health guidelines[1]	NHMRC Aesthetic guidelines[2]
pH	pH units	6.8	--	6.5 – 8.5
EC	µS/cm	110	--	800
Nitrate	mg/L	1.53	50	--
Hardness	Total mg/L as $CaCO_3$	20	--	200
Alkalinity	mg/L as $CaCO_3$	22	--	--
Sulfate	mg/L	3.8	500	250
Sodium	mg/L	15	--	180
Calcium	mg/L	3.43	--	--
Magnesium	mg/L	2.77	--	--
Potassium	mg/L	<5	--	--
Copper	mg/L	<0.01	2	1
Iron	mg/L	<0.01	--	0.3
Manganese	mg/L	<0.01	0.5	0.1
Chloride	mg/L	19	--	250

NOTES:

1. NHMRC Health related guidelines are the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC, 2011).
2. NHMRC Aesthetic related guidelines are the concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer; for example, appearance, taste and odour (NHMRC, 2011).

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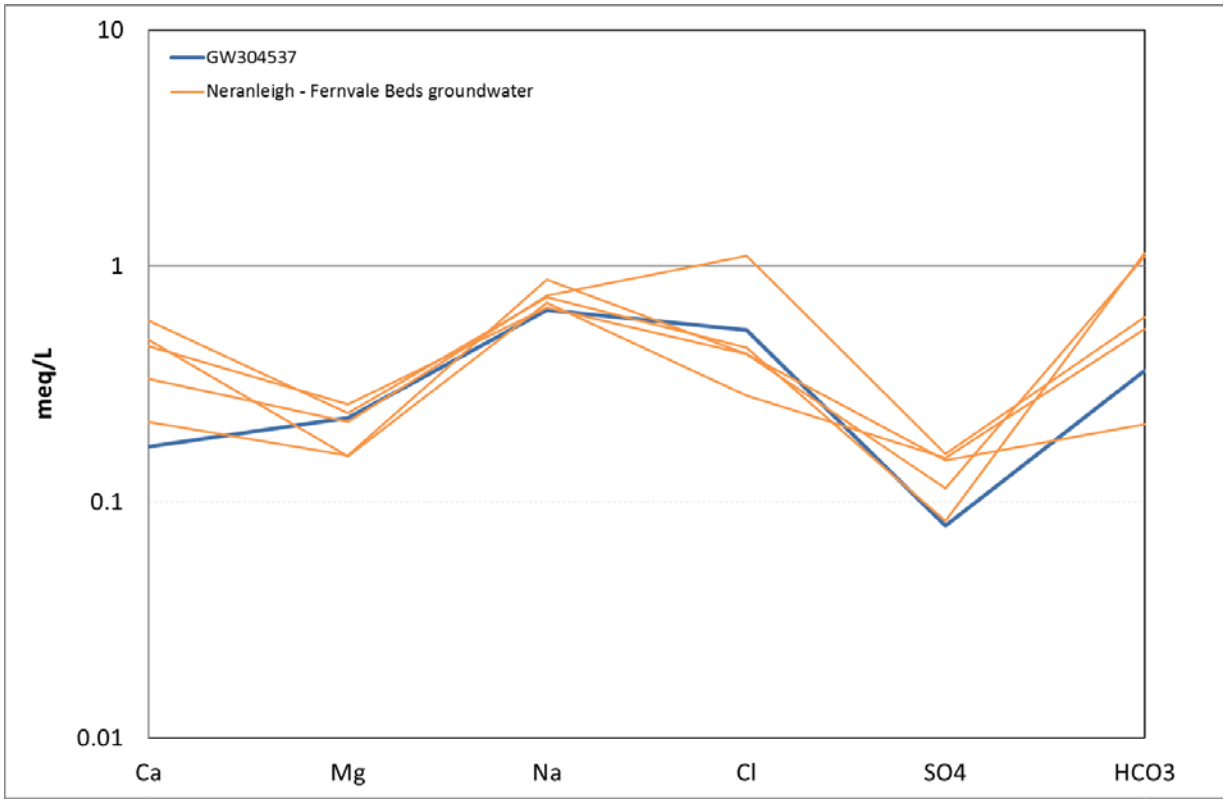

Figure 4-4: Groundwater quality of GW304537 vs. samples from the Neranleigh-Fernvale fractured rock aquifer.

4.2 Groundwater dependent ecosystems

A search for potential terrestrial and aquatic groundwater dependent ecosystems (GDEs) was undertaken within the site area using the available mapped GDE information from the BoM (2017) National GDE Atlas, and information on high priority GDEs listed within the WSP.

The *NSW Water Management Act 2000* classes GDEs as “high”, “moderate” or “low” priority in terms of ecological value and, therefore, the priority for management action. The following moderate priority GDEs were identified as potentially present within 1.5 km of the site. No high priority or moderate priority GDEs were identified at the site.

- Aquatic GDEs
    - Rowlands Creek floodplain wetlands
    - Located 300 m to the north-east, and 800 m north-west of the site
- Terrestrial GDEs
    - Located ~1.5 km south of the site, within the Mt Jerusalem National Park
    - Wet Bangalow-Brushbox
    - Sub-tropical and warm temperature rainforest
    - Lowlands Scribbly Gum

Figure 4-5 presents the locations of the known and registered GDEs above in relation to the site area.

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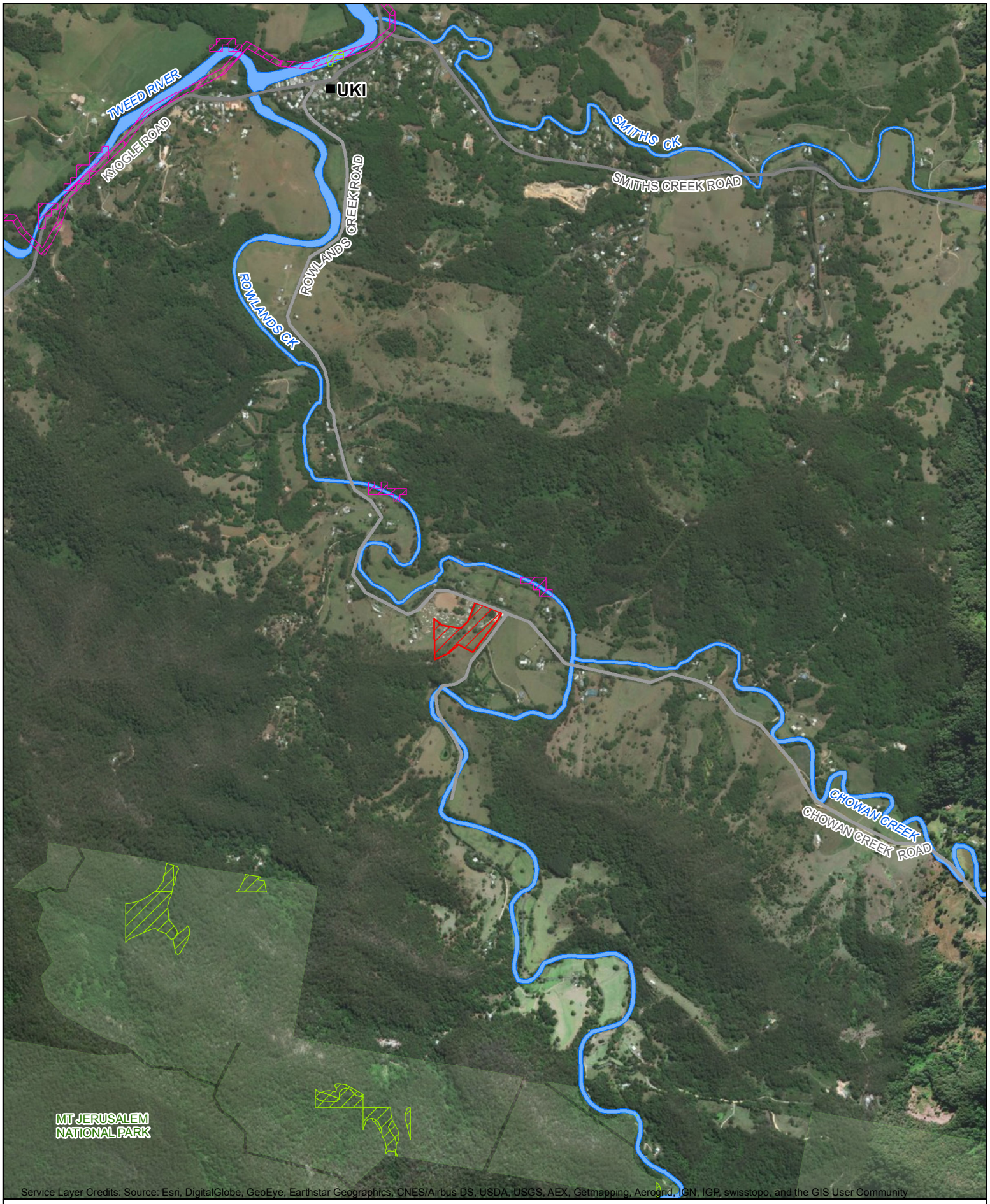

Site area (Lot 3/ DP 815475)
National Parks
Rivers / Creeks
Locality
Roads

Potential GDEs (BoM, 2017)
Terrestrial
Aquatic (floodplain wetlands)

0 162.5 325 650
Metres
Datum/Projection:
GDA 1994 MGA Zone 56

N

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Figure 4-5: Identified potential GDEs (moderate priority)

5 Site visit

5.1 Field measured data and information

A site inspection was conducted at 350 Rowlands Creek Road on the 18th December 2017, to observe the GW304537 bore and collect field measurements (e.g. standing water level and bore depth), photos and anecdotal information and local references from the site.

Table 5-1 summarises the field measurements and information that were collected during the site inspection.

Table 5-1: Bore information gained during site inspection

Item	Value	Comments
Standing water level	11.60 mbTOC*	Manually dipped 11:30AM 18/12/17. Dynamic water level could not be established during the inspection due to the pump cutting out as the water tanks onsite were filled.
Total bore depth	16.55 mbTOC*	--
Water access license (WAL)	WAL38385	Certificate of title provided by bore owner
Work approval number	30CA314315	Available on NOW Water Register (online) using WAL.
NOW reference number	30AL314314	Certificate of title provided by bore owner
Licensed extraction volume	25 ML/year	Assigned under the *North Coast Fractured and Porous Rock* (2016) Water Sharing Plan, for the New England Fold Belt Coast groundwater source.
Water quality data	--	Water quality data from previous sampling of GW304537 groundwater during 2005. Data and analysis is presented in **Section 0**.
Current groundwater pump details	--	Unable to identify pump currently installed within bore. Control box next to bore shows CentriPro CPC/S3, 0.75Kw.
Potential groundwater – surface water interaction	--	Unable to confirm during site inspection, but hydraulic connection is considered unlikely due to available drilling logs and geological records for bores in the near vicinity of the site.

(*: mbTOC: metres below top of casing)

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6 Drilling and bore completion

The DPI Water requested the drilling of an additional monitoring bore adjacent to the proposed production bore. Universal Drilling was contracted to undertake the drilling and bore installation works.

The monitoring bore was drilled using the air hammer drilling technique and screened off in the Neraneleigh-Ferndale fractured phyllite aquifer (NFA) using 50mm class 18 PVC with 6m of machine slotted casing at the bottom. Bore construction allow measuring of the water table during test pumping to assess hydraulic properties and aquifer parameter estimations. The geology of the borehole was logged and summarized in **Table 6-3**. Initial hydrogeological information was collected during drilling and summarized in **Table 6-1**, while **Table 6-2** provides final bore construction details. A bore construction log is provided in Appendix C.

Table 6-1 Hydrogeological Field data

Bore ID	Drilled Depth (mbgl)	Bore Diameter (mm)	Water strike
			Depth (mbgl)
Monitoring bore	21	140	15

Table 6-2 Borehole construction

Bore ID	Completed Depth (mbgl)	Casing Diameter (mm)	Screened Interval		Final Measurements	
Monitoring Bore			From (mbgl)	To (mbgl)	TDS (ppm)	Standing WL (mTOC)
	21	50	15	21	80	12

Table 6-3: Summary of geology encountered

Depth From (m)	Depth To (m)	Lithology
0	0.15	Soil
0.15	15	Clay
15	20	Shale[1]
20	21	Basalt

[1] Resource: KEAREY, P. *Dictionary of Geology*. 2nd ed. England: Penguin Books, 2001.

Phyllite: A Regionally metamorphosed, foliated, **pelitic rock**.

Pelitic rock: with a similar chemical composition to Shale

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7 Aquifer testing

7.1 Constant rate test and recovery test

A constant rate test (CRT) was undertaken by Quick Draw Pump Services on the 11th of April 2018 at the production bore GW 304537 at a rate of 0.8L/s for a 24-hour period. The data obtained from the testing was analysed to determine the hydraulic parameters of the aquifer and the long-term sustainability of the bore. Drawdown in the newly installed monitoring bore, located approximately 30m away was measured for the full duration of the test.

The data from the aquifer test was analysed using the Flow Characteristics (FC) method (Water Research Commission Report No III6/1/02). From **Figure 7-1** the first derivative from the log-log diagnostics plot depicts a period of radial flow with a small fracture dewatered at approximately 420minutes. The water level then rises slightly at late time indicating that the fracture received water, most likely from storage in the matrix until the end of the test.

The log derivative of the test pumping data yielded a value of 0.02, which is indicative that the aquifer from which the bore is abstracting water has a very good fracture network.

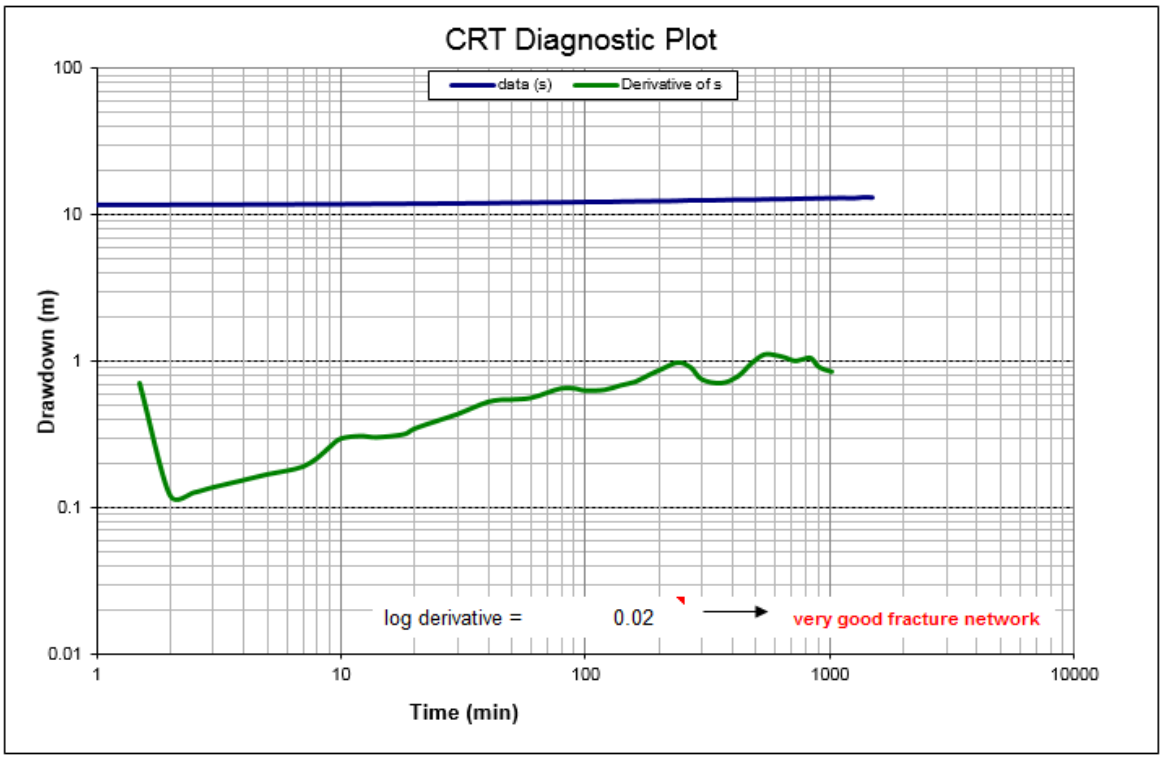

Figure 7-1: Constant rate test Diagnostic plot

The Cooper-Jacob (1946) method, a semi-log plot (**Figure 7-2**) was used to estimate the Transmissivity (T) of the aquifer. This method can only be used where radial flow is taking place. With the limited drawdown achieved during the aquifer test the Cooper-Jacob method was used to obtain a median T value across the entire data set. The method yielded a median T value of 43.4 m^2/d. The diagnostics of the semi-log plot shows no change in the gradient of the plot at late time due to the conservative pump rate (equal to proposed and licensed abstraction rate) selected. As a result no aquifer boundary has been reached during the test.

Aquifer Storativity of the matrix was estimated for the fractured rock aquifer based on standard industry published data. The Storativity for the aquifer was estimated to be 3.30E-04.

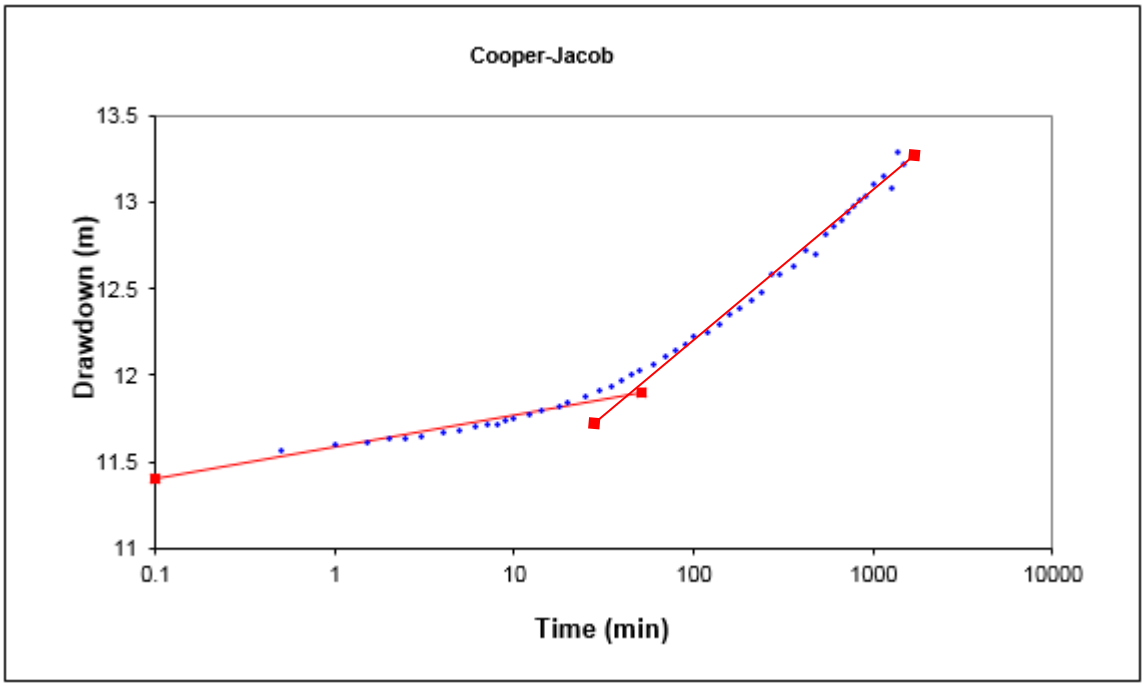

Figure 7-2: Constant rate semi-log plot for GW304537

Recovery testing was undertaken immediately after the completion of the CRT. Data were collected to monitor water level recovery following cessation of pumping to achieve either recovery within 5% of pre-pumping standing water level, or over a further 24-hour period. The test bore recovered to the initial rest water level prior to testing.

The Theis (1935) recovery method (**Figure 7-3**) was used to estimate the T-value of the aquifer. A fit on the graph is usually made where a straight line can be observed in the data. The fit may not be made where a flattening in the curve can be observed. The estimated T-value from the recovery data is 21.4m2/day.

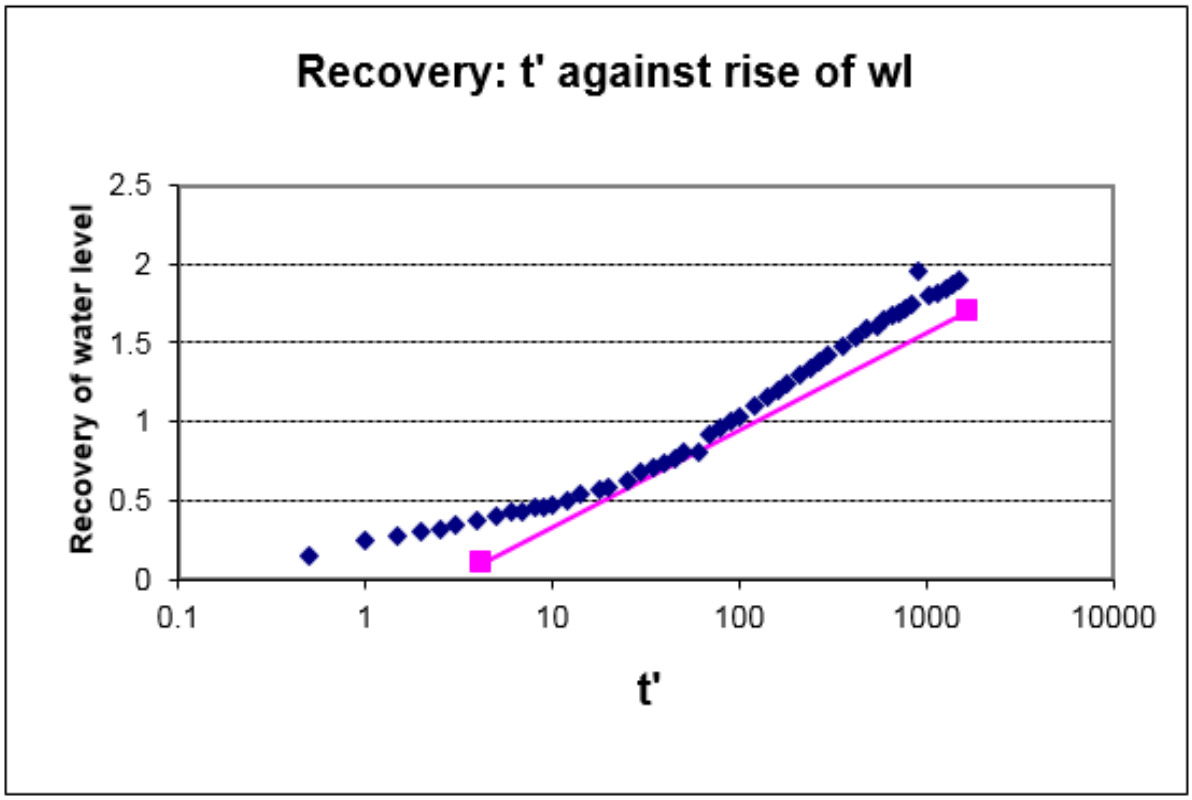

Figure 7-3: Recovery graph: t' against the rise in WL

Drawdown in the monitoring bore (approximately 30m away) was 0.025m (2.5cm) after a period of 24 hours. The theoretical radius of influence or propagation of drawdown was also calculated using the Theis method (**Figure 7-4**) with the proposed abstraction rate of 0.8L/s, no recharge and extrapolating time to 365 days (utilising the bore for 24hrs 7 days a week). The maximum average drawdown within the fractured rock aquifer at a distance of 175m (creek location) equated to 0.99m after one year of continuous pumping. Based on the observations during the pump test and the analytical modelling of the effective radius of influence, the potential propagation of drawdown as a result of the pumping of the production bore provides a conservative result.

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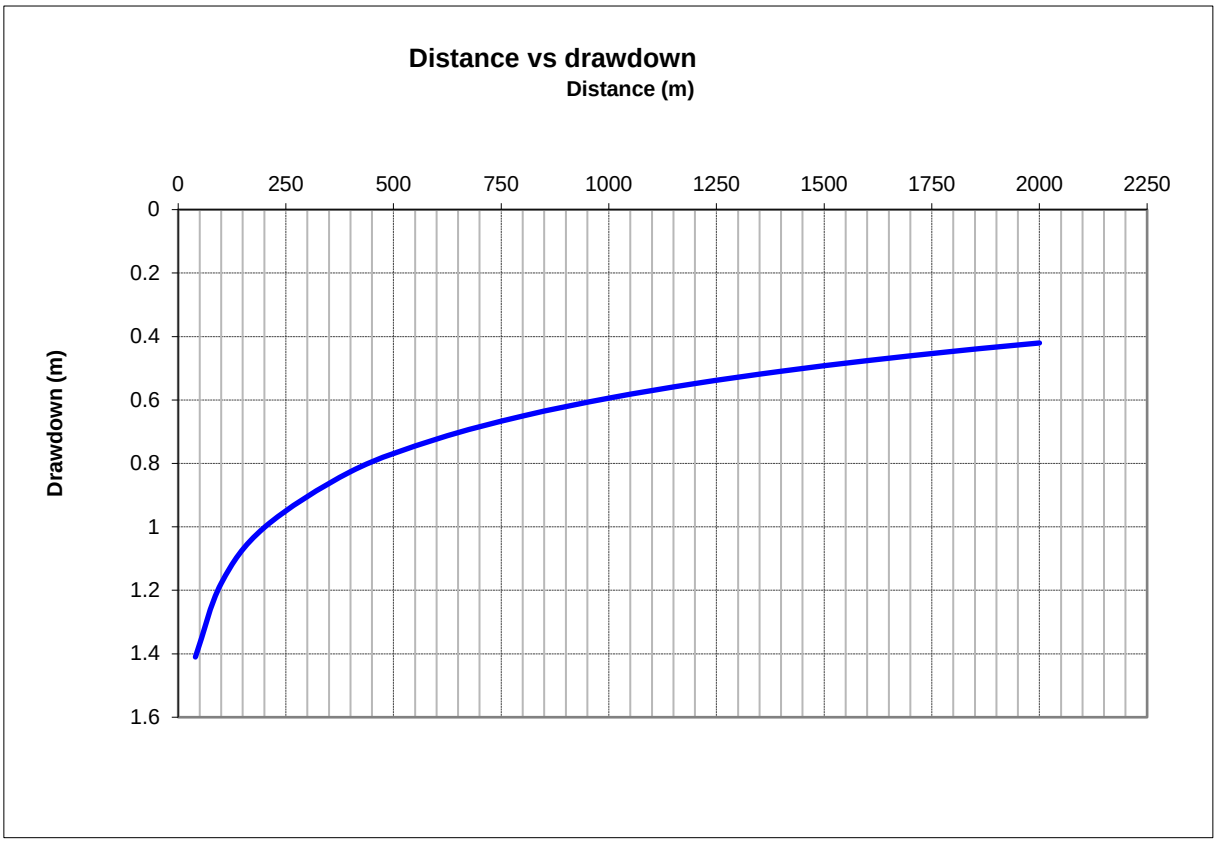

Figure 7-4: Radius of influence

8 Site conceptualisation

The site conceptual model has been developed based on the two alignments presented in **Figure 7-5** and using the available registered bore information and the geology of the newly drilled monitoring bore 30m from the proposed production bore. **Figure 7-6** and **Figure 7-7** present the site conceptual models developed (note: not to scale).

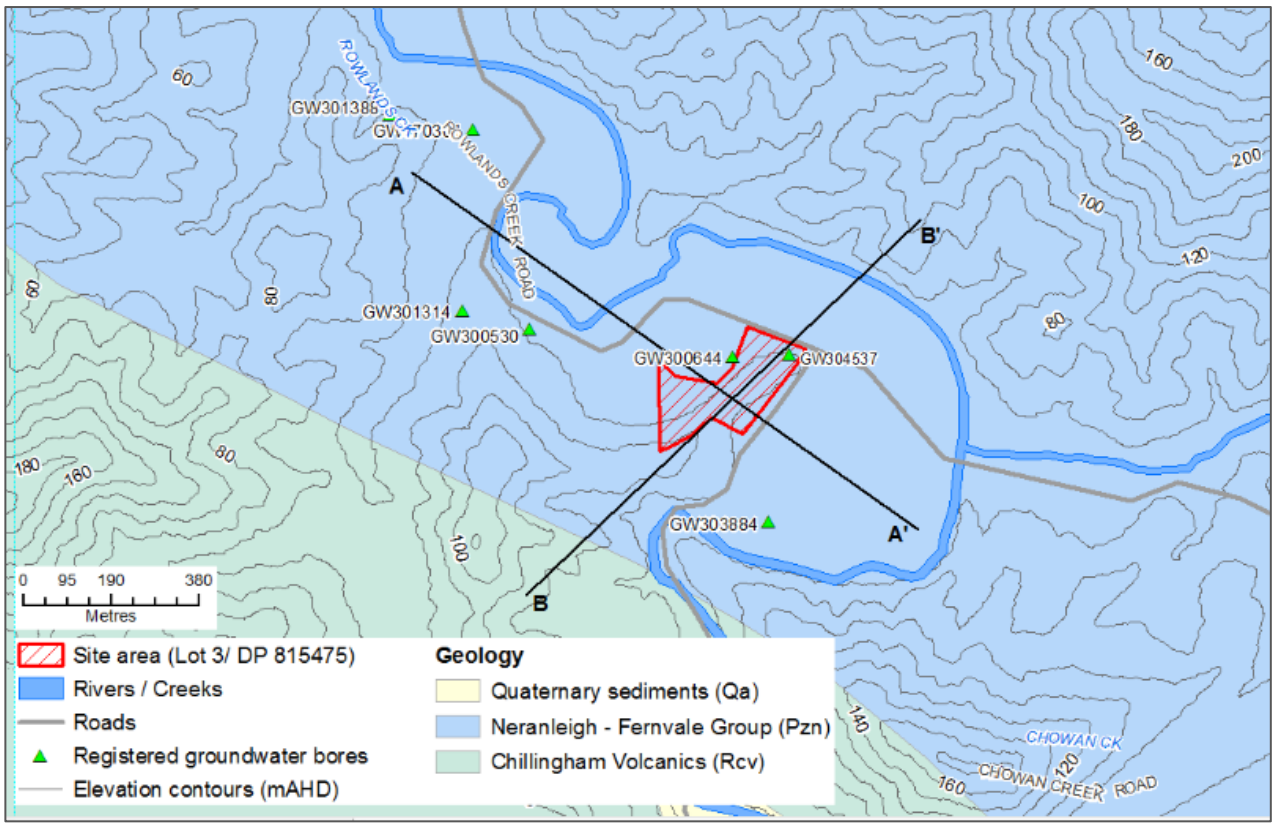

Figure 7-5: Conceptualised cross-section areas

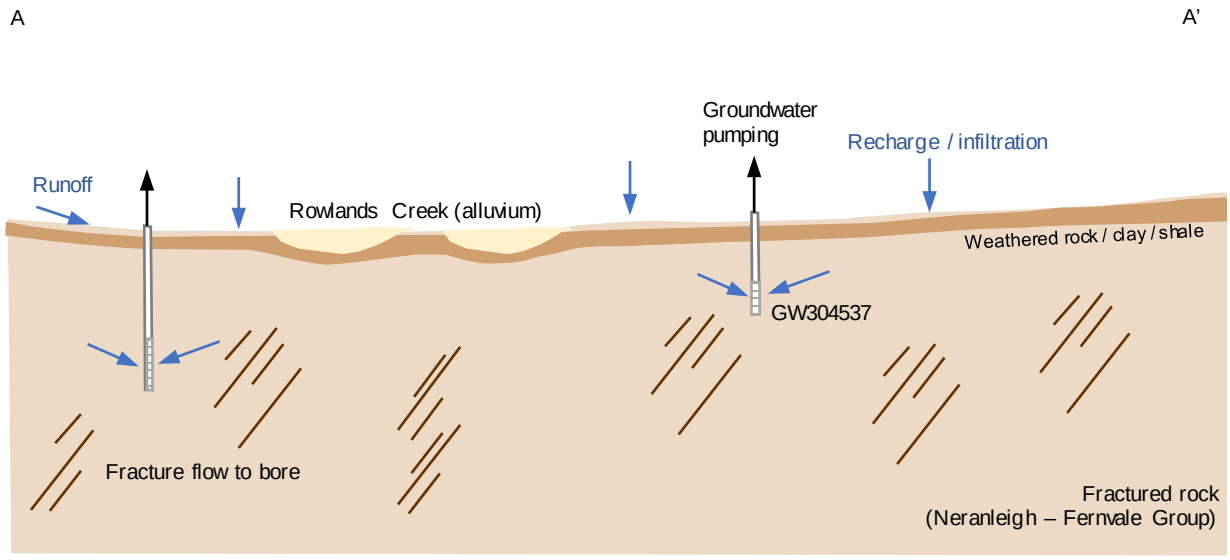

Figure 7-6: Site conceptual model (A – A') – not to scale

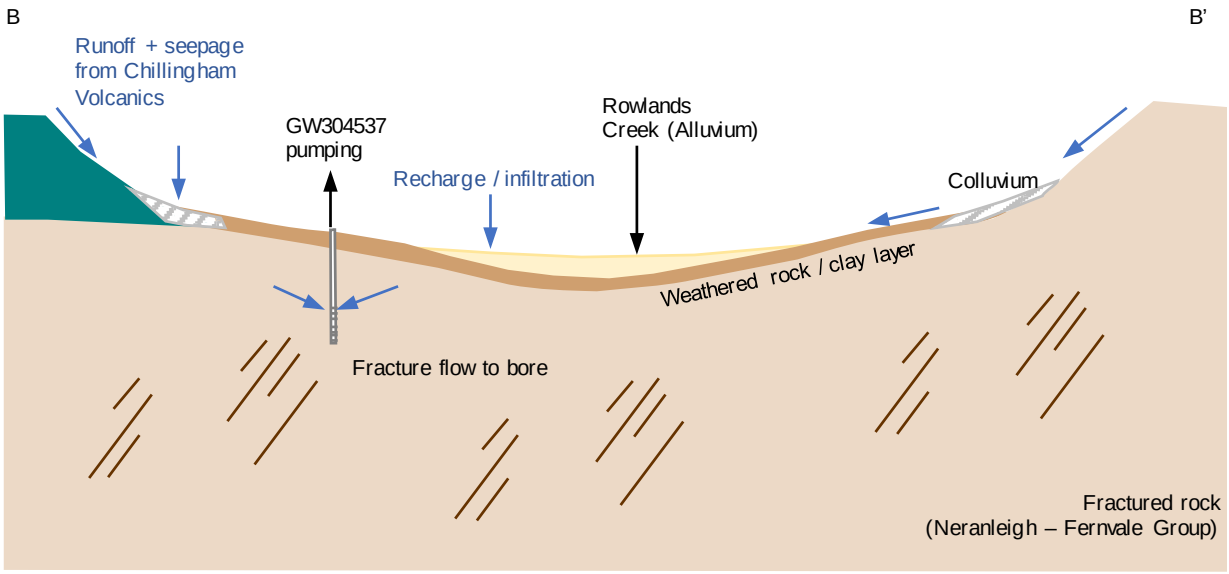

Figure 7-7: Site conceptual model (B - B') – not to scale

The conceptual models shown in **Figure 7-6** and **Figure 7-7** can be summarised as follows:

1. Rainfall produces surface water runoff from higher elevation areas surrounding the site towards the valley.
2. Groundwater recharge is via infiltration of rainfall / runoff. Seepage recharges groundwater within the shallow alluvial and colluvial deposits of Rowlands Creek. Recharge to the fractured rock aquifer is assumed to occur through seepage through the Chillingham Volcanics and colluvium deposits, and potentially via leakage through the low permeability weathered layer.
3. Groundwater discharge within the shallow alluvial aquifer is to the north of the site (assumed to follow surface water flow), towards the Tweed River. Groundwater discharge from the fractured rock aquifer is not known based on the available information.
4. Groundwater pumping from the proposed production bore (GW304537) occurs from the fractured greywacke / phyllite aquifer of the Neranleigh-Fernvale Group beneath the weathered regolithic horizon.
5. A hydraulic connection between the alluvial aquifer and the fractured rock aquifer is unlikely due to the presence of a clay and weathered rock layer, with an envisaged low permeability, within the upper Neranleigh-Fernvale Group. This layer is likely to form a barrier to groundwater flow between the two aquifers, in addition to preventing groundwater – surface water interactions from occurring between the Neranleigh – Fernvale fractured rock aquifer and:
    - Rowlands Creek;
    - alluvial / colluvial deposits associated with Rowlands Creek; and
    - the potential GDEs (floodplain wetlands) that were identified along Rowlands Creek within the vicinity of the site (Section 4.2).
6. The low permeability weathered layer may potentially allow some/limited leakage of shallow groundwater to the underlying fractured rock aquifer. This implies that groundwater extraction at GW304537 may potentially cause a flux from Rowlands Creek towards the pumping bore. However, this flux is considered to be negligible given the distance between GW304537 and the creek (approximately 200 m), the presence of a defined clay layer at GW304537 and a low extraction rate (24ML/a or <1L/s) associated with limited available drawdown within the bore.

8.1 Summary

From the aquifer test analysis, it is evident that the abstraction rate of 0.8L/s (licence restriction of 25ML/a) for this bore was conservative for the yielding capacity of the bore since no visible boundary effects was observed during the test.

Based on the aquifer parameters determined and the analytical modelling undertaken it is recommended that a sustainable pump rate of 0.67L/s (22 ML/a) over a 24-hour period of 7 days a week be adopted. Further calculations indicated that the radius of influence in the fractured rock aquifer at 175m is approximately 0.99m if the borehole was pumped at a rate of 0.8L/s. Thus, a lower abstraction rate will result in a lower distance-drawdown relationship.

9 Impact assessment

A preliminary impact assessment has been undertaken following the desktop review, and is summarised below. It should be noted that the assessment is qualitative only, and is based on the (few) available data records and information acquired during the desktop review and site visit.

9.1 Potential groundwater receptors

Groundwater and surface water receptors have been identified to facilitate an assessment of potential impacts to these receptors as a result of the proposed groundwater extraction, and to enable development and implementation of appropriate management and mitigation strategies (if required).

Two types of groundwater receptors (environmental and economic) have been identified within the vicinity of the site:

1. Environmental
    - Potential GDEs (terrestrial and aquatic); and
    - Groundwater – Surface Water interaction with Rowlands Creek.
2. Economic
    - Existing groundwater users.

9.2 Potential impacts

Potential impacts to the receptors above have been identified based on the site conceptualisation and the proposed groundwater extraction volumes, and can be grouped under the following categories:

- Groundwater quantity;
- Groundwater quality;
- Surface water flow (volumes and direction); and
- Surface water quality.

9.2.1 Environmental receptors

A hydraulic connection, whilst minor, may potentially exist between the fractured phyllite aquifer and Rowlands Creek. If so, pumping within the aquifer theoretically could cause drawdown impacts within the shallow alluvial deposits within the creek area, as well as impacts to surface water (flow and quality) within Rowlands Creek.

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As discussed in Section 4.2, no high priority or registered GDEs have been identified within the study area. Based on the desktop study, including some analytical modelling related to drawdown propagation, no impacts to groundwater and surface water (quantity and quality) are anticipated that may impact the potential aquatic and terrestrial GDE sites identified within the region and the Rowlands Creek surface water system, in terms of changes to water levels, flows (volumes and direction) and/or water quality.

This relates to the proposed groundwater extraction occurring from within the Neranleigh-Fernvale fractured rock aquifer. No impacts are anticipated due to the presence of the clay (as observed in the recently completed geological log) and weathered rock layer (envisaged low permeability) between the Neranleigh-Fernvale Group and the shallow groundwater and surface water system, which is considered likely to act as a barrier to flow between these units.

9.2.2 Economic receptors

Existing groundwater users utilising groundwater from the Neranleigh-Fernvale Group fractured rock aquifer may theoretically experience impacts to groundwater quantity and quality due to drawdown of groundwater levels caused by the proposed groundwater extraction from GW304537. Five existing registered bores were identified during the desktop review (Section 4.1.3), within a 1 kilometre radius of the site and known to be installed within the Neranleigh-Fernvale formation (GW300644, GW300530, GW301314, GW070304 and GW301388 bores). These bores are registered for stock and domestic use, hence do not require a groundwater extraction licence. Data obtained during the test pumping of proposed production bore GW304537and analytical modelling suggest that drawdown propagation and resulting impacts to existing groundwater users and Rowlands Creek is limited as a result of the pumping of the proposed production bore.

The following available information is also used to assess the likelihood of potential impacts:

- The nearest existing abstraction groundwater bore to the site is GW300644, which is located approximately 120 m west of the site. All other identified existing users are located greater than 500 m from the site.
- The project is proposing to extract 24 ML/year of groundwater from the New England Fold Belt Groundwater source, which holds an upper extraction limit of 375,000 ML/year under the WSP for the *North Coast Fractured and Porous Rock Groundwater Source*s (2016).
    - DPI Water (2016) have reported the current total water requirements for the New England Fold Belt groundwater source at 35,468 ML/year, with almost half of this volume attributed to Town Water Supply requirements.
    - Based on this requirement, a total of 24,532 ML/year unassigned water has been estimated for this water source (i.e. water that may be made available for new access licences) (DPI Water, 2016), which greatly exceeds the proposed extraction volumes for the Project (24 ML/year).
    - The assessment indicates that the proposed groundwater extraction at the site (current licence WAL38385) forms less than 0.1% of the estimated unassigned water allocation, as determined by the DPI Water, within the WSP requirements.
- Low electrical conductivity (EC) was reported from a previous water sample collected from GW304537 during 2005. EC concentration was 110 µS/cm (equivalent to ~70 mg/L), which is considered “fresh” and falls within the accepted ranges of the NHMRC (2011) drinking water guidelines.
- The available information provided by the PINEENA Groundwater database for GW304537 consists of a comment stating, “bore has never gone dry, even during drought while constantly using water”. Although this is anecdotal evidence provided, it can be concluded with a great level

of certainty following the aquifer testing and analytical modelling on drawdown propagation of the bore that the statement made in the PINEENA database is validated.

From the information obtained from the newly drilled monitoring bore 30m from the production bore, it is confirmed that GW304537 is installed within a fractured section of the Neranleigh – Fernvale aquifer. The constant rate test analysis confirmed the bore to be transmissive, and moderate to high yielding. The relatively high transmissivity is supported by the low salinity and suggests the aquifer regularly receives recharge. Therefore, it is anticipated that significant drawdowns will not be encountered during pumping of GW304537 and that the analytical modelling of the drawdown propagation is a conservative assessment.

9.3 Impact assessment summary

Table 9-1 presents a summary of the findings of the preliminary impact assessment. Based on the available information, the resulting impact to the potential receptors identified in Section 9.1 is considered low, to very low.

Table 9-1: Groundwater impact assessment summary

Potential receptor	Potential impact	Comment
Existing groundwater users	Low	Based on the available data records (including water quality and anecdotal information) for boreGW304537,it is concluded that the bore is installed within a relatively transmissive (T value = 43.5 m^2/d) section of the fractured rock aquifer. Impacts to groundwater quality and quantity to existing groundwater users as a result of groundwater extraction from GW304537 are considered unlikely to occur (low) due to low pumprate and drawdown propagation (Figure 8-5)
GDEs	Very low to negligible	No high priority GDEs have been identified within 1.5 km of the site. Moderate priority aquatic GDEs (floodplain wetlands) were identified along Rowlands Creek; however, no impacts to GDEs in terms of groundwater quantity or quality are expected due to lack of hydraulic connection between the shallow groundwater system and the Neranleigh-Fernvale groundwater source as well as the limited propagation of drawdown from the production bore.
Rowlands Creek	Very low to negligible	Based on the available information and information obtained from the recently completed geological log, aquifer testing and analytical modelling, there is no evidence to suggest a connection between the surface water system at Rowlands Creek and groundwater within the Neranleigh-Fernvale formation.

9.4 AIP (2012) assessment

The AIP assesses potential impacts to other groundwater users and GDEs. The findings of the preliminary impact assessment have been assessed against the NSW Aquifer Interference Policy (AIP) (**Table 3-1**), for the Neranleigh – Fernvale fractured rock aquifer, and is summarised in **Table 9-2.**

The assessment concludes that under the AIP terms the proposed extraction, the GW304537 bore does not cause a potential material impact to other groundwater users or GDEs.

Table 9-2: Assessment against the AIP (2012) Level 1 Minimal Impact Considerations for highly productive, fractured rock groundwater source.

Level 1 Minimal Impact Consideration criteria	Assessment
Water table: Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: (c) High priority groundwater dependent ecosystem; or (d) High priority culturally significant site; listed in the schedule of the relevant water sharing plan. OR: A maximum of a 2m decline cumulatively at any water supply work.	The Neranleigh – Fernvale Beds are locally confined based on the available (including recently completed bore) bore log information, with assumed leakage. No high priority GDEs have been identified within 1.5km of the site. As discussed in **Section 0** and **Section 9.2.1**, it is also considered unlikely that a connection exists between the Rowlands Creek surface water system (including GDEs accessing shallow groundwater within the area) and the Neranleigh-Fernvale Beds groundwater system due to the presence of a low permeable clay / confining layer. Therefore, groundwater extraction from the fractured rock aquifer is unlikely to impact the surface water system or existing GDEs.
Water pressure: A cumulative pressure head decline of not more than a 2m decline, at any water supply work.	Five registered groundwater users were identified within 1km of the site (**Section 4.1.3**); however, all bores are registered for stock / domestic use (i.e. does not require a groundwater extraction licence). There are currently no recorded large volumes of groundwater extracted within 1km of the area, that may be potentially impacted by the proposed extraction works at GW304537. Collated information, including recent test pumping of the bore, also suggests the GW304537 bore targets a relatively highly transmissive region of the fractured rock aquifer, hence the drawdowns are expected to be minimal (confined to the site). Drawdown of 1.3m within bore GW304537 (0.025m in the monitoring bore) was confirmed through aquifer testing prior to commencing groundwater extraction
Water quality: Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.	Groundwater extraction from GW304537 is unlikely to cause a change in groundwater quality at the site, or beyond 40m of the activity, because there is no defined mechanism by which derogatory water quality could be introduced by the proposed groundwater pumping. Based on the available and collated information there is no evidence to suggest a hydraulic connection between

Level 1 Minimal Impact Consideration criteria	Assessment
	the surface water and fractured rock groundwater sources. There are no known or listed historic or current contaminants or industrial areas (which may potentially contain contaminants) on the site or in the near vicinity. It was brought to our attention that there are some groundwater use associated with commercial / industrial activities, but this could not be confirmed through existing on-line databases (PINEENA and BOM Groundwater Explorer).

9.5 Assessment against the WSP criteria

As discussed in Section 9.2.2, the assessment indicates that the proposed groundwater extraction at the site (current licence WAL38385) is equivalent to less than 0.1% of the estimated unassigned water allocation within the New England Fold Belt Groundwater source WSP requirements. The current licence is attached in Appendix B.

10 Conclusions

A hydrogeological assessment (including desktop study, site inspection and subsequent drilling and aquifer testing) has been undertaken to identify potential groundwater and surface water related impacts associated with proposed commercial groundwater extraction from an existing bore located at Lot 3 / DP815475, 350 Rowlands Creek road, NSW. Commercial groundwater extraction of 24 ML/year is proposed from the existing bore, under the water access licence (WAL) 38385.

The assessment is required to satisfy the requirements of the Development Application and the Tweed LEP (2014), as well as the relevant NSW water legislation and policy (*Water Management Act* 2000 and NSW AIP 2012). The following presents a summary of the assessment findings:

- The site groundwater resources are covered under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Source (2016), within the New England Fold Belt Coast Groundwater Source;
- The proposed groundwater bore was identified within the NSW Office of Water PINEENA groundwater registered bore database under identification number 'GW304537', and is considered to access groundwater within the fractured rock aquifer of the Neranleigh – Fernvale Group. This aquifer forms the most significant and productive groundwater resource within the region with groundwater yields up to 10 L/s observed (generally in highly fractured areas);
- Few existing hydrogeological data records and information were available for the proposed production bore and site area. Interpretation of the available geological data (including drillers logs) and groundwater level and quality data suggests that a hydraulic connection between the fractured rock aquifer of the Neranleigh – Fernvale Group and the Rowlands Creek surface water system is unlikely. This is mainly due to the presence of a clay / weathered rock layer at the top of the Neranleigh – Fernvale formation, with envisaged low permeability. Therefore, no impacts to the Rowlands Creek surface water system are anticipated due to groundwater extraction from the Neranleigh – Fernvale aquifer;
- The low permeability weathered layer may potentially allow some/limited leakage of shallow groundwater to the underlying fractured rock aquifer. This results in the assumption that pumping at GW304537 may potentially cause a flux from the creek to GW304537. This flux is considered to be negligible given the distance between GW304537 and the creek (approximately 200 m), a low extraction rate (24ML/a or <1L/s) and the limited modelled propagation of drawdown as a result of pumping from the production bore (Figure 8-5).
- Two types of potential groundwater receptors were identified for the project; 1) Environmental (GDEs (terrestrial and aquatic) and groundwater – surface water interactions with Rowlands Creek); and 2) Economic (existing groundwater users).
    - Five registered existing groundwater users were identified within 1 km of the site, with the nearest bore (GW300644) located approximately 120 m from the site. These bores provide groundwater supply from the fractured rock aquifer for stock / domestic use, and do not require a water access licence. Existing and new information suggests the proposed production bore is installed within a fractured, transmissive section of the Neranleigh - Fernvale aquifer; therefore, significant drawdowns (which may cause potential impacts to existing groundwater users in terms of groundwater quantity and quality) are not considered likely..
    - No 'high' priority GDEs were identified at the site, or within 1.5 km of the site. Terrestrial and aquatic GDEs classified as 'moderate' priority were identified within 1.5km of the site. Groundwater extraction from the Neranleigh – Fernvale Group is unlikely to cause impacts to the identified GDEs, due to the lack of hydraulic connection inferred between the shallow alluvial and deeper groundwater systems.

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- Assessment against the NSW AIP and WSP requirements concludes that the proposed extraction from the GW304537 bore does not cause a potential material impact to other groundwater users or GDEs, and does not exceed the WSP requirements. The proposed groundwater extraction is low in magnitude in comparison to the estimated volume of unallocated water within the WSP (less than 0.1% of the estimated unassigned water available within the WSP requirements).

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Appendix A | Laboratory certificate

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Tweed Laboratory Centre

Tweed Laboratory Centre, 46 Enterprise Avenue, Tweed Heads South NSW 2486 Australia
Phone: 07 5569 3103 Fax: 07 5524 2676 Email: samplereception@tweed.nsw.gov.au ABN: 90 178 732 496
(All correspondence: Tweed Shire Council PO Box 816 Murwillumbah NSW 2484)
www.tweed.nsw.gov.au/tweedlab/

FINAL CERTIFICATE OF ANALYSIS

Client: Jack Hallam
Address: 350 Rowlands Creek Road
UKI
NSW 2484

Lims1 Report No: 181335
Attention: Jack Hallam
Client Reference:
Copy To:
Date of Report: 06/04/2018

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Taken By:	Client	**No of Samples:**	2
Date Taken:	05/04/2018	**Date Testing Commenced:**	05/04/2018
Date Received:	05/04/2018	**Date Testing Completed:**	06/04/2018

BACTO ANALYSIS **Job Description:** Bore and Creek Water Samples - Bacto

LIMS No.	Sample/Site Identification	Sample/Site Description
181335-1	Bore Water	1
181335-2	Creek Water	2

COMMENTS:
Results refer to samples as received at the Laboratory.
< = Less than, **>** = Greater than

NATA ACCREDITED FOR TECHNICAL COMPETENCE
Accredited for compliance with ISO/IEC 17025 - testing
Accreditation No: 12754 & 13538

Dr Sally Hinton
(Senior Technical Officer - Phycology)
shinton@tweed.nsw.gov.au

TWEED SHIRE COUNCIL

Tweed Laboratory Centre

Client: Jack Hallam

Address: 350 Rowlands Creek Road

UKI
NSW 2484

Attention: Jack Hallam

Lims1 Report No: 181335
Date Testing Completed: 06/04/2018
Date of Report: 06/04/2018

BACTO ANALYSIS **Job Description:** Bore and Creek Water Samples - Bacto

Sample Identification: Date Taken: Test	Method	Units	Bore Water 05/04/2018 181335-1	Creek Water 05/04/2018 181335-2
E. coli colilert	B12	MPN/100mL	<1	1,300
Total coliforms colilert	B12	MPN/100mL	91	6,500

Tweed Laboratory Centre

Tweed Laboratory Centre, 46 Enterprise Avenue, Tweed Heads South NSW 2486 Australia
Phone: 07 5569 3103 Fax: 07 5524 2676 Email: samplereception@tweed.nsw.gov.au ABN: 90 178 732 496
(All correspondence: Tweed Shire Council PO Box 816 Murwillumbah NSW 2484)
www.tweed.nsw.gov.au/tweedlab/

FINAL CERTIFICATE OF ANALYSIS

Client: Jack Hallam
Address: 350 Rowlands Creek Road
UKI
NSW 2484

Lims1 Report No: 181336
Attention: Jack Hallam
Client Reference:
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Date of Report: 17/04/2018

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Taken By:	Client	**No of Samples:**	2
Date Taken:	05/04/2018	**Date Testing Commenced:**	05/04/2018
Date Received:	05/04/2018	**Date Testing Completed:**	17/04/2018

CHEMICAL ANALYSIS **Job Description:** Bore and Creek Water Samples

LIMS No.	Sample/Site Identification	Sample/Site Description
181336-1	Bore Water	1
181336-2	Creek Water	2

COMMENTS:
Results refer to samples as received at the Laboratory.
< = Less than, **>** = Greater than

NATA ACCREDITED FOR TECHNICAL COMPETENCE
Accredited for compliance with ISO/IEC 17025 - testing
Accreditation No: 12754 & 13538

Dr Paul J Wright
(Laboratory Coordinator)
paulw@tweed.nsw.gov.au

TWEED SHIRE COUNCIL

Tweed Laboratory Centre

Client: Jack Hallam

Address: 350 Rowlands Creek Road

UKI
NSW 2484

Attention: Jack Hallam

Lims1 Report No: 181336
Date Testing Completed: 17/04/2018
Date of Report: 17/04/2018

CHEMICAL ANALYSIS **Job Description:** Bore and Creek Water Samples

Sample Identification: Date Taken: Test	Method	Units	Bore Water 05/04/2018 181336-1	Creek Water 05/04/2018 181336-2
pH	P1	pH units	5.6	7.1
Conductivity	P2	μScm^{-1}	100	100
Nitrite-N	C4	mg/L	<0.02	<0.02
Nitrate-N	C4	mg/L	1.44	0.02
Hardness Total $CaCO_3$	M8A	mg/L	16	16
Calcium	M8	mg/L	3.0	3.0
Magnesium	M8	mg/L	2.1	2.2
Aluminium (Total)	M16	mg/L	<0.01	0.49
Arsenic (Total)	M16	mg/L	<0.001	0.002
Chromium (Total)	M16	mg/L	<0.001	<0.001
Copper (Total)	M16	mg/L	0.002	<0.001
Iron (Total)	M16	mg/L	<0.01	0.87
Manganese (Total)	M16	mg/L	0.002	0.022
Nickel (Total)	M16	mg/L	0.001	<0.001
Zinc (Total)	M16	mg/L	0.011	<0.005
Cadmium (Total)	M16	mg/L	<0.001	<0.001

Appendix B | Water access licence

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BOX 1026Y
(AM436181)

NEW SOUTH WALES

CERTIFICATE OF TITLE

WATER MANAGEMENT ACT, 2000

WAL TITLE REFERENCE	
WAL38385	
EDITION	DATE OF ISSUE
1	8/6/2017
CERTIFICATE AUTHENTICATION CODE	
RX3Y-K2-SR6C	

This certificate is issued under s87B of the Water Management Act, 2000.

ANY ATTEMPT TO ALTER THIS CERTIFICATE COULD RESULT IN HEAVY FINES OR IMPRISONMENT (S.141 REA., PROPERTY ACT).

WARNING NOTE: INFORMATION ON THIS REGISTER IS NOT GUARANTEED

TENURE TYPE: CONTINUING

HOLDER(S)

JACK ROWLAND HALLAM (WB AM215279)

ENCUMBRANCES
---
1. SECURITY INTERESTS IN THE WATER ENTITLEMENT REPLACED BY THIS ACCESS LICENCE THAT WERE REGISTERED OR CAPABLE OF BEING REGISTERED WITH LPI OR ASIC BEFORE THE COMMENCEMENT DATE OF THIS LICENCE 1/7/2016 MAY BE RECORDED ON THIS LICENCE WITHIN THREE YEARS FROM THE COMMENCEMENT DATE. SEE NOTES.
2. TERM TRANSFER: NIL

ACCESS LICENCE DETAILS

CATEGORY: AQUIFER

SHARE COMPONENT:
SHARE - 25 UNITS
WATER SOURCE - NEW ENGLAND FOLD BELT COAST GROUNDWATER SOURCE
WATER SHARING PLAN - NORTH COAST FRACTURED AND POROUS ROCK GROUNDWATER SOURCES 2016

EXTRACTION COMPONENT:
TIMES/RATES/CIRCUMSTANCES - SUBJECT TO THE CONDITIONS OF THE WATER ACCESS LICENCE
EXTRACTION FROM - AQUIFER
EXTRACTION ZONE - WHOLE WATER SOURCE

NOMINATED WORKS:
WORK APPROVAL NUMBER(S) - 30CA314315
INTERSTATE TAGGING ZONE - NIL

CONDITIONS

LICENCE CONDITIONS FORM A PART OF THIS LICENCE AND AFFECT THE SHARE AND EXTRACTION COMPONENTS. CONDITION STATEMENTS ARE AVAILABLE FROM THE NSW OFFICE OF WATER (NOW).

NOTES

A WATER LICENCE INFORMATION SHEET IS AVAILABLE FROM THE NSW OFFICE OF WATER (NOW) AND SHOULD BE REFERRED TO IN INTERPRETING THIS LICENCE. NOW WEBSITE WWW.WATER.NSW.GOV.AU, PHONE 1800 353 104, EMAIL INFORMATION@WATER.NSW.GOV.AU

END OF PAGE 1 CONTINUED OVER

BOX 1026Y
(AM436181)

NEW SOUTH WALES

CERTIFICATE OF TITLE

WATER MANAGEMENT ACT, 2000

WAL TITLE REFERENCE	
WAL38385	
EDITION	DATE OF ISSUE
1	8/6/2017
CERTIFICATE AUTHENTICATION CODE	
RX3Y-K2-SR6C	

This certificate is issued under s87B of the Water Management Act, 2000.

NOTES (CONTINUED)

NOW REFERENCE NUMBER: 30AL314314
PREVIOUS WATER ACT LICENCE NUMBER(S): 30PT921362, 30BL184137.

**** END OF CERTIFICATE ****

Appendix C | Monitoring borehole log

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GROUNDWATER LOG : MONITORING BORE

PROJECT NUMBER 9023
PROJECT NAME Rowlands Creek Hydrogeology
CLIENT Jim Glazebrook
ADDRESS 350 Rowlands Creek Road, NSW
LICENCE NO. --

DRILLING DATE 29/03/2018
TOTAL DEPTH 21 m below ground level
DIAMETER 140 mm
CASING 50 mm Class 18 PVC
SCREEN 50 mm Class 18 PVC (Slotted)

COORDINATES --
COORD SYS MGA Zone 56
COMPLETION 21 m below ground level
SURFACE ELEVATION --
WELL TOC 800 mm above ground level

COMMENTS Monitoring bore installed 30 m from GW304537

LOGGED BY Universal Drilling
CHECKED BY CVM

PID	Samples	Analysed	% Recovery	Depth (m)	Graphic Log	Material Description	Well Diagram	Elevation (m)
				0		TOPSOIL	Surface seal (0 - 1 m grout)	
				1		CLAY		
				2			100 mm surface casing	
				3			50 mm Class 18 PVC (0 - 21 m) Stickup (800 mm)	
				4				
				5				
				6				
				7			Backfill (0 - 13 m)	
				8				
				9				
				10				
				11				
	SWL = 12 mbgl			12				
				13				
				14			Bentonite (13 - 14 m)	
				15		SHALE		
	Water strike at 15mbgl			16			Slotted PVC casing (15 - 21 m)	
				17				
	EC = 80 ppm			18			Filter pack (14 - 21 m)	
				19				
				20		BASALT		
				21		End of borehole: 21 m		

Disclaimer This bore log is intended for environmental not geotechnical purposes.

produced by ESlog.ESdat.net on 02 May 2018

ecological AUSTRALIA

ISO 14001 Environmental Management

AS/NZS 4801:2001 Occupational Health and Safety Management

ISO 9001 Quality Management

HEAD OFFICE
Suite 2, Level 3
668-672 Old Princes Highway
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

CANBERRA
Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 9542 5622

COFFS HARBOUR
35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

PERTH
Level 1, Bishop's See
235 St Georges Terrace
Perth WA 6000
T 08 9227 1070
F 02 9542 5622

MELBOURNE
Level 1, 436 Johnston St
Abbotsford, VIC 3076
T 1300 646 131

SYDNEY
Suite 1, Level 1
101 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9542 5622

NEWCASTLE
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 9542 5622

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2685
F 02 9542 5622

WOLLONGONG
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 9542 5622

BRISBANE
Suite 1, Level 3
471 Adelaide Street
Brisbane QLD 4000
T 07 3503 7192

HUSKISSON
Unit 1, 51 Owen Street
Huskisson NSW 2540
T 02 4201 2264
F 02 9542 5622

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4302 1266
F 02 9542 5622

MUDGEE
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1234
F 02 6372 9230

GOSFORD
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1221
F 02 9542 5622

ADELAIDE
Level 2, 70 Pirie Street
Adelaide SA 5000
T 08 8470 6650
F 02 9542 5622