Central Queensland Coal Project

Appendix 6d – Surface Water / Groundwater Interactions Report

Central Queensland Coal

CQC SEIS, Version 3

October 2020

Technical Report - Investigations on Groundwater – Surface Water Interactions

Central Queensland Coal

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Project Number	14860
Project Manager	Miles Yeates
Prepared by	Lauren Stephens
Reviewed by	Richard Cresswell
Approved by	Johan Du Plooy
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Template 2.8.1

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1. Introduction

1.1 Overview

Central Queensland Coal (CQC) is seeking to gain approval to undertake the development of a proposed open cut coal mine and related infrastructure within the Styx River Catchment, approximately 130 km north-west of Rockhampton, Queensland (the Project; Figure 1). The Project's environmental approvals process is at an advanced stage, with the Environmental Impact Statement (EIS) submitted to the Department of Environment and Science (DES) during 2017 and responses to submission of the EIS addressed through the development of a Supplementary EIS (SEIS) during 2018.

Eco Logical Australia Pty Ltd (ELA) has been engaged by CQC, on the advice of Orange Environmental, to undertake additional technical studies to investigate groundwater – surface water interactions in relation to groundwater dependent ecosystems (GDEs) for the Project, to support the update of the Project's SEIS (SEIS Version 3) following further responses received on the 2018 SEIS Version 2 submission.

1.2 Background

It is understood that the Department of Environment and Science (DES) has requested additional technical studies be undertaken following adequacy review of Version 2 of the SEIS, which identified potential Project impacts to GDEs has not been sufficiently addressed. Additional technical studies since completed by CQC include a regional groundwater model and hydrological modelling of surface water flows. The development of an integrated groundwater-surface water model will have ongoing benefits for the implementation of mitigation and management strategies through an adaptive management approach, as outlined in the Project GDE Management and Monitoring Plan (GDEMMP).

The development of a fully integrated model is an ongoing process, utilising the results of recently completed regional groundwater modelling, surface water modelling and onsite drilling assessments. To support the current supplementary impact assessment, ELA has been engaged to undertake technical studies in the short term to increase the understanding of groundwater – surface water interactions that occur in the Project area and to characterise the relationship with identified riparian vegetation and GDEs.

This report presents the scope, methodology and findings of the technical studies undertaken to support the updated SEIS.

Figure 1: CQC Project location

1.3 Scope of work

The scope of work consisted of the following:

- Characterisation of groundwater – surface water interactions and the relationship with identified riparian vegetation and potential GDEs located within and adjacent to the Project area.
- Further definition and description of GDE characterisation, functionality and vulnerability to assist with the development of a GDE conceptualisation.
- Development of conceptual and numerical (1-D and 2-D) models for the identified GDE areas that detail potential groundwater – surface water interactions in relation to the GDEs within the Project area.
- Development of a scope description, framework and requirements for an integrated numerical groundwater – surface water model, to be built based on the information gained from the technical studies outlined above and manage the potential Project impacts to GDEs.

Details on the specific technical studies undertaken and the associated methodologies has been provided in Section 2 below. The findings of all the technical studies will inform the GDE impact assessment and risk assessment detailed within the updated SEIS v3.

2. Methodology

The scope of work has been addressed by applying the following tasks and methodologies, undertaken in the following order:

- A review of the existing, available GDE studies and ecological surveys, including the 3D Environmental (2020) GDE assessment report, which identifies and characterises Aquatic and Terrestrial GDEs for the Project.
- Review of hydrogeological and geological data sourced from the alluvial drilling program undertaken on site by CQC (drilled 15 boreholes in 3 transects across Deep Creek and Tooloombah Creek) to confirm the hydraulic properties of the alluvium and creek / river bank deposits, estimate the base of the alluvium aquifer and thickness, the extent of the underlying weathered Styx Coal Measures interval and outcropping of the Styx Coal Measures (if present).
- Review of laboratory analysis results for particle size distribution (PSD), soil moisture content and salinity analyses, from soil samples collected during the drilling program. The data was used to estimate aquifer properties including hydraulic conductivities of the alluvial sediments, to assess the potential to provide water to support GDEs.
- Generation of geological cross-sections based on the transect profiles and existing bore logs, to estimate the extent and connectivity of the alluvium (unconsolidated sand and gravel sediments) with Tooloombah Creek and Deep Creek surface water features and pools, and the presence of clay layers within the profile that may inhibit groundwater-surface water flow and connection.
- Spatial analysis and mapping of groundwater level and quality data collected at the end of the wet and dry seasons in relation to the Deep Creek and Tooloombah creek bed elevation and locations of permanent surface water pools, to identify potential groundwater - surface water exchange in the region (i.e. groundwater losing and gaining conditions and estimated timing of these interactions).
- Development of analytical solutions to estimate river-water table fluxes and potential groundwater discharge volumes and rates from the alluvial aquifer to Deep Creek and Tooloombah Creek. Estimates were based on data obtained from the alluvial drilling program and laboratory analysis, and simulations were setup and run for each drilling transect.
- Review of existing baseflow assessments for all available stream gauges to characterise local and temporal groundwater – surface water interactions.
- Review and refinement of the recharge conceptualisation and validation against other markers / tracers (e.g. chloride profiles and isotopes) to verify groundwater model parameters and spatial discretisation.
- Develop a scope of the requirements, feasibility and framework for the development of a regional integrated numerical groundwater - surface water model to allow predictive scenarios to be run to inform GDE and riparian management and monitoring strategies.

- Provide recommendations on additional technical studies to be undertaken, if considered critical to the development of the integrated numerical groundwater – surface water model.

The technical studies above aim to gain further understanding of the groundwater – surface water interactions regarding GDEs at Tooloombah Creek and Deep Creek by specifically addressing the following information gaps to form a basis for development of the integrated numerical model:

- Confirmation of the alluvial aquifer unit extent and thickness.
- Assessment regarding bank storage as a feasible mechanism for groundwater - surface water interaction and the ability to provide water to sustain GDEs as proposed by 3D Environmental (2020).
- Assessment on whether bank storage is critical to the site and, if so, at which locations.
- Estimation / review of aquifer properties, soil moisture and salinity.
- Potential interactions between alluvial groundwater and surface water pools present at Tooloombah and Deep Creek.
- Potential volumes of groundwater available to sustain GDEs through bank storage mechanisms.

3. Data review

A review of the existing, available data and information relating to groundwater, surface water and GDEs has been undertaken for the Project area and has formed the basis of this work. The data sources that were reviewed included:

- Previous studies and reports completed for the site
  - 3D Environmental (2020) Groundwater Dependent Ecosystem Assessment – Central Queensland Coal Project, May 2020.
  - WRM (2020) Flood study and site water balance technical report, Central Queensland Coal Project, prepared for Central Queensland Coal Pty Ltd, 1596-01-E, 23 July 2020.
  - HydroAlgorithmics (2020) Numerical Groundwater Model and Groundwater Assessment Report – for the Central Queensland Coal Project Supplementary Environmental Impact Statement Version 3 – Responses to Submissions, Version 4 – Draft for Final Stage Peer Review, May 2020.
  - AMEC (2019) Groundwater Report for the Central Queensland Coal Project, prepared for Central Queensland Coal Pty Ltd by Australian Mining Engineering Consultants, November 2019.
  - Orange Environmental (2020a) Data summary tables for Groundwater.
  - Orange Environmental (2020b) Surface Water Quality Technical Report, Draft version A, August 2020.
- Available hydrogeological data from previous drilling programs and field surveys conducted onsite, including geological data and bore construction logs, core test data and estimated hydraulic parameters, downhole geophysics survey data, bore condition surveys and aquifer testing data.
- Available groundwater monitoring data (levels and quality) from the Project groundwater monitoring bores and registered bores within the region, sourced from Orange Environmental (2020a).
- Available surface water monitoring data (flow rates and volumes, and quality) from surface water monitoring sites, including identified permanent pools, and the Deep Creek and Tooloombah Creek streamflow gauging stations (DeGS1 and ToGS1 respectively), sourced from Orange Environmental (2020b).
- Geological data from the alluvial drilling program conducted by CQC at Deep Creek and Tooloombah Creek. Data consisted of stratigraphic logs, geological cross-section diagrams and laboratory analysis of sediment samples (PSD, soil moisture and salinity) collected from 15 boreholes, across 3 transects.
- Data and findings from previous leaf water potential, stable isotope and soil moisture data analyses and investigations for the Project.

- Available spatial data and information including digital elevation model (DEM) and LiDAR data for the region.

4. Regional setting

Information gained from the data sources reviewed in Section 3 was used to develop an understanding of the site and regional setting, from which the technical studies could provide further clarity on interactions between groundwater and surface water, and potential interactions with GDEs.

The following sections present a summary of the current understanding of the site and regional setting, in terms of the hydrogeological and hydrological systems and potential GDEs that have been identified for the Project to date. Further details on all aspects of the regional setting are provided in the SEIS Version 3 (CQC, 2020).

4.1 Climate

The Project region experiences a sub-tropical climate with a distinct wet season and dry season. The wet season occurs over the summer months (typically December to March) and the dry season extends from winter to early spring (June to September).

An increase in storm events is observed during the wet season, with the events being relatively short in duration but with intense rainfall and cyclonic rain depressions that form over the area. Figure 2 presents a summary of the average monthly climate conditions (rainfall and temperature) for Strathmuir, Ogmore (station 033189) located approximately 7 km from the Project. The average annual rainfall is 752 mm, with the highest and lowest average rainfall levels recorded at 143 mm and 16 mm during the months of February and September respectively. Mean maximum and minimum temperature was not available for the Strathmuir station and has been sourced from the St Lawrence station (033065) located approximately 55 km north-west of the Project. Temperature records for this station indicate mean maximum temperature ranges from 31.7°C in January to 23.8°C in July, with mean minimum temperature recorded at 22.5°C and 10.8°C also during these months.

As shallow groundwater and surface water generally receives the majority of recharge through rainfall infiltration, based on Figure 2, recharge to groundwater and stream runoff is highest during the summer months (wet season) when rainfall is highest. While this may be the case, long-duration rainfall events that occur throughout the year may also provide sustained rates of recharge to the groundwater and surface water systems (CQC, 2020).

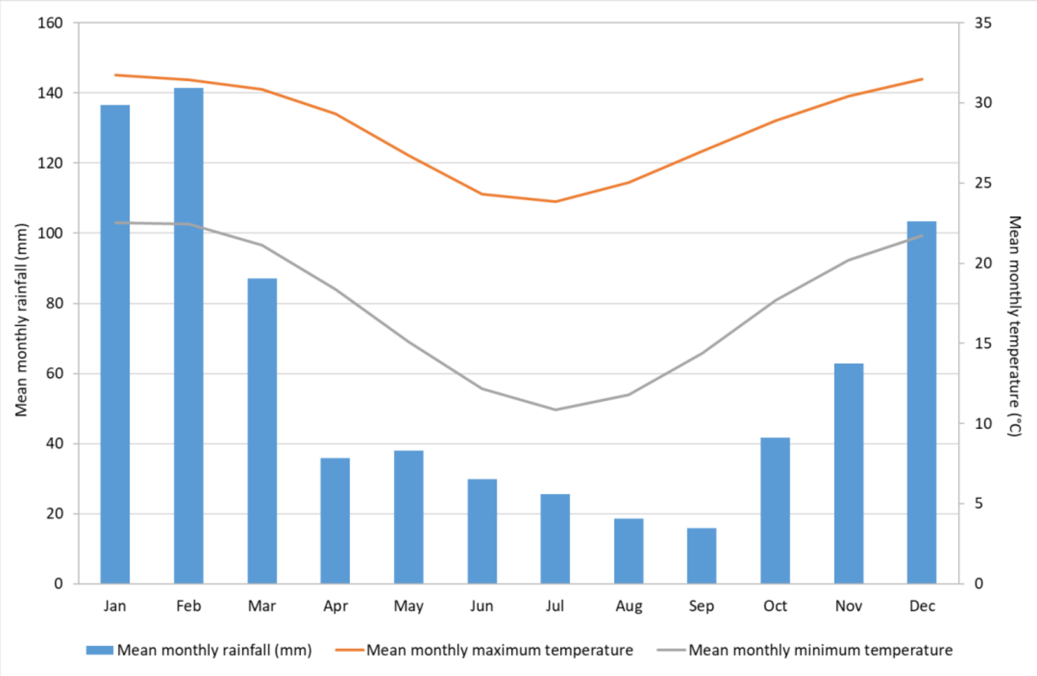

Figure 2: Mean monthly rainfall and temperature for the Project area

4.2 Topography

The Project is situated within the Styx River Catchment, within the Styx River Basin, and consists of flat or undulating terrain ranging in elevation between 0 mAHD and 540 mAHD across the catchment and between 4.5 mAHD and 155 mAHD within the Mining Leases (MLs) (CQC, 2020, SEIS version 3). Further, the elevation ranges from 11.4 to 43.8 mAHD within the disturbance footprint.

The catchment drains to the north via several smaller creeks and tributaries to the Styx River and estuary, before discharging to the Coral Sea (CQC 2020, version 3). The region is bordered by the Mount Buffalo State Forest and Mount Gardiner located to the west, and mountain ranges within the Bukkulla Conservation Park and Marlborough State Forest also exist to the east of the Project (Figure 3).

4.3 Geology

The Project targets the coal resources of the Styx Basin, known as the Styx Coal Measures. The Styx Basin is considered to have formed during the early-Cretaceous period and contains up to 1,000 m of siliclastic sediments and coal measures. The basin is approximately 2,000 km^2 in size and extends offshore to up to 100 m depth below sea level.

The Styx Coal Measures dip to the east and outcrop and subcrop beneath surficial Cenozoic alluvial/colluvial deposits along the western and central regions of the basin, from the St Lawrence township south to the headwaters of Tooloombah Creek (Figure 4). The coal measures comprise variably weathered quartzose sandstone, siltstone/mudstone, pebble conglomerates and coal that unconformably overlie the Permian Back Creek Group and are faulted against the Boomer Formation to the east (Figure 5). The Project is located within the southern portion of the Styx Basin and is bordered on the east by a post-depositional, high-angle reverse fault. Folding and faulting of the Cretaceous and Permian units has been observed on both sides of the fault (CQC 2020, version 3).

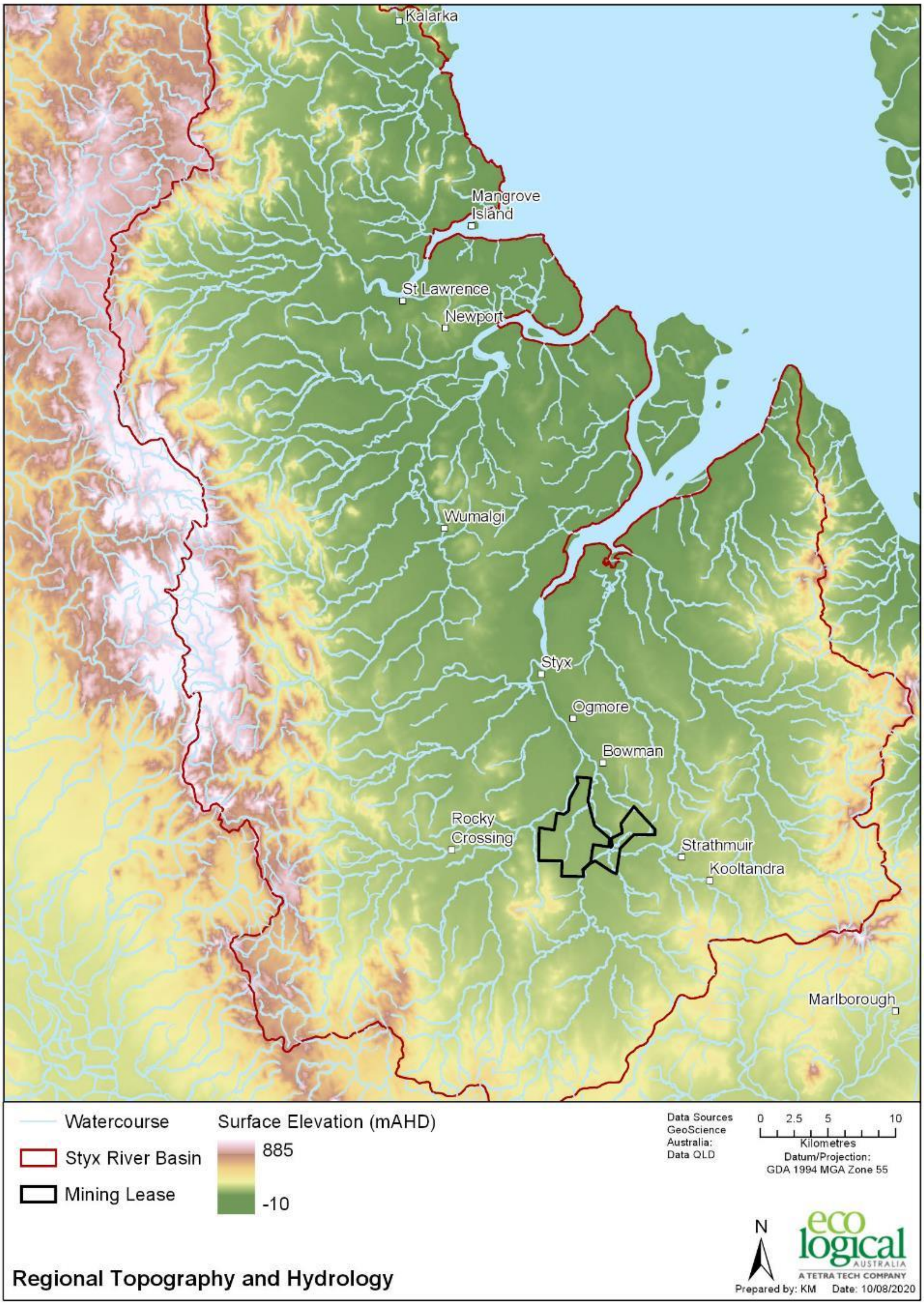

Figure 3: Regional topography and hydrology

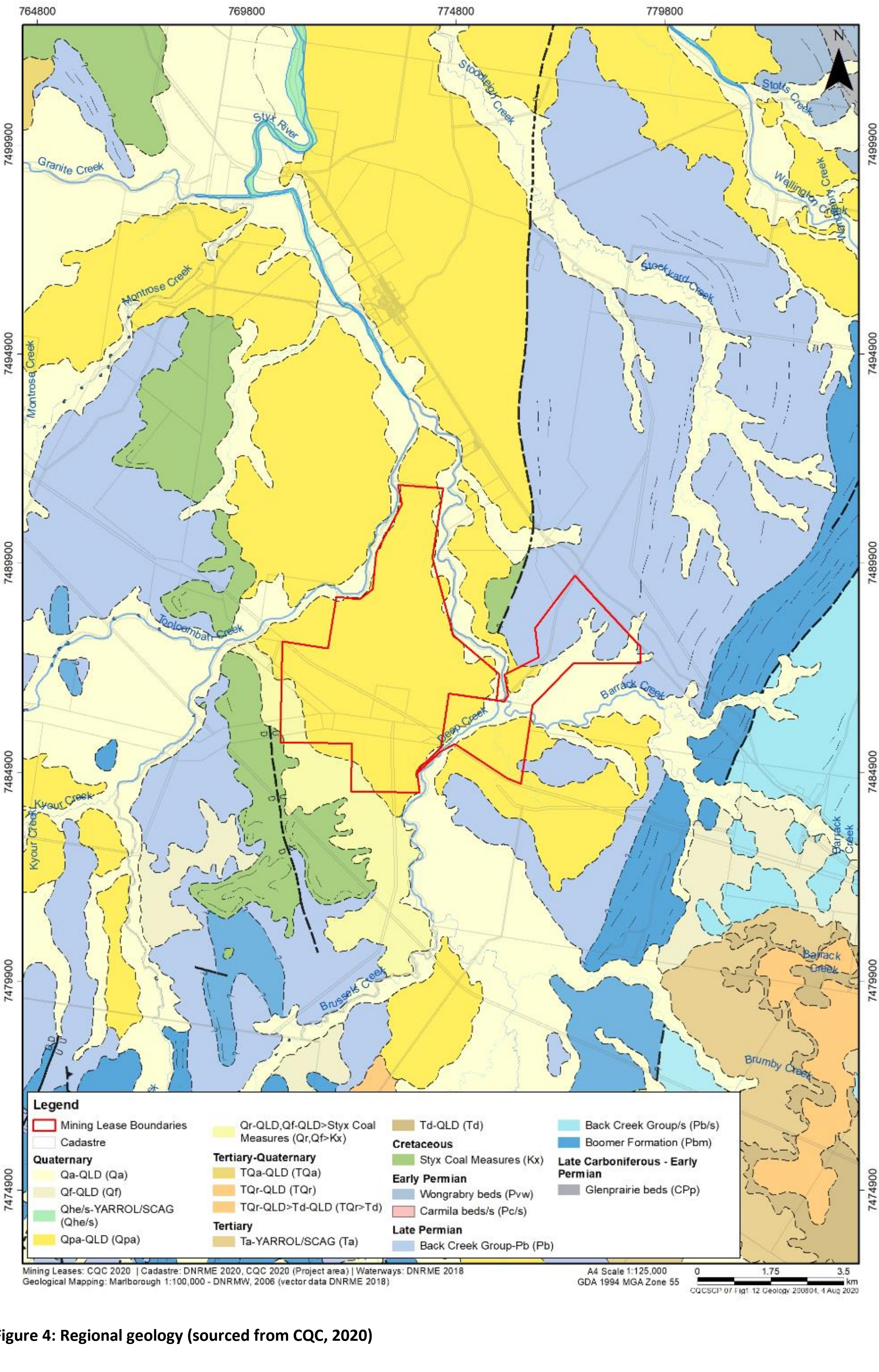

Figure 4: Regional geology (sourced from CQC, 2020)

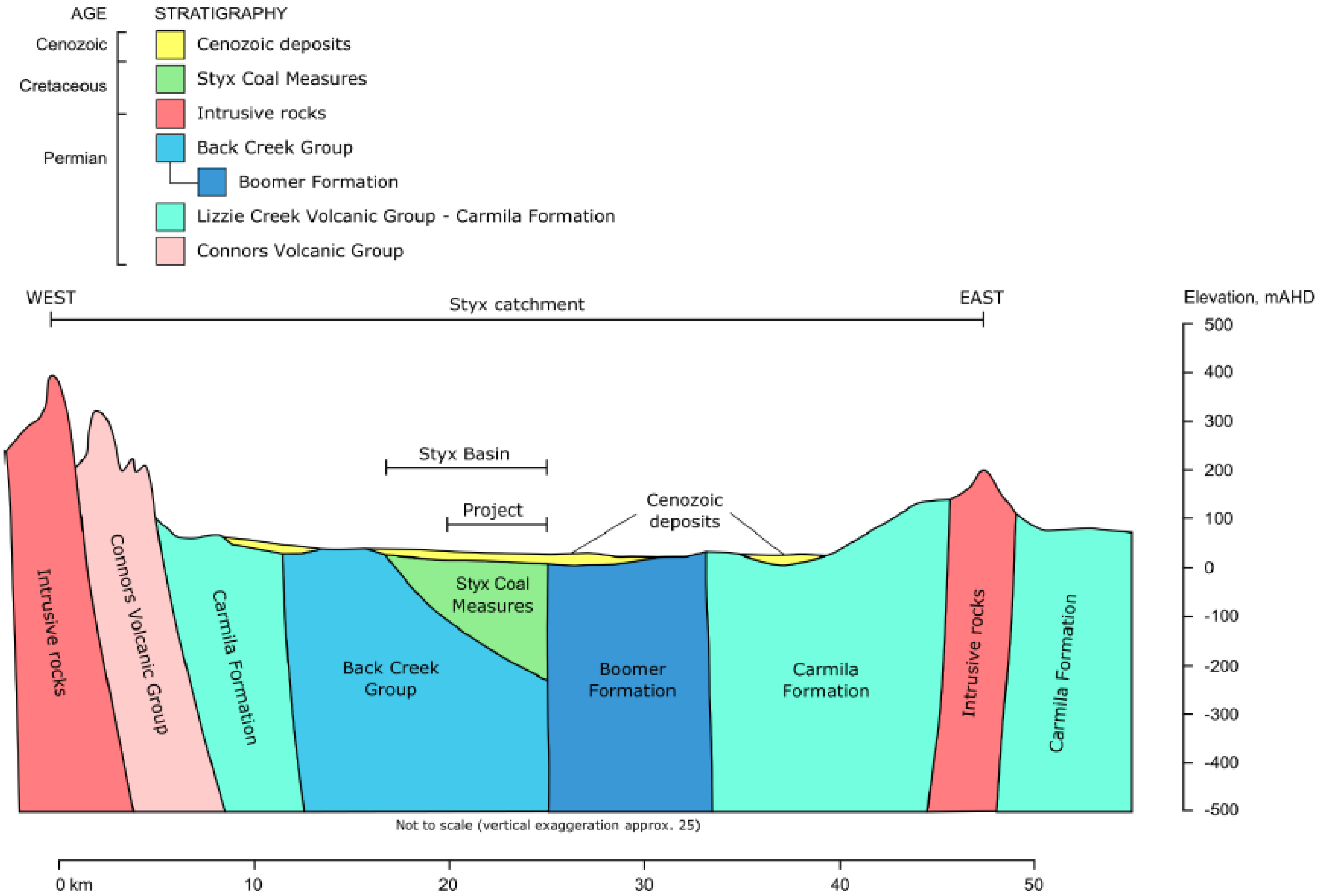

Figure 5 Stylised geological cross-section across the Styx Catchment

4.4 Surface water

The Styx River catchment is drained by Tooloombah Creek and Deep Creek, which are major tributaries to the Styx River, which is located north of the Project and drains to the Coral Sea. Tooloombah Creek and Deep Creek are located outside the mining lease (ML), along the western and eastern boundaries respectively (Figure 6), however the Project area is contained within their catchments. Minor ephemeral tributaries, ranked as first or second order drainage features, exist to both creeks and traverse the Project area. A number of pools exist along both creeks, with some considered to be permanent, while others have been observed to dry out during extended periods of low rainfall (WRM, 2020). The locations of the identified pools are provided in Figure 6.

The confluence of Tooloombah and Deep Creeks is located approximately 2.3 km downstream (north) of the Project area. Surface water is drained from the creeks to the Styx River and further north to Broad Sound Estuary, prior to discharging to the ocean (CDM Smith, 2018). The Styx River receives tidal influences on some extent downstream of the confluence of Deep Creek and Tooloombah Creek and is characterised by coastal and estuarine conditions in this area.

The following sections present further information on Deep Creek and Tooloombah Creeks as a basis to this study.

4.4.1 Deep Creek

Deep Creek is classed as a minor, ephemeral creek and is located within a catchment area of 298 km^2. The Deep Creek headwaters are located south of the Project and extend to the north between ML 80187 and ML 700022 before intersecting Tooloombah Creek at the confluence, approximately 2.3 km downstream of the Project. One streamflow gauge has recently been installed approximately 5 km upstream of the confluence with Tooloombah Creek (DeGS1), along the creek centreline. Surface water quality has been monitored at five sites with one located upstream (De1), two located adjacent to the Project (De2 and De3) and two located downstream relative to the Project (De4 and De5).

Deep Creek reaches approximately 8 -10 m depth (top of bank to creek bed) based on cross-sections generated by WRM (2020) for the region adjacent to the ML to the north of Bruce Highway, and cross-sections developed in this report at the southern and eastern boundary of ML 80187 (refer to Section 5.2.2 below). The creek width ranges from 2 to 3 m upstream to 5 to 10 m downstream of the Project. Stream stage height reaches approximately 4 m above the creek bed during large seasonal flow events, which often extend over several days. The creek bed consists of silts, sands and clays and is considered to facilitate recharge via infiltration to the underlying shallow alluvial aquifer.

The Deep Creek surface water is generally fresh, with electrical conductivity (EC) measured between 80 and 1,250 µS/cm. Salinity shows an increase during periods of low streamflow and immediately following the first flush of salts and nutrients that occurs at the beginning of the wet season.

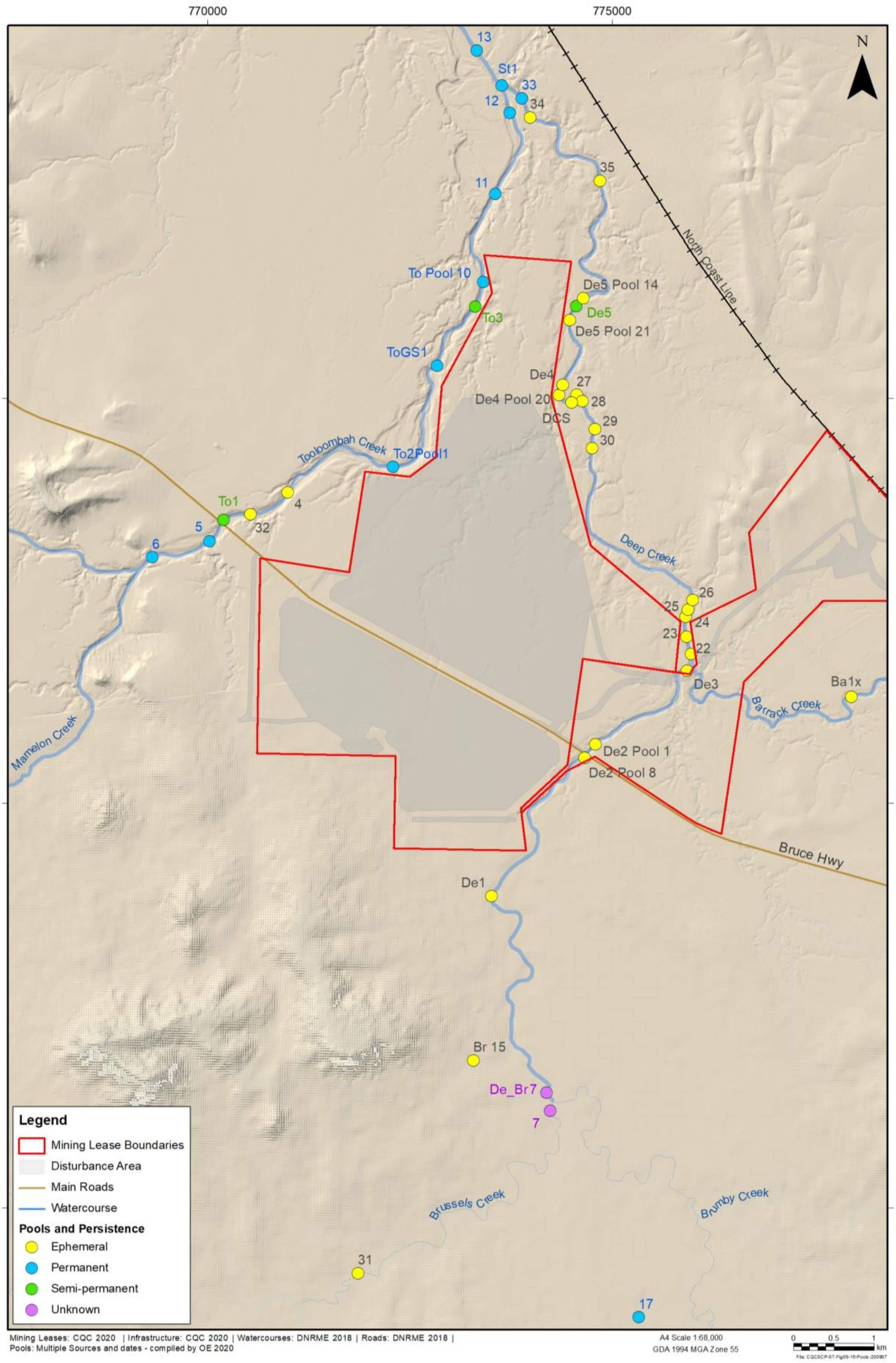

Figure 6: Tooloombah Creek, Deep Creek and identified surface water pools (OE, 2020b)

4.4.2 Tooloombah Creek

Tooloombah Creek is a major, ephemeral creek and runs from the south-west of the Project area to the north-east along the western Project boundary. Tooloombah Creek sits within a catchment of approximately 370 km^2. Similarly to Deep Creek, one streamflow gauge has recently been installed along Tooloombah Creek, approximately 4 km upstream of the confluence, along the creek centreline and adjacent to the location of DeGS1 installed at Deep Creek. Surface water quality is monitored at five sites with two located upstream (To4 and To1), one located adjacent to the Project (To2) and two located downstream relative to the Project (To3 and St1). Site St1 is located at the confluence of Deep and Tooloombah Creeks, but is still considered part of Tooloombah Creek.

In comparison to Deep Creek, Tooloombah Creek is significantly deeper and up to 15 m deep in some sections, with steep sided slopes that are fully vegetated. The channel width ranges from 4 to 5 m upstream and increases to 10 to 15 m width downstream. The creek bed is more rugged than that observed in Deep Creek, consisting of rocks, gravels and boulders. Outcrops of sandstone from the Styx Coal measures have been observed along the creek bed in different sections of the creek. Anecdotal evidence suggests the creek receives an average of three flow events per year, with stage heights reaching approximately 7 m (from gauging station data). Due to the constrained catchment size, streamflow has been observed to occur over a short duration (approximately 1 - 2 days) following these events (based on gauging station data).

The Tooloombah Creek 'pinch point' is located to the west of the CQC Project, downstream of the Tooloombah Creek and Mamelon Creek confluence and between Mt Brunswick and Mt Mamelon at approximately 25 mAHD elevation (HydroAlgorithmics, 2020). This feature is considered to have formed where the creek incises through the sandstone ridge and acts to typically restrict / concentrate flow within Tooloombah Creek and the shallow alluvial aquifer at this location. This potentially causes local groundwater levels to be elevated compared to the surrounding areas. One stream monitoring point (To4) is present upstream of this location; To1 is located immediately downstream.

Surface water samples collected from Tooloombah Creek between 2011 and 2018 show higher salinities than Deep Creek, with EC ranging from approximately 190 µS/cm to 3,530 µS/cm, with one pool (the gauging station) recording EC up to 9,300 µS/cm. This is explored below (Section 5.2.3). As observed for Deep Creek, salinity at Tooloombah Creek also increases during periods of low streamflow and immediately following the first flush of salts and nutrients at the beginning of each wet season (CDM Smith, 2018).

4.5 Groundwater

4.5.1 Hydrostratigraphic units

The regional groundwater system comprises the following four hydrostratigraphic units (or aquifers) that are relevant to the Project, as conceptualised and modelled by HydroAlgorithmics (2020):

- **Alluvial (Holocene) groundwater system:** includes alluvial sediments within deep cut infills of Tooloombah Creek and Deep Creek, in addition to estuarine sediments towards the Styx River mouth to the north (downstream) to the CQC Project.

- **Alluvial (Pleistocene) groundwater system:** includes Cenozoic sediments that overlie the Early Cretaceous Styx Coal Measures.
- **Sedimentary rock groundwater system:** consists of the shallow Early Cretaceous Styx Coal Measures including the relatively higher permeability coal seams.
- **Sedimentary and fractured (basement) rock groundwater systems:** includes the shallow and deep fractured rock aquifer and the Permian Back Creek Group, to Carmila Beds and the Lizzie Creek Volcanic Group to the Connors Volcanic Group.

The studies detailed in this report focus on the shallow alluvium aquifer; an unconfined aquifer consisting of local unconsolidated Cenozoic alluvium, colluvium, soils and estuarine deposits of low to high productivity, depending on the thickness and depth. The underlying Styx Coal Measures is also significant to the assessment, to identify the potential connection and contribution of groundwater from the coal measures with shallow alluvial groundwater and surface water, and potentially supporting GDEs.

ALLUVIUM

The alluvium sediments are associated with watercourses and flood plains and watercourses and swamp deposits located higher within the catchment and in the coastal and estuarine areas of the lower catchment. Geological mapping indicates the alluvium sediments outcrop at surface largely throughout ML 80187, except for within the south-western corner where the Styx Coal Measures is observed at surface. The mapping shows the Quaternary Pleistocene (Qpa) units (consisting of sand, mud and gravel) overlie much of the Styx Coal Measures in the vicinity of the CQC Project area. In terms of conceptualisation, a separation has been identified between the Quaternary (Holocene) Alluvium and the Quaternary Pleistocene Alluvium / Regolith on the basis of their hydraulic properties (HydroAlgorithmics, 2020).

Groundwater level within the Quaternary alluvial aquifer generally reflects the regional topography, with depth to groundwater varying from approximately 10 to 15 m below ground level (mbgl) across most of the Project area and the surrounding creeks (HydroAlgorithmics, 2020).

STYX COAL MEASURES

The Styx Coal Measures consist of an isolated block of Lower Cretaceous sediments comprising interbedded, overlying and underlying sandstone and mudstone units that unconformably overlie the Permian aged Back Creek Group (HydroAlgorithmics, 2020). The coal measures are described as a poor aquifer due to the typically low hydraulic conductivities observed. Groundwater exists within the sequence of coal seams and interburden rocks due to the higher permeabilities encountered in some of these layers. Groundwater level has been recorded at depths between 8 m and 18 mbgl for bores installed within the coal measures (overburden, interburden and underburden).

4.5.2 Aquifer properties

A review of the hydraulic properties obtained from aquifer testing, published reports and previous modelling studies for the Project area was considered during the development of the CQC Project hydrogeological conceptualisation and numerical groundwater model by HydroAlgorithmics (2020). The hydraulic conductivities obtained from the review are summarised below:

- Quaternary Alluvium: K = 0.0001 – 10 m/day
- Styx coal measures
  - Overburden: K = 0.0075 m/day
  - Coal seams and interburden: K = 0.0001 to 0.22 m/day
  - Underburden: K = 0.005 m/day

Permeability tests undertaken by AMEC (2019) on four shallow groundwater monitoring bores in the vicinity to Tooloombah Creek and Deep Creek also reported the following hydraulic conductivities:

Located between Tooloombah Creek and Open Cut 2

- Upper Quaternary Alluvium: K = 2.2×10^{-3} m/day
- Lower Quaternary Pleistocene Alluvium / Regolith: K = 9.5×10^{-5} m/day

Located between Deep Creek and Open Cut 2

- Upper Quaternary Alluvium: K = 3.2×10^{-3} m/day
- Lower Quaternary Pleistocene Alluvium / Regolith: K = 1.1×10^{-3} m/day

Based on the review of information and the updated conceptualisation, the following aquifer hydraulic conductivity parameters were used in the design of the CQC Project numerical model developed by HydroAlgorithmics (2020):

- Quaternary Alluvium: K = 4.1 to 10 m/day
- Styx coal measures
  - Overburden: K = 0.02 m/day
  - Coal seams and interburden: K = 0.003 to 0.22 m/day
  - Underburden: K = 0.004 m/day

4.5.3 Groundwater flow

Groundwater flow is generally to the north towards the Styx River and the coast, however can vary across the catchment depending on local scale recharge and discharge. The regional water table generally reflects the topography, with groundwater flow lines for the upper catchment region converging at the lower reaches of Tooloombah and Deep Creek. The lower catchment area shows flowlines converge at the Styx River and Broad Sound Estuary (HydroAlgorithmics, 2020).

4.5.4 Groundwater quality

Groundwater sourced from the Quaternary alluvial aquifer ranges from 469 to 12,362 µS/cm, except for one bore (BH25) where electrical conductivity (EC) ranges from 11,620 to 40,600 µS/cm. Groundwater pH generally ranges from slightly acidic to slightly alkaline (6.5 to 8.0 respectively). This is considered suitable for most purposes; however, EC may exceed Queensland Water Quality Guidelines (QWQG) for aquatic ecosystems (HydroAlgorithmics, 2020).

The Quaternary Pleistocene alluvium / regolith reports EC from less than (<) 1,000 µS/cm to greater than (>) 47,000 µS/cm, with pH ranging from slightly acidic to slightly alkaline (5.9 to 8.6 respectively). Groundwater pH may exceed Queensland Water Quality Guidelines (QWQG) for aquatic ecosystems (HydroAlgorithmics, 2020).

Salinity is generally higher within the deeper Styx Coal Measures and generally exceeds 14,000 µS/cm. The pH levels have been recorded between 6.8 to 8.2 (slightly acidic to slightly alkaline). No notable trend in higher salinity across the Project area has been observed.

FRESHWATER – SALTWATER INTERFACE

The Project is not expected to result in any discernible change to the location of the freshwater-saltwater interface. HydroAlgorithmics (2020) undertook a review of available groundwater quality datasets and found there is no idealistic freshwater-saline groundwater interface evident, which is not unexpected given the geological and geomorphological history of the region. Also, the theoretical interface depth (based on the Ghyben-Herzberg Relationship) is much deeper than areas to be disturbed or affected by the Project (HydroAlgorithmics 2020).

4.6 Groundwater dependent ecosystems

4.6.1 Identified GDEs

Several field studies undertaken by 3D Environmental (2020), including leaf water potential analysis, core drilling, soil moisture potential and stable isotope analysis of twig xylem, soil moisture and surface water and groundwater, have formed the basis for the identification of aquatic and terrestrial GDEs for the Project, detailed in Table 1.

Aquatic GDEs are defined as ecosystems that are dependent on the surface expression of groundwater and include wetlands and springs. Terrestrial GDEs are defined as ecosystems that are reliant on the subsurface presence of groundwater and include terrestrial vegetation. These GDE types were assessed by 3D Environmental (2020) at the following five assessment areas (Figure 7):

- Wetland 1;
- Wetland 2;
- Tooloombah Creek;
- Vine Thicket (part of Tooloombah Creek); and
- Deep Creek.

Table 1 presents a summary of the potential GDEs identified at each of the assessment areas. 3D Environmental (2020) note that no terrestrial GDEs were identified within the Wetland 2 assessment area; the study findings indicate Wetland 2 is a surface drainage feature with no connectivity to deeper groundwater sources.

Table 1 : Potential Aquatic and Terrestrial GDEs associated with the Project (based on 3D Environmental, 2020)

Assessment area	Potential GDE	Description
Wetland 1	YES - *Melaleuca viridiflora* (broad-leaved paperbark) accesses water from a perched aquifer and is a Terrestrial GDE.	Wetland 1 is a Wetland Protection Area (WPA) and consists of wetlands with *Melaleuca* species and / or Forest Red Gum (*Eucalyptus tereticornis*) (Eco Logical Australia, 2020). The study indicated that vegetation at Wetland 1 sources water from a perched aquifer, generated by surface water infiltration, with a maximum depth of approximately 8 m. Vegetation is unlikely to source water from the deeper groundwater system where aquifer depth is 13.5 mbgl. The use of a perched aquifer by the broad-leaved paperbark at Wetland 1 is consistent with the definition of a Terrestrial GDE.
Wetland 2	NO - *Eucalyptus tereticornis* (red gum) is present, however is not identified as a Terrestrial GDE.	Wetland 2 is a surface drainage feature with no connectivity to deeper groundwater sources. There is no indication that trees are accessing moisture from depths greater than 4 mbgl. *Eucalyptus crebra* (ironbark) trees are present, however are not considered to access groundwater due to their shallow root system.
Vine Thicket (located on the southern bank of Tooloombah Creek)	NO – The Vine Thicket vegetation community is not utilising groundwater.	Located on the southern bank of Tooloombah Creek and bound to the north by the main channel of the creek and a flood overflow channel to the south.
Tooloombah Creek	YES - *Eucalyptus tereticornis* (red gum; Terrestrial GDE); *Melaleuca fluviatilis* (weeping paperbark; Aquatic GDE); and *Casuarina cunninghamii* (river oak)	Located approximately 1km downstream of the Vine Thicket assessment area. Red gum, weeping paperbark, river oak (*Casuarina cunninghamii*) and bottle brush (*Melaleuca viminalis*) are present.
Deep Creek	YES - *Eucalyptus tereticornis* (red gum; Terrestrial GDE); *Melaleuca leucadendra* (weeping paperbark; Aquatic GDE)	Located on Deep Creek upstream of the confluence with Barrack Creek. Tall red gum (up to 35 m height) exist along the margins of the alluvial terrace and a mid-dense sub-canopy of *Melaleuca leucadendra* (weeping paperbark) is present along the inner terrace adjacent to the creek. The *Melaleuca leucadendra* (weeping paperbark) species at Deep Creek relies on access to surface water in stream pools and water held in fluvial sands, instead of through a deep root system, and meets the definition of an Aquatic GDE.

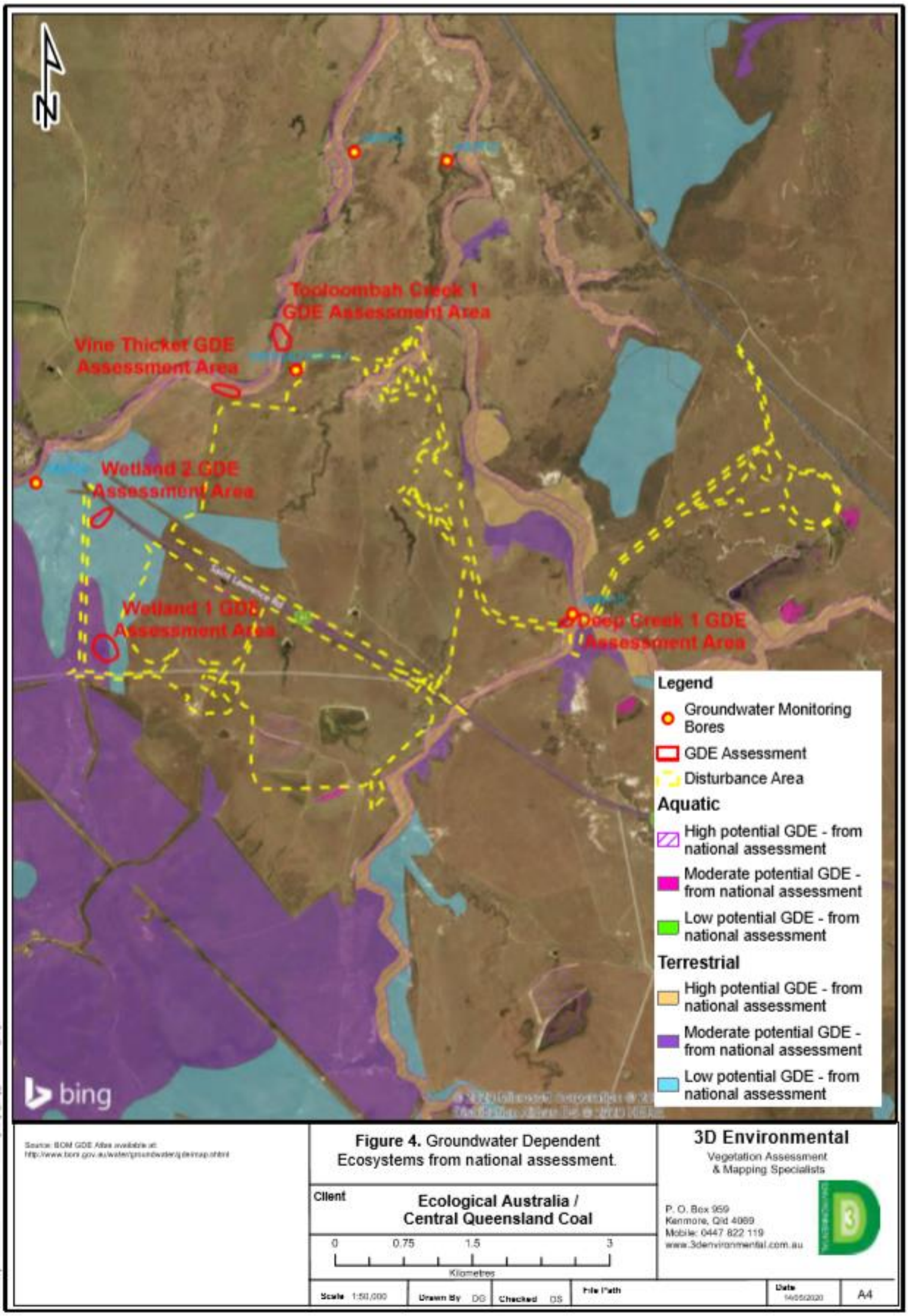

Figure 7: GDE assessment areas (sourced from 3D Environmental, 2020)

4.6.2 GDE conceptual models

The following conceptual models for the Tooloombah Creek, Vine Thicket and Deep Creek GDE assessment areas have been developed by 3D Environmental (2020) and are located within the technical study areas for this report. The results of the technical studies (detailed in Section 5) will be used to verify these conceptual models. The conceptual model developed for the Wetland 1 GDE assessment area has not been included due to its location outside of the three transects investigated during the alluvial drilling program for this report.

TOOLOOMBAH CREEK & VINE THICKET AREAS

The conceptualisation considers that vine thicket species access soil moisture from the alluvial sediments in the unsaturated zone of Tooloombah Creek, with no indication of groundwater being utilised on a seasonal basis at this site. The conceptualisation considers soil moisture is dependent on bank storage, where seasonal rainfall and flooding in Tooloombah Creek provides recharge to the shallow alluvial groundwater system in the creek bank via lateral infiltration, with water returning to the creek through interflow from the banks in the dry season (Figure 8 to Figure 10).

Regarding the regional groundwater table, the Tooloombah Creek and associated pools are considered to experience losing stream conditions during the dry season when the regional groundwater level generally drops below the base of the creek, causing the hydraulic gradient to shift, with surface water providing recharge via vertical infiltration to the regional groundwater table (Figure 10). The balance of inflows to outflows varies pool to pool, depending on the surrounding alluvial geology; return flows from the alluvial banks and possible influence from the underlying regional water table. This variability is explored through technical studies outlined below in Section 5.

The red gum species identified in this area, however, is considered to access deeper, more saline groundwater held in saprolite and associated thin weathered coal seams below the alluvium / Styx Coal Measures (3D Environmental, 2020).

The Tooloombah Creek conceptualisation closely mimics the vine thicket assessment area for the river red gum species. However, the weeping paperbark is better represented by the Deep Creek conceptualisation presented in Figure 11 to Figure 13.

3D Environmental (2020) reported the potential for a hydraulic connection to exist between the surface water pools in this area and the alluvial groundwater system. This is also considered a possible cause for the changes in salinity observed within the pools, which ranges from approximately 1,000 to 9,300 µS/cm.

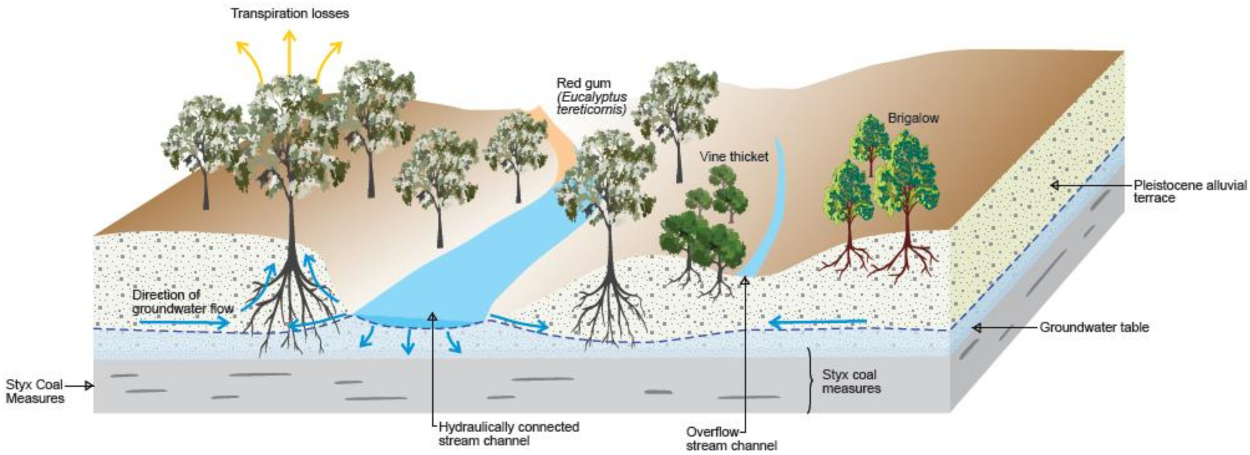

Figure 8: Tooloombah Creek Vine Thicket Dry season conceptualisation (sourced from 3D Environmental, 2020)

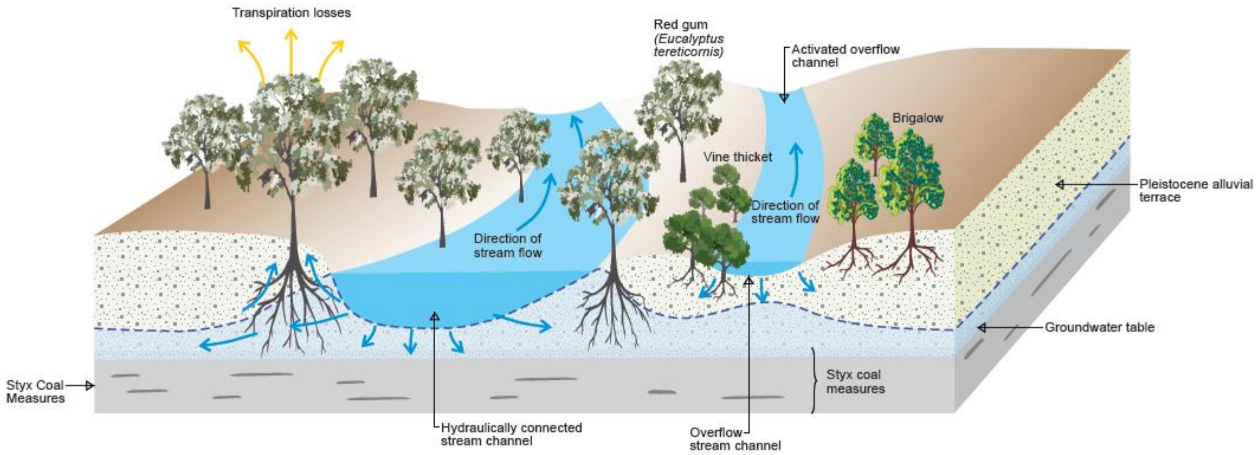

Figure 9: Tooloombah Creek Wet season conceptualisation (sourced from 3D Environmental, 2020)

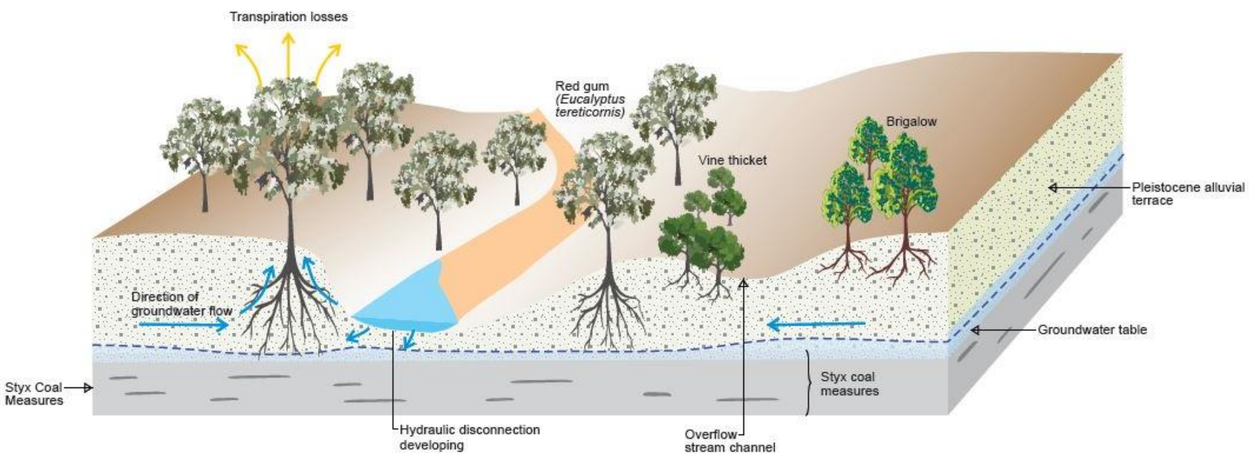

Figure 10: Tooloombah Creek Drought conceptualisation (sourced from 3D Environmental, 2020)

DEEP CREEK

The Deep Creek conceptualisation is similar to Tooloombah Creek and shows baseflow returning to the creek channel during the dry season and wet season flows providing recharge to the alluvial aquifer along the creek banks and levees (bank storage) via lateral flow (Figure 11 and Figure 12). Critically, more extensive overbank flooding results in an expanded aquatic habitat during the wet months allowing weeping paperbank (*M. leucadendra*) to proliferate. The flooding results in recharge that is expected to cause groundwater mounding within the bank adjacent to the creek channel and potentially prolonged groundwater discharge back into the creek and surface water pools via returning bank storage after high stream flow events have passed.

Similar to Tooloombah Creek, Deep Creek experiences losing stream conditions during the dry season when groundwater level generally drops below the base of the creek, causing the hydraulic gradient to shift and surface water provides recharge via vertical infiltration to groundwater (Figure 11 and Figure 13). Thicker postulated sequences of alluvial and weathered sediments compared to Tooloombah Creek, however, mean that groundwater recedes faster and relatively deeper for Deep Creek and only the deeper-rooted River Red Gums (*E. tereticornis*) can access the dropping regional water tables.

It is considered, therefore, that the weeping paperbark and red gum species present at the Deep Creek assessment area access a saturated water source, with the weeping paperbark accessing surface water from pools present at the site (that is, they are essentially an Aquatic GDE), while the red gum is considered to access a non-saline source of water at the base of the weathered zone between the alluvium and underlying Styx Coal Measures (that is, they represent a terrestrial GDE; 3D Environmental, 2020).

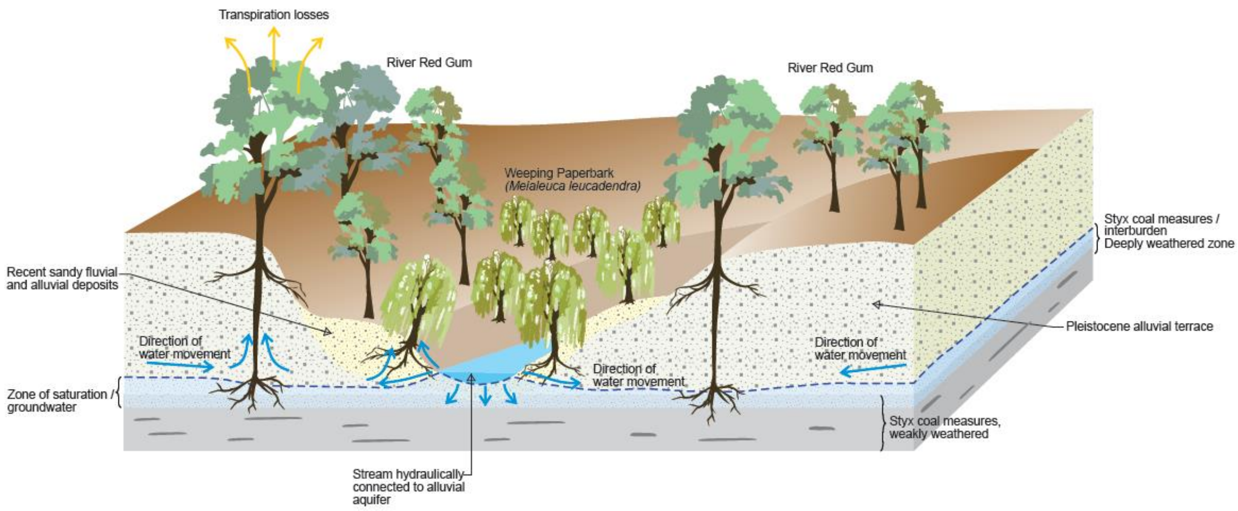

Figure 11: Deep Creek Dry season conceptualisation (sourced from 3D Environmental, 2020)

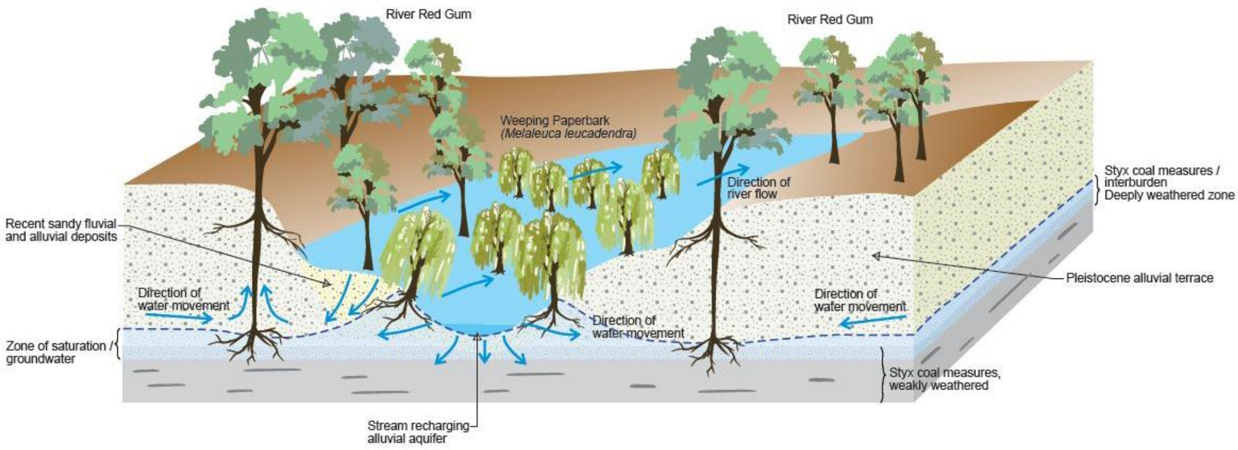

Figure 12: Deep Creek Wet season conceptualisation (sourced from 3D Environmental, 2020)

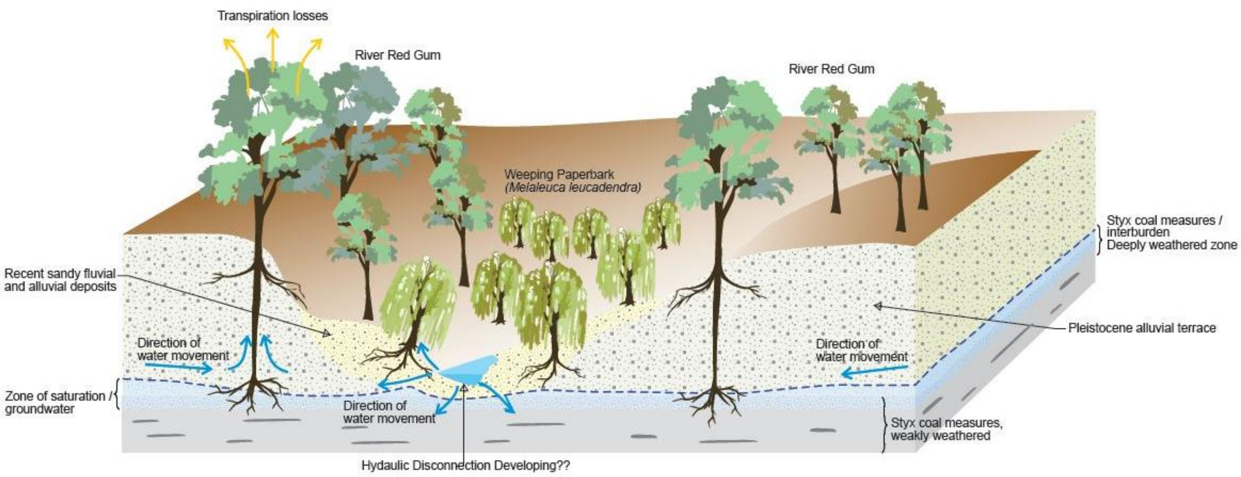

Figure 13: Deep Creek Drought conceptualisation (sourced from 3D Environmental, 2020)

5. Technical studies

As previously discussed in Section 4, the technical studies aim to gain further understanding of the groundwater – surface water interactions regarding GDEs and to verify the Tooloombah Creek and Deep Creek conceptual models presented above. The study aims to specifically address the following information gaps to form a basis for development of the integrated numerical model:

- Confirmation of the alluvial aquifer unit extent and thickness (Section 5.1)
- Assessment regarding bank storage as a feasible mechanism for groundwater - surface water interaction and the ability to provide water to sustain GDEs as proposed by 3D Environmental (2020; Section 5.2.1)
- Assessment on whether bank storage is critical to the site and, if so, at which locations (Section 5.2.2)
- Estimation / review of aquifer properties, soil moisture and salinity (Section 5.2.1)
- Potential interactions between alluvial groundwater and surface water pools present at Tooloombah and Deep Creek (Section 5.2.2)
- Potential volumes of groundwater available to sustain GDEs through bank storage mechanisms (Section 5.2.4)

5.1 Drilling program

It is understood that alluvial groundwater potentially exists as a perched system that resides above impermeable (to some extent) layers of clay and/or weathered Styx Coal Measures. A total of 15 boreholes were drilled within 3 transects intersecting Deep Creek and Tooloombah Creek during May 2020 to define the base and extent of the alluvium, the extent of the underlying weathered Styx Coal Measures and any clay layers present within the profile that may inhibit groundwater flow and potential interaction between groundwater and surface water.

The transect locations are presented in Figure 14 and were selected in the vicinity of the Tooloombah and Deep Creek GDE assessment areas and the Vine Thicket GDE assessment area studied by 3D Environmental (2020; refer to Figure 7). Data from the May 2020 transects has been analysed in this report. However further drilling has since been undertaken (during July 2020) associated with the installation of additional boreholes and transects along Tooloombah Creek (Figure 14). This data may be incorporated into the assessment at a later stage, however a preliminary review of the data indicates the results align with the May 2020 findings. Geological cross-section diagrams for Transects A to C are provided in Figure 15 to Figure 17, with the cross-sections for the July 2020 drilling provided in Appendix B.

The drilling program identified the following:

- Transmissive units exist within the alluvium, typically as sands and gravels. Therefore, bank storage is feasible.

- While the geological cross sections show the Quaternary sediments extend as a continuous unit across the transect, the transmissive alluvial sediments within this formation (specifically sands and gravels) consist in sporadic, discontinuous pockets. Therefore, the drilling data cannot be applied as a blanket across the Project area and further mapping and assessment will be required for finer scale considerations.
- The Deep Creek North transect intersects the north-south trending geological fault line that has been mapped on the eastern side of Deep Creek (Figure 15).
- Deep Creek South: the base of the alluvium (defined as Quaternary, unconsolidated sands and gravels) sits at approximately 30 mAHD to 20 mAHD (1 mbgl) before entering sandstone (i.e. Styx Coal Measures).
- Deep Creek North: the alluvium base sits between 20 and 18 mAHD across the transect (an average of 6 mbgl), with RDK07 (nearest to the creek) reaching 10 mbgl.
- The creek bed at Deep Creek North shows incisions of approximately 8 - 10 m into the Quaternary Alluvium but does not intersect the underlying Styx Coal Measures.
- Tooloombah Creek: the base of the alluvium was recorded between 12 and 16 mAHD (an average of 10 mbgl with RTK03 deepening to 14 mbgl approximately 110 m east of the creek).
    - Investigations conducted within the creek bed to the north-west of the Tooloombah Creek transect showed areas of the creek bed consist of Weathered Styx Coal Measures, with creek incisions at approximately 15 m within the Quaternary Pleistocene Alluvium.
    - Tooloombah Creek also contains a higher clay content, which generally underlies the alluvium sediments and is likely to restrict connection between the alluvial aquifer (where present) and the underlying Styx Coal Measures.

Drilling sediment samples were collected throughout the bank profile to the base of the alluvium and at various depths within the Styx Coal Measures. The samples were submitted to a NATA accredited laboratory to undergo the following testing:

- Particle size distribution (PSD) analysis, to allow estimation of hydraulic conductivity (K; m/s) for the sediments encountered at each depth;
- soil moisture content; and
- salinity.

The laboratory results were used to inform the analytical modelling undertaken in Section 5.2. A summary of the drilling data, in terms of the alluvium extents, depths and estimated hydraulic conductivities using the laboratory results is provided in Table 2. Full analytical results are presented in Appendix C.

Figure 14: Locations of alluvium drilling transects within the CQC Project area

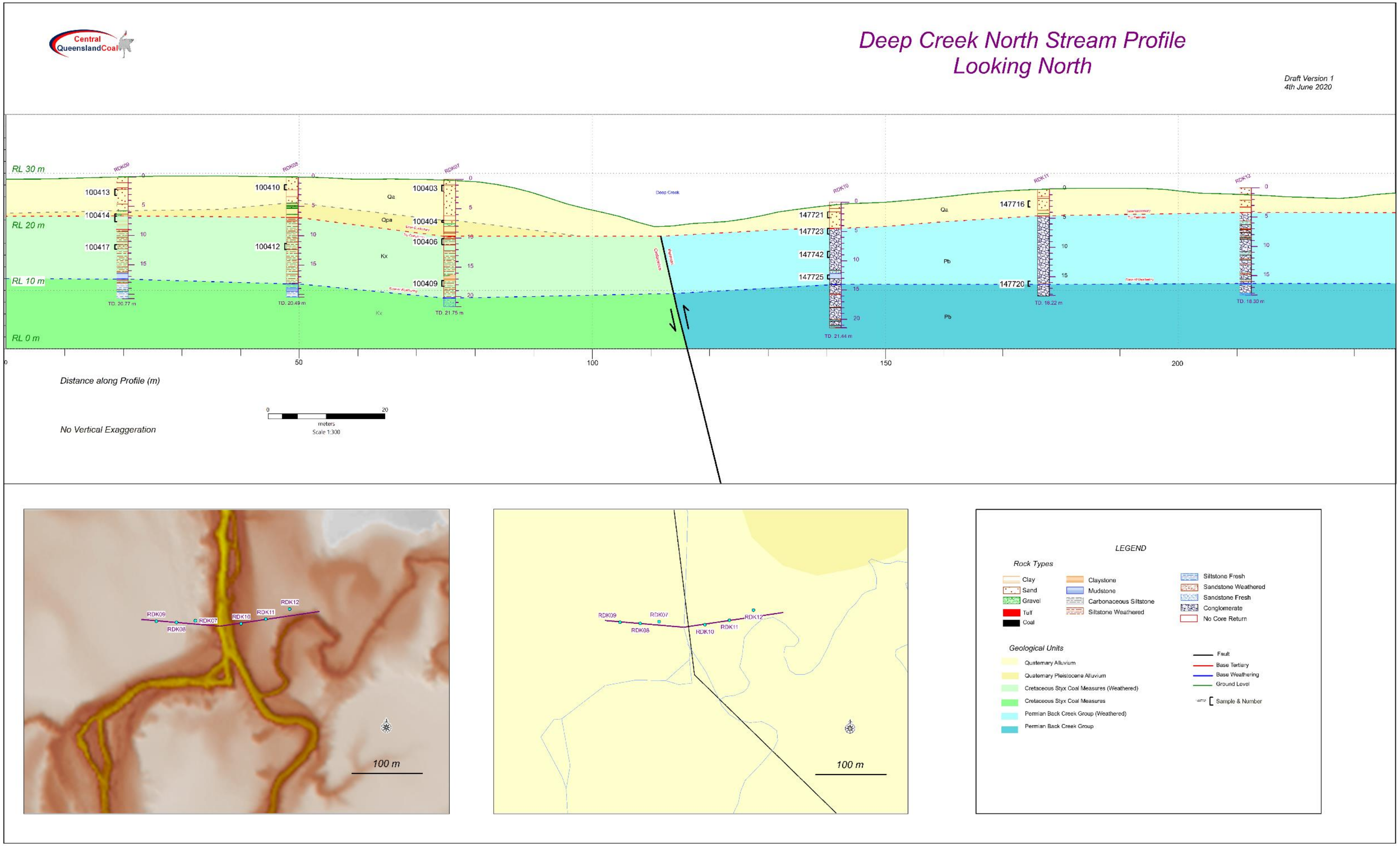

Figure 15: Deep Creek North cross-section (provided by CQC, 2020)

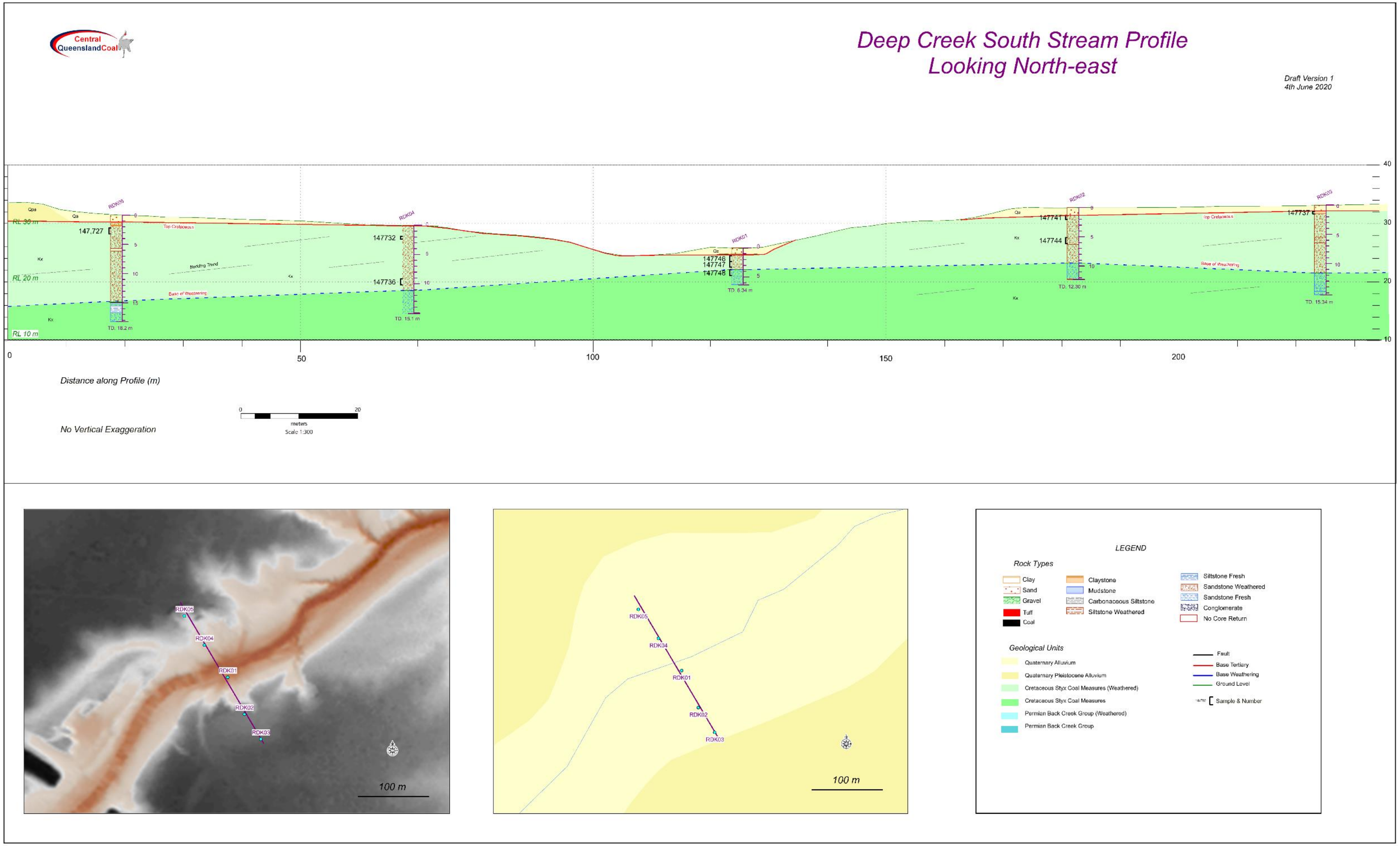

Figure 16: Deep Creek South cross-section (provided by CQC, 2020)

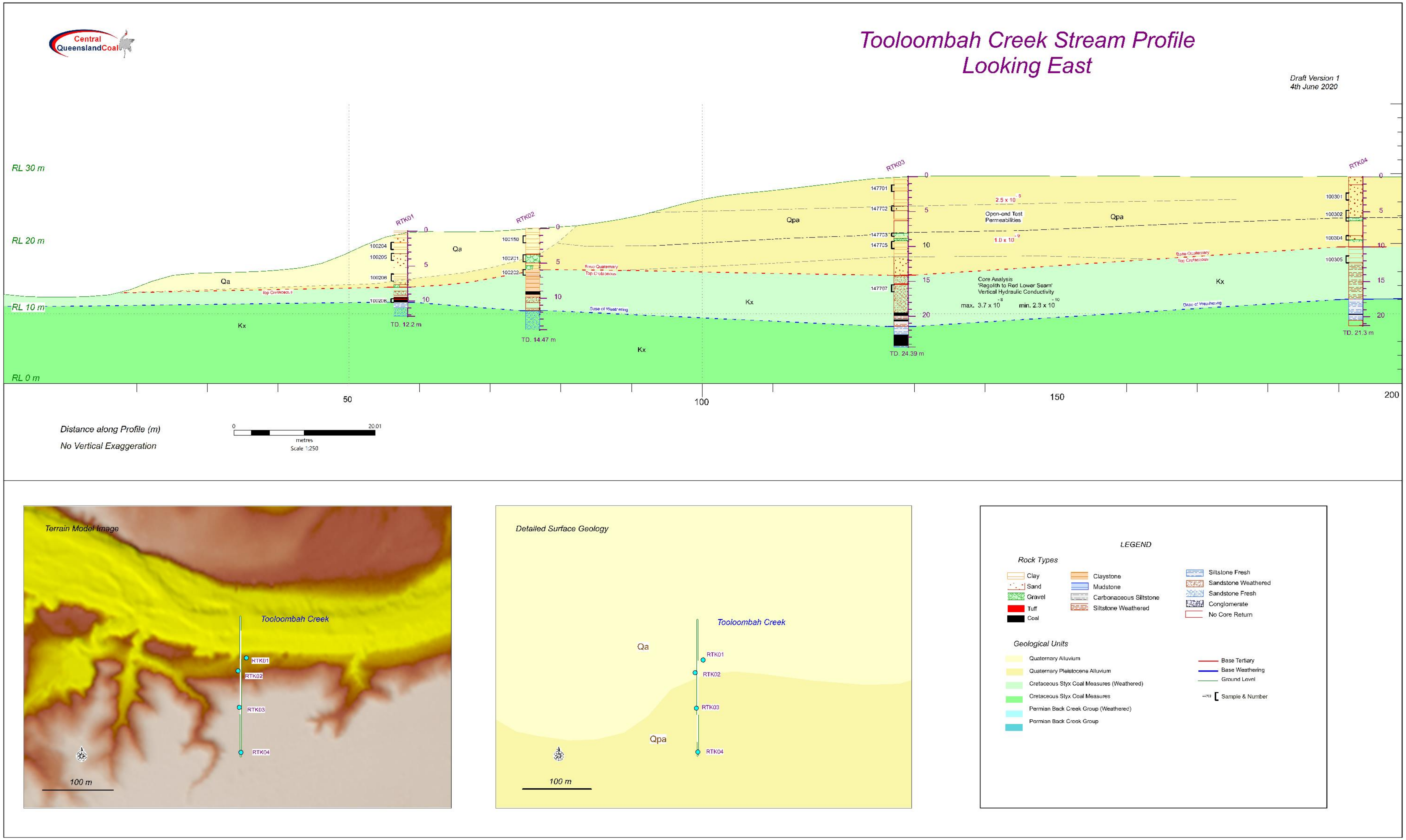

Figure 17: Tooloombah Creek cross-section (provided by CQC, 2020)

5.2 Analytical modelling

5.2.1 Aquifer properties

HYDRAULIC CONDUCTIVITY

Hydraulic conductivity was estimated for the sediments at each drill hole to inform estimates of potential groundwater discharge volumes and rates from the shallow alluvial aquifer to Tooloombah and Deep Creek GDE assessment areas, assuming lateral flow occurs from bank storage. The ability and likelihood for Terrestrial GDEs to utilise groundwater can also be estimated from hydraulic conductivity, on the assumption that plants are unable to take groundwater when hydraulic conductivities are less than in the order of 10^{-7} metres/second (m/s).

A number of the alluvium drilling samples were clay-rich, hence particle size distribution (PSD) was unable to be estimated using the majority of industry accepted methods such as the Beyer (1964) equation and Wang et al. (2017) equation, which use grain size diameter measurements for which 10% and 60% of the sample is finer (i.e. D_{10} and D_{60}). These solutions are valid for 0.06 mm < D_{10} < 0.6 mm; and 0.05 mm < D_{10} < 0.83 mm and 0.09 mm < D_{60} < 4.29 mm respectively (clay grain size is typically < 0.002 mm). Instead, D_{20} measurements were used within empirical calculations to provide the hydraulic conductivity estimates in Table 2. It is noted that hydraulic conductivity could not be estimated for the Deep Creek South samples (RDK01 to RDK05), due to 100% sandstone and claystone sediments encountered.

Table 2: Alluvium drilling data and estimated hydraulic conductivity

Location	Bore ID	Alluvium base (mbgl)	SWL (mbgl)	Sample ID	Sediment type	Sample depth (mbgl)	K (m/s)	K (m/d)	Interpreted geology*
Tooloombah Creek	RTK01	8	8	100203	Sand	1 – 1.62	ND	ND	Qa
				100204	Clay	1.62 – 2.62	8.9E-06	0.77	Qa
				100205	Sand	3.2 – 4.2	8.9E-06	0.77	Qa
				100206	Clay	6.15 – 7.15	4.6E-09	4E-4	Qa / Qpa
				100207	Gravel 40%, sand 60%	7.7 – 8.03	ND	ND	Qpa /Kx (w)
				100208	Coal 82%, tuff 18%	9.48 – 10.2	3.6E-06	0.31	Kx (w)
	RTK02	6	8	100150	Clay	1 - 2	4.6E-09	4E-4	Qa
				100201	Clay 60%, gravel 40%	3.72 – 4.72	2.7E-11	2E-6	Qa / Qpa
				100202	Claystone	5.85 – 6.64	1.6E-07	0.014	Qpa /Kx (w)
	RTK03	14	10	100219	Clay	0.6 – 1.18	ND	ND	Qpa
				147701	Clay	1.18 – 2.12	1.6E-07	0.01	Qpa
				147702	Sand	4.22 – 4.89	4.6E-09	4E-4	Qpa

Location	Bore ID	Alluvium base (mbgl)	SWL (mbgl)	Sample ID	Sediment type	Sample depth (mbgl)	K (m/s)	K (m/d)	Interpreted geology*
				147703	Gravel 40%, sand 60%	8.09 – 8.55	2.7E-11	2E-6	Qpa
				144704	Clay	9.16 – 9.3	ND	ND	Qpa
				147705	Clay	9.3 – 10.3	4.6E-09	4E-4	Qpa
				144706	Sand	11.5 – 12.3	ND	ND	Qpa
				147707	Sandstone	15.49 – 16.49	7.7E-07	0.07	Kx (w)
				147708	Sandstone	18.3 – 19.3	ND	ND	Kx (w)
				147709	Coal	19.5 – 19.9	ND	ND	Kx (w)
				100401	Coal	20.5 – 20.7	ND	ND	Kx (w) / Kx
				100402	Coal	22.65 - 24.23	ND	ND	Kx
	RTK04	10	9	100301	Sand	2.3 – 3.3	2.7E-11	2E-6	Qpa
				100302	Sand	4.8 – 5.85	2.7E-11	2E-6	Qpa
				100303	Gravel	5.85 – 6.3	7.7E-07	0.07	Qpa
				100304	Sand	8.41 – 9.02	3.6E-06	0.31	Qpa
				100305	Clay	11.3 – 12.3	ND	ND	Kx (w)
				100306	Siltstone	12.3 - 12.9	ND	ND	Kx (w)
				100307	Siltstone	12.9 – 13.1	ND	ND	Kx (w)
Deep Creek North (Western bank)	RDK07	10	8	100403	Sand	1 - 2	3.6E-06	0.31	Qa
				100404	Sand	7 – 7.32	8.9E-06	0.77	Qa / Qpa
				100406	Siltstone	10.12 –	ND	ND	Kx (w)
				100407	Siltstone	13.2 – 14.2	ND	ND	Kx (w)
				100408	Clay 60%, gravel 40%	16.39 – 16.52	ND	ND	Kx (w)
				100409	Siltstone	17.25 -	ND	ND	Kx (w)
	RDK08	7	6	100410	Sand	1.31 – 2.16	1.7E-05	1.45	Qa
				100411	Siltstone	7.8 – 8.8	ND	ND	Qpa
				100412	Siltstone	11.32 -	ND	ND	Kx (w)
	RDK09	6.5	3	100413	Sand	2.1 – 3.1	3.6E-06	0.31	Qa
				100414	Gravel 40%, Sand 60%	6.35 – 6.65	3.6E-06	0.31	Qpa /Kx (w)
				100415	Clay	6.65 - 7.65	ND	ND	Qpa /Kx (w)

Location	Bore ID	Alluvium base (mbgl)	SWL (mbgl)	Sample ID	Sediment type	Sample depth (mbgl)	K (m/s)	K (m/d)	Interpreted geology*
				100416	Siltstone	9.3 – 10.3	ND	ND	Kx (w)
				100417	Sandstone	11.57 - 12.32	ND	ND	Kx (w)
Deep Creek North (Eastern bank)	RDK10	4.5	5	147721	Sand	1.65 – 2.65	1.7E-05	1.45	Qa
				147722	Sand	3.71 – 4.45	ND	ND	Qa
				147723	Conglomerate	4.45 – 5.45	ND	ND	Qa / Pb (w)
				147742	Conglomerate	8.4 – 9.42	ND	ND	Pb (w)
				147725	Conglomerate	12.41-	ND	ND	Pb (w)
				147726	Conglomerate	14.43-	ND	ND	Pb (w) / Pb
	RDK11	5	8.5	147716	Sand	1.52 – 2.52	3.6E-06	0.31	Qa
				147717	Conglomerate	4.5 – 5.15	ND	ND	Qa / Pb (w)
				147718	Conglomerate	6.25 – 7.25	ND	ND	Pb (w)
				147719	Conglomerate	9.2 – 10.2	ND	ND	Pb (w)
				100720	Conglomerate	15.2 –16.06	ND	ND	Pb (w) / Pb
	RDK12	4	7	147711	Clay 24%, Sand 76%	1.86 – 2.86	ND	ND	Qa / Pb (w)
				147712	Conglomerate	4.62 – 5.62	ND	ND	Pb (w)
				147713	Conglomerate	9.32 –10.32	ND	ND	Pb (w)
				147714	Conglomerate	13.2 -14.15	ND	ND	Pb (w)
				147715	Conglomerate	16.34 -17.2	ND	ND	Pb
Deep Creek South	RDK01	1.2	4	147746	Sandstone	1.33 – 2.33	ND	ND	Kx (w)
				147747	Sandstone	2.33 – 3.3	ND	ND	Kx (w)
				147748	Sandstone	3.72 – 4.76	ND	ND	Kx
	RDK02	1	10.5	147741	Sandstone	1.35 – 2.02	ND	ND	Qa / Kx (w)
				147742	Sandstone	2.34 – 3.3	ND	ND	Kx (w)
				147743	Sandstone	4.6 – 5.14	ND	ND	Kx (w)
				147744	Sandstone	5.14 – 6.14	ND	ND	Kx (w)
				147745	Sandstone	9.3 – 10.3	ND	ND	Kx (w) / Kx
	RDK03	1	7.5	147737	Claystone	1.08 – 1.5	ND	ND	Qa / Kx (w)
				147738	Sandstone	1.5 – 2.04	ND	ND	Kx (w)
				147739	Sandstone	2.04 – 3.04	ND	ND	Kx (w)
				147740	Sandstone	5.53 – 6.3	ND	ND	Kx (w)

Location	Bore ID	Alluvium base (mbgl)	SWL (mbgl)	Sample ID	Sediment type	Sample depth (mbgl)	K (m/s)	K (m/d)	Interpreted geology*
	RDK04	No alluvium	Dry	147732	Sandstone	1.86 – 2.34	ND	ND	Kx (w)
				147733	Sandstone	2.34 – 3.1	ND	ND	Kx (w)
				147734	Sandstone	5.17 – 6.11	ND	ND	Kx (w)
				147736	Sandstone	9.16 –	ND	ND	Kx (w)
	RDK05	1	7	147727	Sandstone	2.15 – 3.15	ND	ND	Kx (w)
				147728	Sandstone	4.84 – 5.68	ND	ND	Kx (w)
				147729	Sandstone	8.15 – 9.15	ND	ND	Kx (w)
				147730	Sandstone	11.18 –	ND	ND	Kx (w)
				147731	Sandstone	13.3 - 14	ND	ND	Kx (w)

NOTES: ND = Not determined; *Qa = Quaternary (Holocene) Alluvium; Qpa = Quaternary Pleistocene Alluvium; Kx (w): Weathered Styx Coal Measures; Kx = Styx Coal Measures; Pb(w) = Permian Back Creek Group (Weathered); Pb = Permian Back Creek Group.

Information presented in Table 2 suggests that the alluvial sediments (Qa and Qpa), classified as sand and gravels, are generally sufficiently transmissive (i.e. K = 10^{-7} m/s or higher) to facilitate lateral flow through bank storage and facilitate groundwater uptake by local Terrestrial GDEs. This is observed at all locations along the Deep Creek North transect, and to a lesser extent at Tooloombah Creek, where a significant portion of the observed profiles at RTK02, RTK03 and RTK04 have lower estimated conductivities (i.e. order of 10^{-9} to 10^{-11} m/s). This is likely due to the higher clay content observed in the drilling data for this region and this may restrict groundwater uptake for plants in these areas.

The samples collected from the Quaternary Pleistocene Alluvium (Qpa) and the weathered Styx Coal Measures (Kx (w)) interface within the bore profiles also show similar conductivities to the overlying alluvium (i.e. K = 10^{-6} and 10^{-7} m/s). These conductivities may provide an indication of surface water infiltration through the outcropped weathered Styx Coal Measures observed within the creek beds. Further assessment is required on the more recent (July 2020) drilling program results to confirm these observations at other sites.

The increase in K observed towards Tooloombah Creek also suggests that bank storage groundwater flows towards RTK01 and the creek bed. At Deep Creek, K increases from RDK07 to RDK09 suggesting that bank storage groundwater flows away from the creek in this area. The increase in K (m/s) values away from the creek, and the direction of the hydraulic gradient (also away from the creek), facilitates groundwater flows in this direction.

The range in hydraulic conductivities observed throughout the profiles of each drill hole (i.e. 10^{-5} to 10^{-11} m/s for sands and gravels) supports the notion that the transmissive alluvial units are discontinuous and exist in pockets throughout the region.

SOIL MOISTURE & SALINITY

The soil moisture content and salinity results from each drill hole were plotted against the sample depth (in mAHD) for sand and gravel sediments, clays and the Styx Coal Measures (claystone, sandstone, siltstone, etc.) based on the field geologist's lithological interpretation of the bore hole during drilling. Figure 18 to Figure 22 present the plots for Tooloombah Creek and Deep Creek North.

The salinities and soil moisture values were also mapped on the cross-section diagrams below for the Tooloombah Creek and Deep Creek transects to help infer spatial trends (Figure 23 and Figure 24). The results suggest the following:

- An increase in salinity with increasing depth (except for RTK03 at Tooloombah Creek) and an increase in soil moisture with depth. There is also evidence to suggest fresher water exists in pockets throughout the creek profiles.
- Salinity within the alluvium does not exceed 7800 EC at Tooloombah Creek and 3060 EC at Deep Creek North; therefore, moisture can be considered reasonable for GDEs to use (assuming water up to 10,000 µS/cm EC is suitable for tree use).
- Soil moisture below 13% has been considered indicative of relatively dry soil. The few samples which show higher moisture (15 – 20%) are located around RL 15 - 20 mAHD depth and tend to consist of the sands and gravels, and at Tooloombah creek, potentially saturated clays within these layers.

Based on the above, moisture appears to more easily travel through the sands and gravels than through the finer grained units (e.g. clays) as would be expected. This supports the hydraulic conductivities estimated in Table 2 that suggest the alluvium units are generally transmissive enough to facilitate lateral flow through bank storage, as well as groundwater uptake by Terrestrial GDEs.

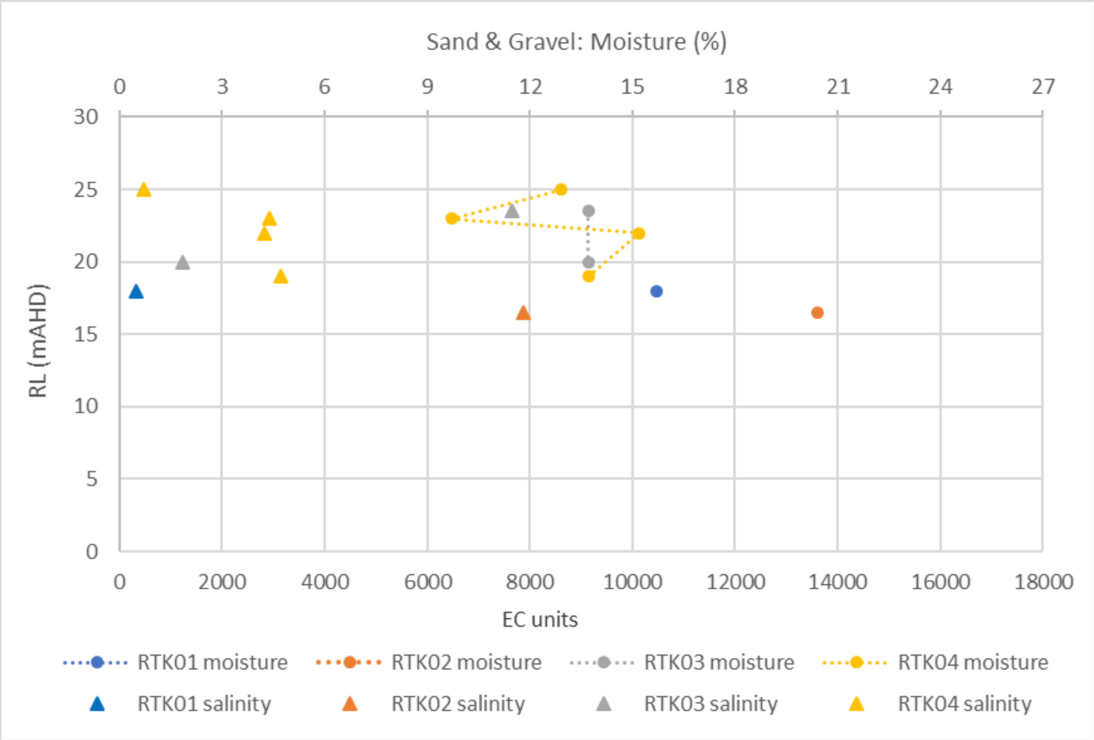

Figure 18: Tooloombah Creek soil moisture and salinity vs. depth for sand and gravel units

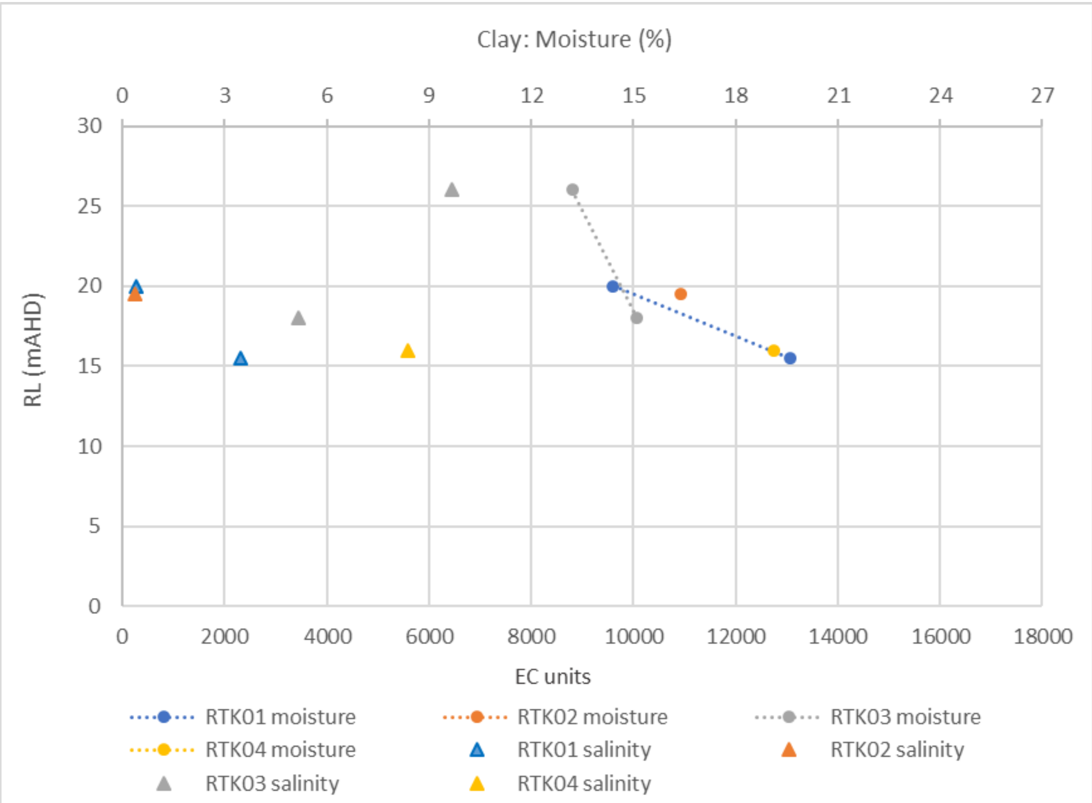

Figure 19: Tooloombah Creek soil moisture and salinity vs. depth for clay units

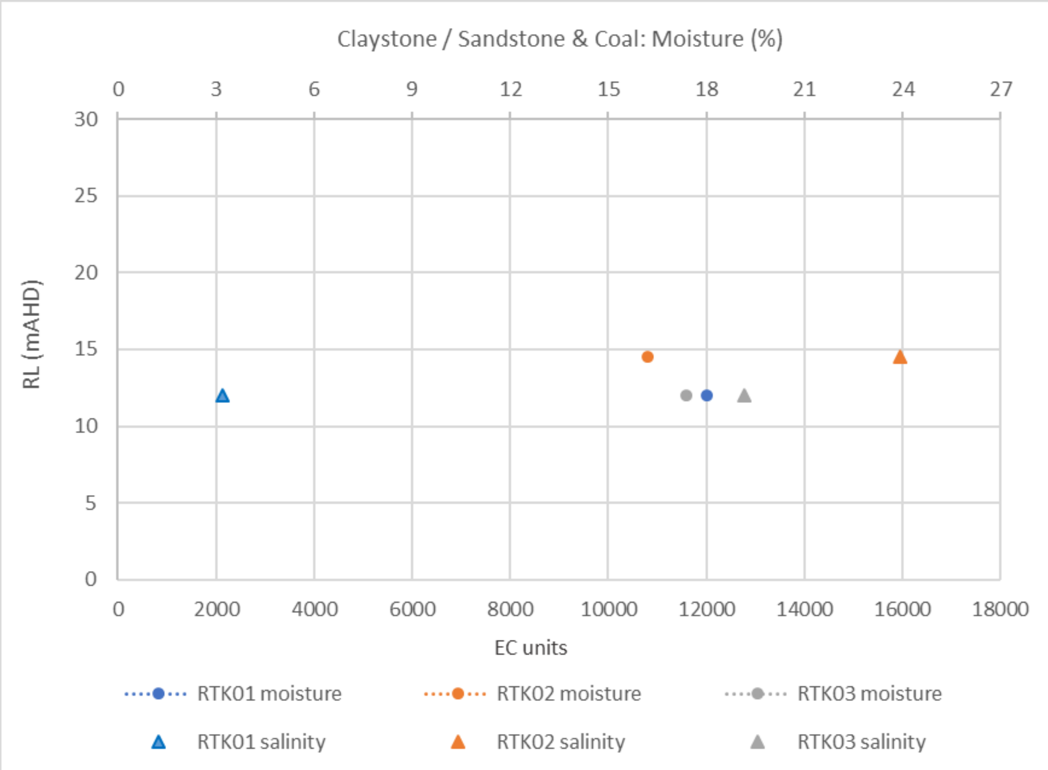

Figure 20: Tooloombah Creek soil moisture and salinity vs. depth for the Styx Coal Measures (claystone, sandstone and coal)

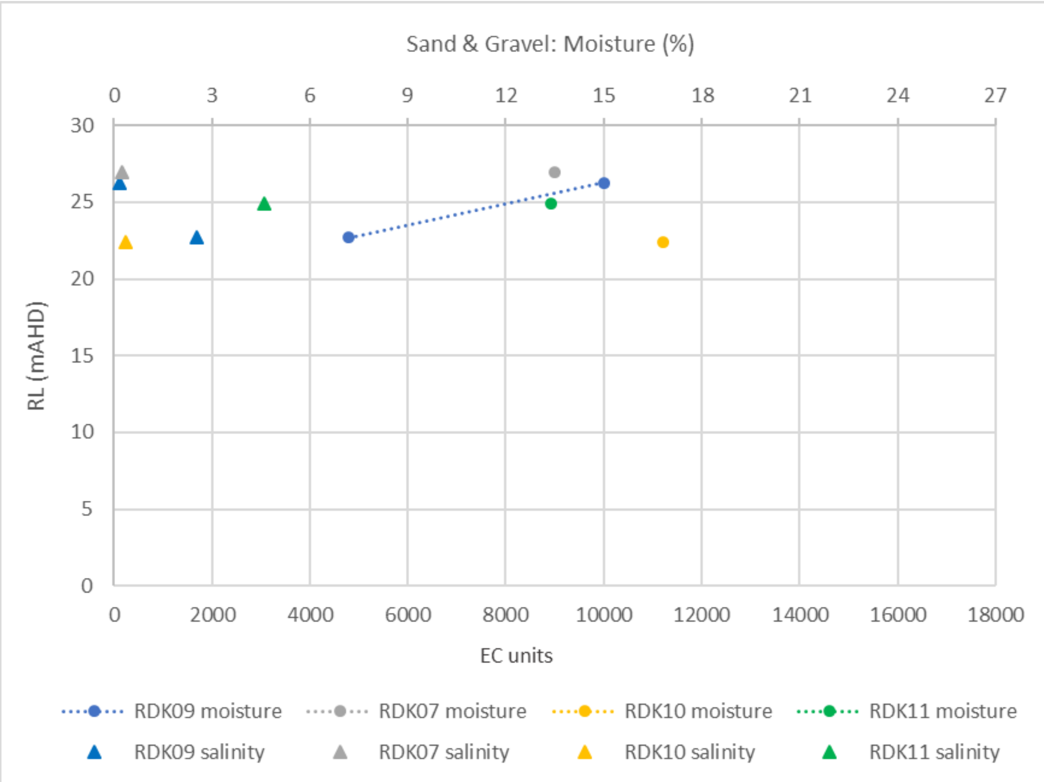

Figure 21: Deep Creek North soil moisture and salinity vs. depth for sands and gravels

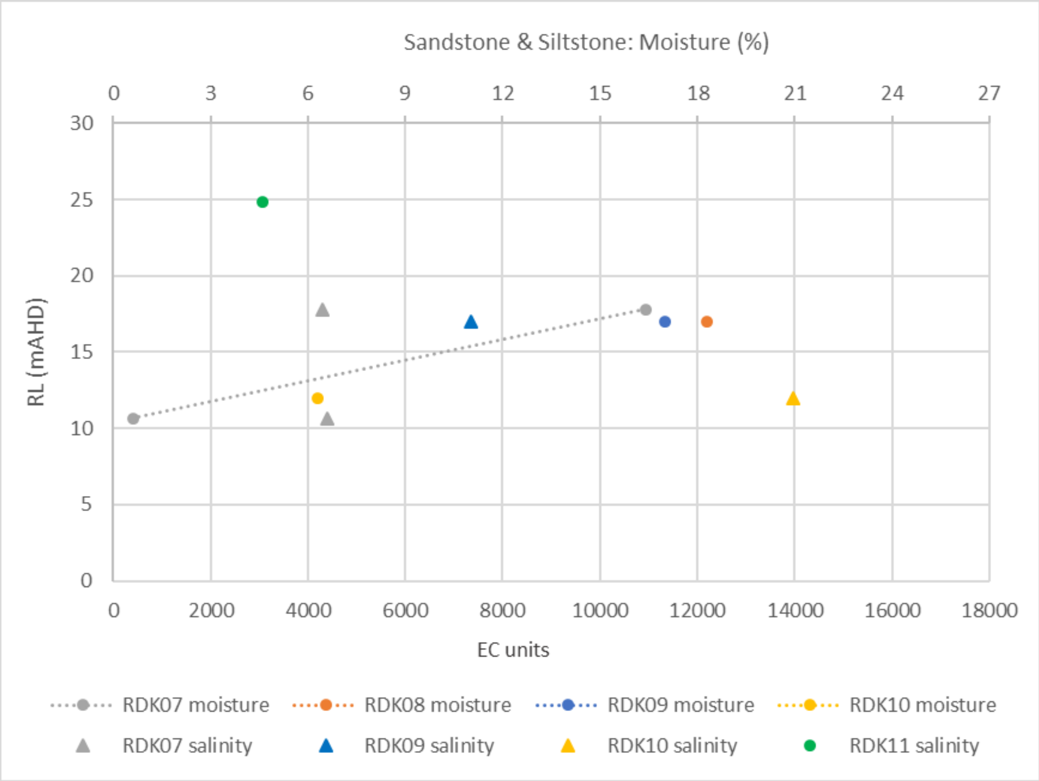

Figure 22: Deep Creek North soil moisture and salinity vs. depth for the Styx Coal Measures (sandstone and siltstone)

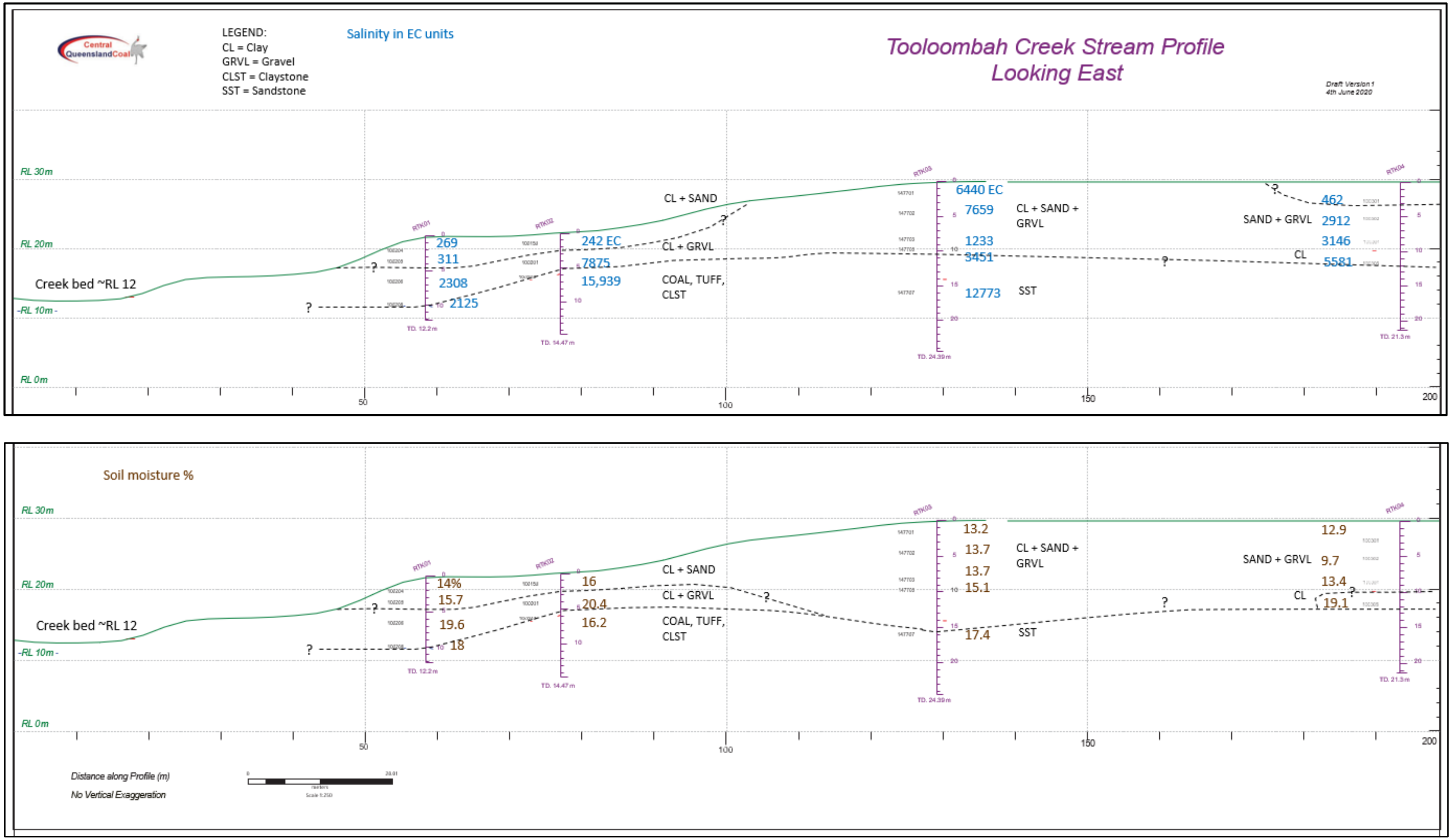

Figure 23: Tooloombah Creek salinity and soil moisture mapping (based on cross-section diagram provided by Central Queensland Coal Pty Ltd)

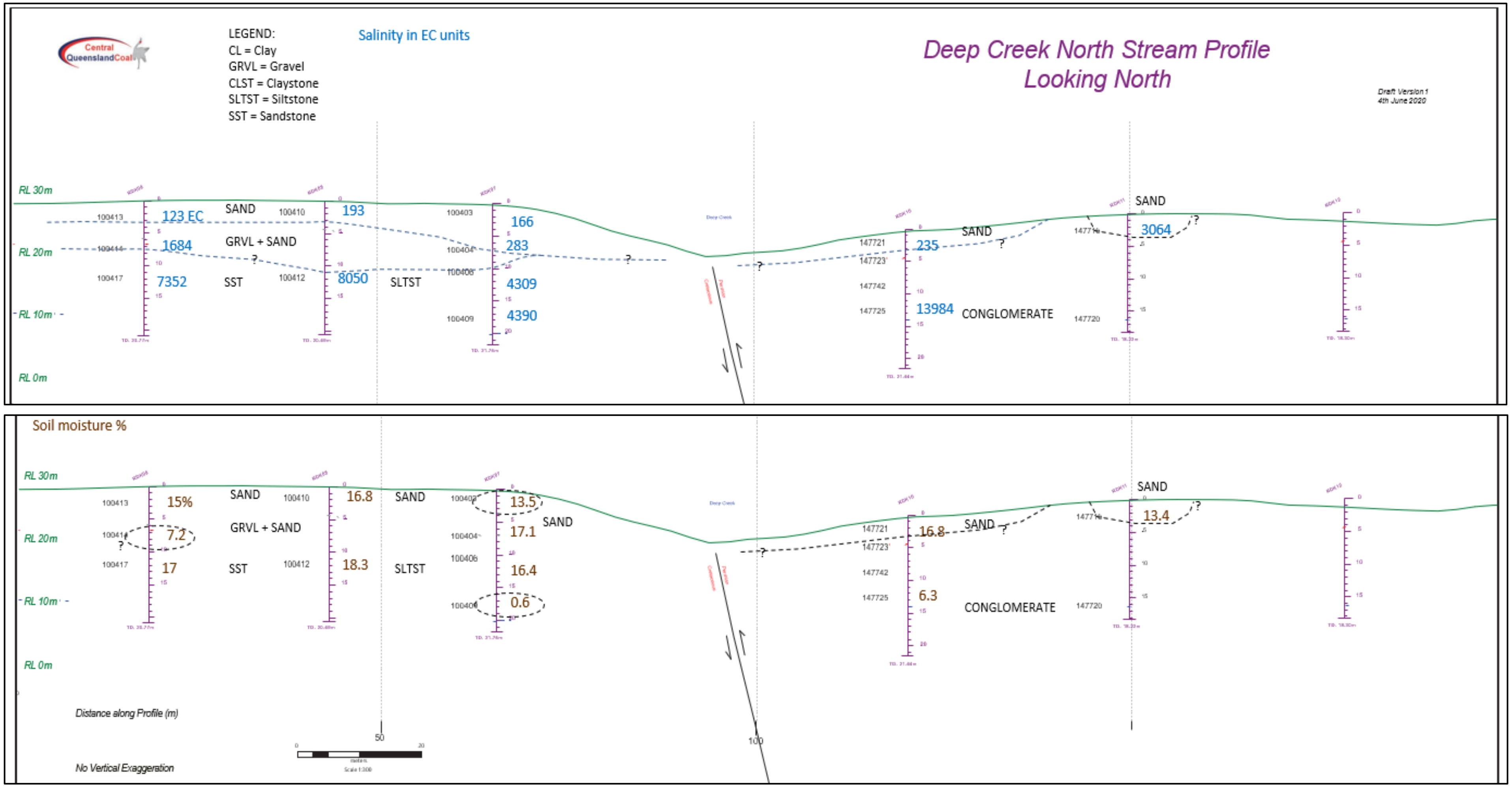

Figure 24: Deep Creek salinity and soil moisture mapping (based on cross-section diagram provided by Central Queensland Coal Pty Ltd)

5.2.2 Groundwater – surface water interactions

SPATIAL ANALYSIS

Spatial analysis was undertaken using ArcGIS Pro to identify trends and potential relationships between the shallow alluvial groundwater system and Tooloombah and Deep Creeks. The available groundwater level monitoring data for the Project was mapped in relation to the creek bed elevation sourced from LiDAR data and the base of the alluvium identified during the alluvial drilling program (Section 5.1), to identify potential groundwater losing and gaining conditions to surface water within the creeks.

Regional groundwater level data was selected from the Project monitoring bores within a week timeframe at the end of the wet season and dry season where possible, depending on the available monitoring data, to identify potential groundwater – surface water interactions due to seasonal changes. The following months presented an adequate dataset for the timing required and this data was interpolated and mapped across Transect 1 to 4:

- March and May 2019 (end of wet season)
- September and November 2019 (end of dry season)
- January, March and May 2020 (end of wet season)

Groundwater levels recorded during the alluvial drilling program undertaken at the Tooloombah Creek and Deep Creek (North and South; Transect A, B and C respectively) has also been included and defined as local interpolated data. Figure 25 to Figure 29 present the location and plots of the individual creek bed elevations and the base of the alluvium and groundwater levels for Transect A to C, with the plots for Transect 1 to 4 provided in Appendix A.

The plots indicate groundwater level remains below the creek bed, at the end of the wet and dry seasons, for all transects except for Transect A, B and C and Transect 3. Groundwater level intersects the creek bed, and may be observed at the ground surface, during March and May 2019 and 2020 towards the end of the wet season.

Interpolation of groundwater levels in shallow bores provides an estimate of the groundwater surface across the study area (Figure 30). This surface can then be intersected with the land surface DEM and this can provide an indication of the depth to groundwater interpolated across the study area (Figure 31).

Combining the wettest and driest periods from the available data, Figure 32 presents the approximate locations where the interpolated groundwater table is expected to be at ≤ 2 mbgl (very shallow) and at ≤10 mbgl (shallow) during January 2020 and March 2019. While January 2020 is technically into the wet season, the 2019/20 wet season did not start until January 2020, with no significant rain (>40mm/month) since April 2019. Hence, January 2020 is representative of dry season conditions. March 2019 is close to the end of the wet season so is likely to show the effects of the recent wet season.

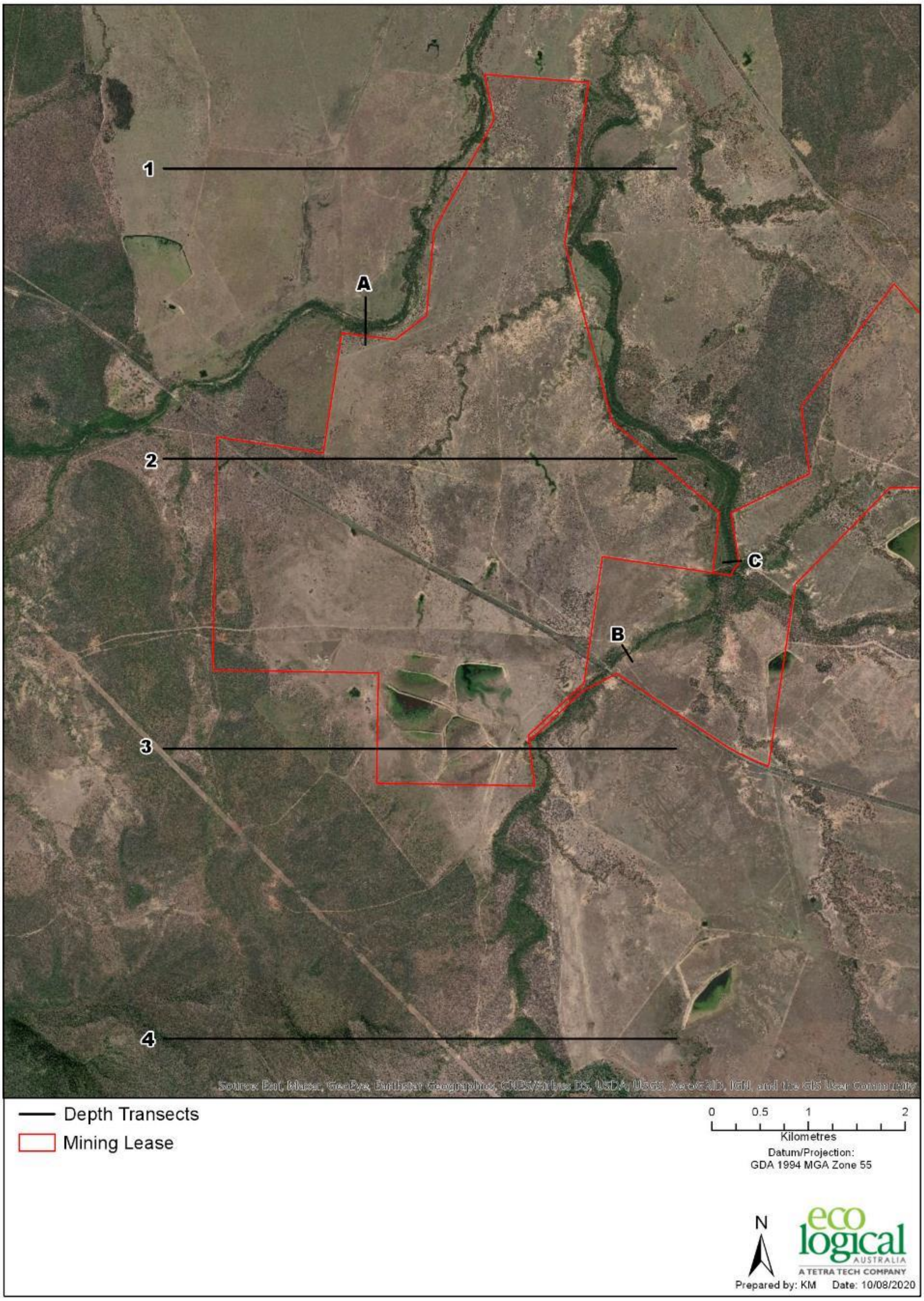

Figure 25: Transects generated for spatial analysis

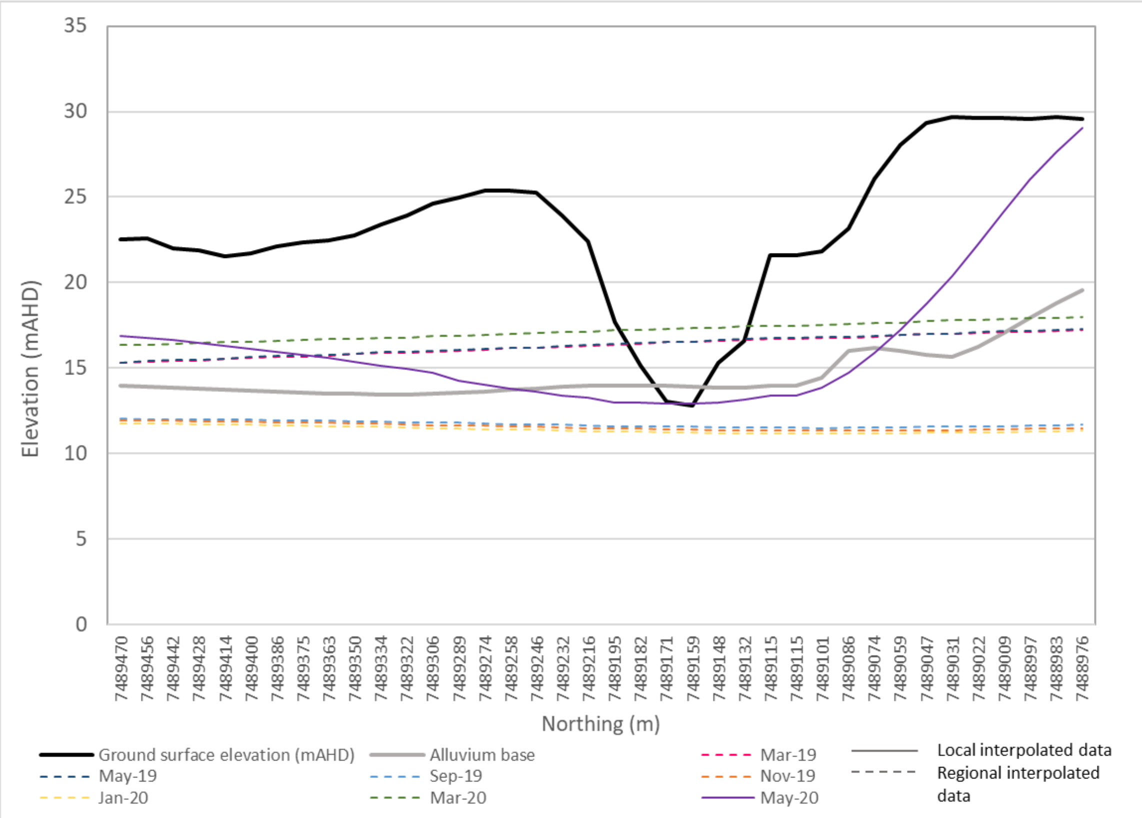

Figure 26: Transect A (Tooloombah Creek) groundwater level vs. creek elevation and base of alluvium

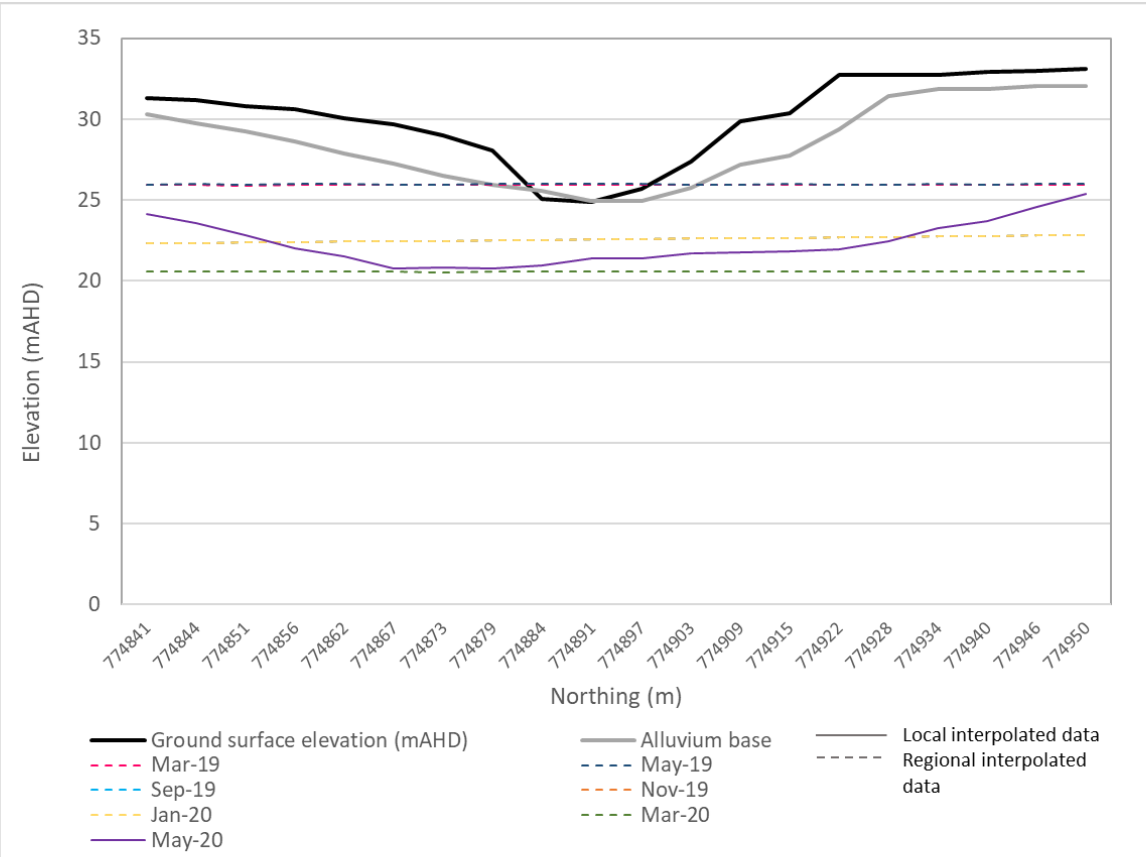

Figure 27: Transect B (Deep Creek South) groundwater level vs. creek elevation and base of alluvium

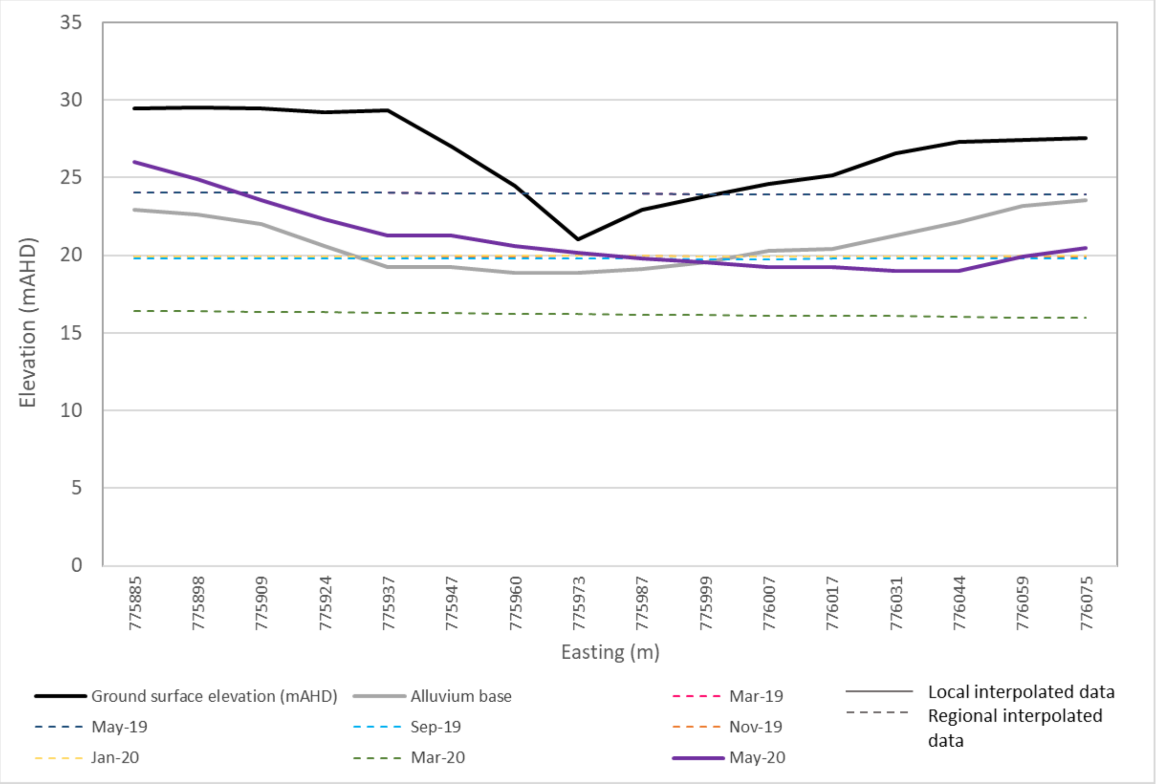

Figure 28: Transect C (Deep Creek North) groundwater level vs. creek elevation and base of alluvium

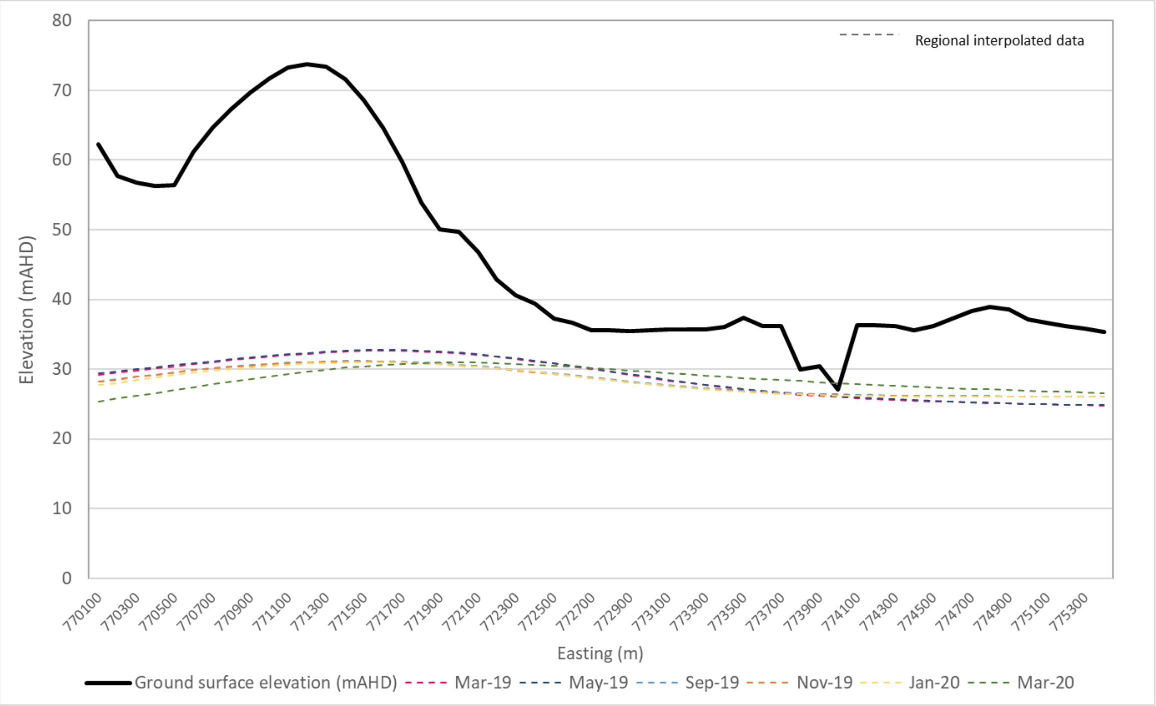

Figure 29: Transect 3 (Deep Creek) groundwater level vs. creek elevation

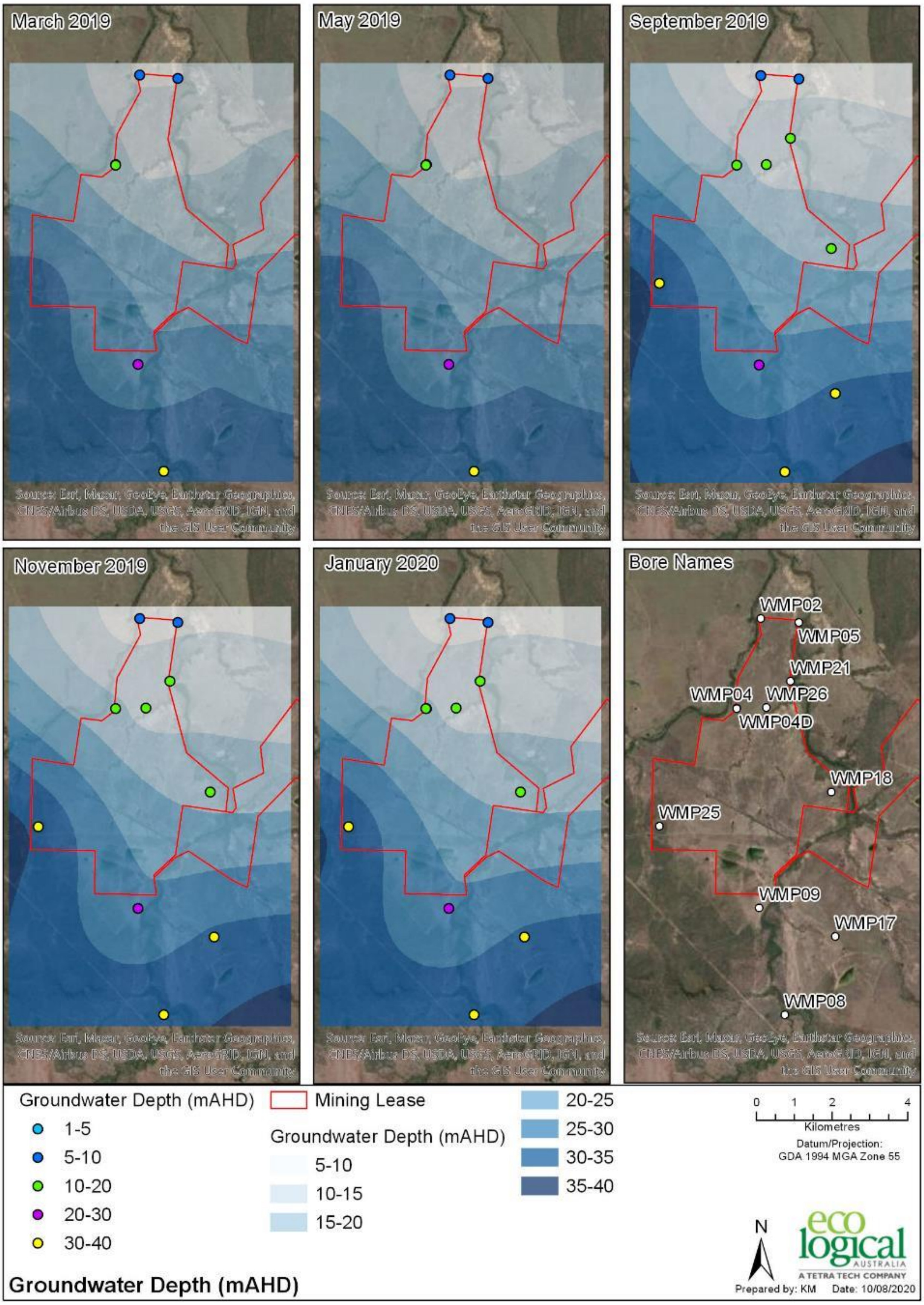

Figure 30: Interpolated groundwater table surface across the study area

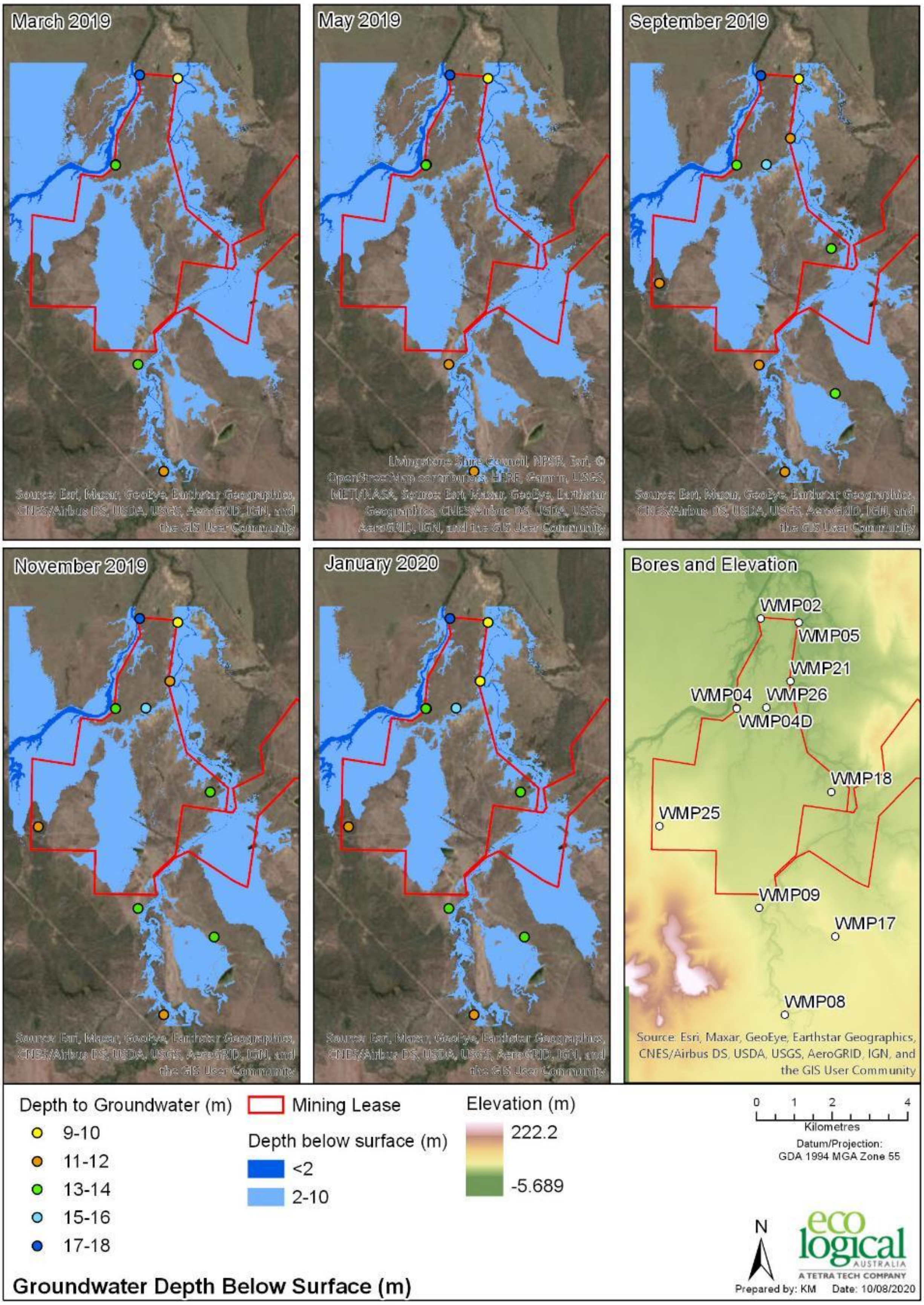

Figure 31: Converted depth to groundwater based on intersection of the interpolated water table surface with the DEM

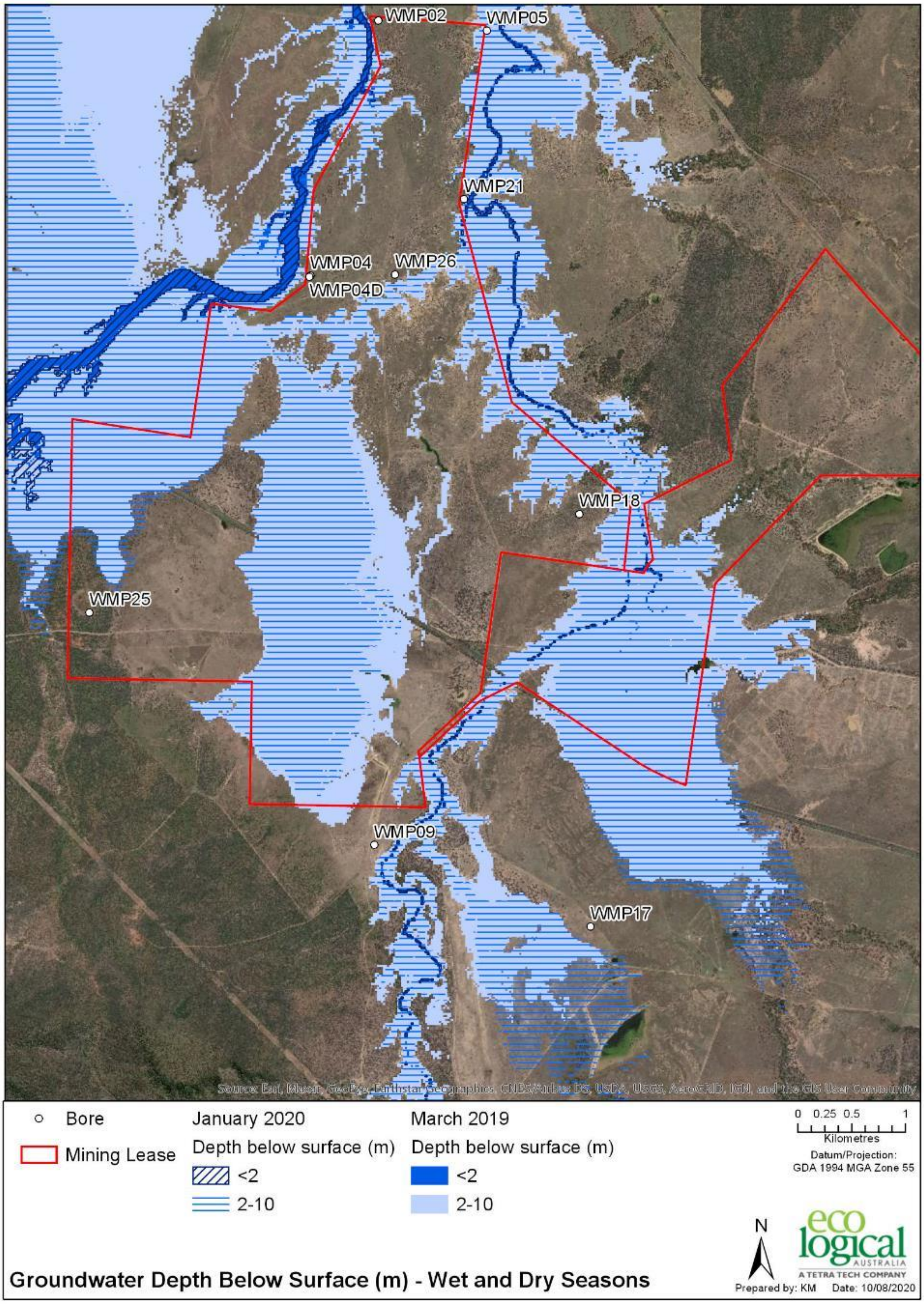

Figure 32: Groundwater level across the CQC Project area and locations of potential surface expression of groundwater (i.e. DTW ≤10 mbgl) during the wet (March 2019) and dry (January 2020) seasons, shown as very shallow (≤2 mbgl) and shallow (2 – 10 mbgl)

Comparison of the groundwater surfaces in Figure 32 to the 3D Environmental (2020) GDE assessment areas presented in Figure 7 of Section 4.6 suggests the following:

- The Tooloombah Creek and Vine Thicket GDE assessment areas likely reflect near-surface expression of groundwater (i.e. SWL is ≤ 2 mbgl) during both the wet and dry seasons. This may potentially be enhanced by the damming effect of the pinch point upstream on Tooloombah Creek, which acts to focus and concentrate surface water and alluvial groundwater flow resulting in elevated groundwater levels in the local area that may maintain surface water pools downstream.

- The Deep Creek GDE assessment area is situated predominantly within the 2 - 10 mbgl zone, with small sections, confined to the creek line, showing groundwater potentially reaches the ground surface (i.e. ≤ 2 mbgl) in this area. This is due to the presence of the south-north trending geological fault adjacent to the GDE assessment area, which brings more transmissive sediments of the Permian Boomer Formation into contact with the alluvium (Figure 15) and is likely to cause groundwater losses with groundwater from bank storage flowing away (east) from the creek.

- The areas located to the south and north (upstream and downstream) of the GDE assessment area are not adjacent to the north-south trending geological fault; therefore, groundwater losses in the area are likely to be lower and the creek in these locations is considered to behave similarly to Tooloombah Creek, i.e. groundwater from bank storage flows towards the creek.

- Wetland 2 is located within the mapped 10 mbgl region hence is unlikely to receive ingress of groundwater at surface. This is consistent with the 3D Environmental (2020) study which did not identify any Terrestrial GDEs at this site.

- Wetland 1 is located outside the extrapolated regional shallow groundwater table in an area where groundwater is expected to be >10 mbgl. The inference is that this area may represent a perched water table, distinct from the regional water table.

It should be reiterated that the results are based on interpolated data from a limited set of bore data and further data collection during the coming summer and winter months, and over a greater areal extent, utilising new shallow piezometers installed as part of the transect drilling program, is required to confirm this. Based on the available data, however, it can be inferred that:

- Tooloombah Creek and Deep Creek are generally under losing stream conditions due to groundwater level sitting below the base of the creek.
- The data shows there are times, often towards the end of the wet season, when groundwater level has been observed to rise and intersect the creek base, causing gaining stream conditions to occur (i.e. groundwater flows to surface water features) and potentially surface expression of groundwater at these times.
- Bank storage is feasible for both creeks and critical to maintain current ecosystem function along Tooloombah Creek. Based on estimated hydraulic conductivities and the distribution of lithofacies, the indications are that bank storage groundwater stored following periods

of high river levels (floods) flows back towards the creek as the river recedes and will be available to support riparian vegetation and GDEs in this area.

- Bank storage may be generated via two mechanisms:
  - During periods of high flood condition, seepage of overland flow into river bank sediments can occur through direct seepage and via lateral flow from the elevated river height.
  - Increased recharge causing the regional water table to rise above the level of the alluvium (as indicated for March 2019, May 2019 and May 2020 water tables) and saturating units in the alluvium and shallow weathered zone.

5.2.3 Surface water pools

As previously discussed in Section 4.4, a number of surface water pools have been identified along Tooloombah and Deep Creeks, including at the surface water gauge stations of both creeks (Figure 6). Previous field surveys undertaken for the Project identified that some pools persist over the dry season and salinities show a significant increase from approximately 1,000 to over 9,000 µS/cm. The change in salinity may potentially be caused by evaporation and/or groundwater recharge to the pools.

WRM (2020) undertook an assessment on whether observed changes in the Tooloombah Creek stream gauge pool water level and salinity were driven by evaporation alone or whether processes such as groundwater inflow were potentially contributing to the changes.

The maximum salinity for the Tooloombah Creek pool was recorded between 8,500 µS/cm and 9,350 µS/cm during January 2020 (Figure 33); however, the water balance model suggests the salinity could significantly increase above this level during extreme drought. The assessment concluded that groundwater, or some other non-rainfall dependent source, is likely feeding the Tooloombah Creek pool (Figure 33 and Figure 34). A groundwater ingress between 2.5 kL/day and 6.5 kL/day (average of 4.5 kL/day) was reported to achieve a maximum salinity of 15,000 µS/cm (WRM, 2020).

During the current study, a simple volume and salinity calculator was used to assess the potential for multiple sources of water supporting two monitored pools and incorporating evaporative loss based on pool surface area.

A regional average pan evaporation of 2.7 mm/day was adopted based on average annual conditions and a water source was introduced with a defined salinity to generate resultant level and salinity profiles which were visually compared to the observed data collected from the Tooloombah Creek and Deep Creek pools (near to the To2 and De2 surface water sites, respectively). Ingress rate and salinity were adjusted until a best (visual) fit was observed, noting that multiple combinations of salinity and ingress (and to a lesser degree, evaporation) can develop the same profile. The aim was to demonstrate feasibility of processes rather than provide definitive, quantitative answers in the absence of quantified end members for each water source. In particular, the variability in groundwater salinity in nearby bores requires temporal site-specific groundwater data, though values are commensurate with local bore information.

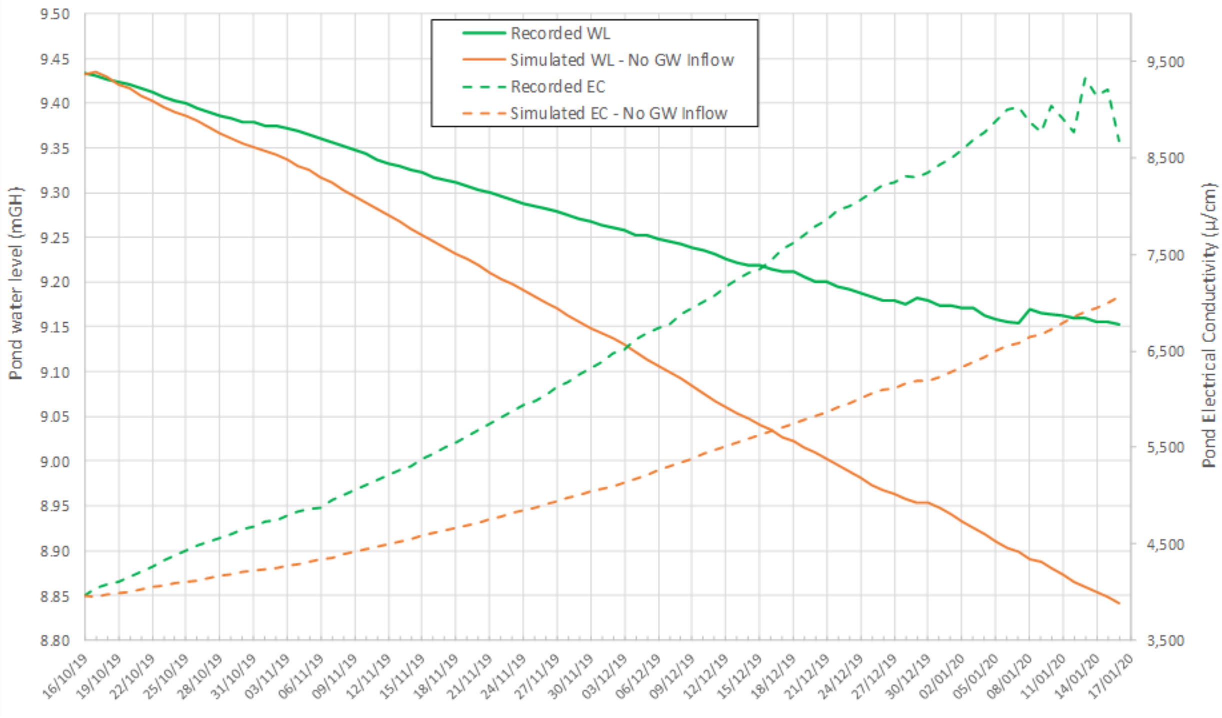

Figure 33: Simulated vs. recorded water level and salinity in Tooloombah Creek pool with no external inflow and outflow (sourced from WRM, 2020)

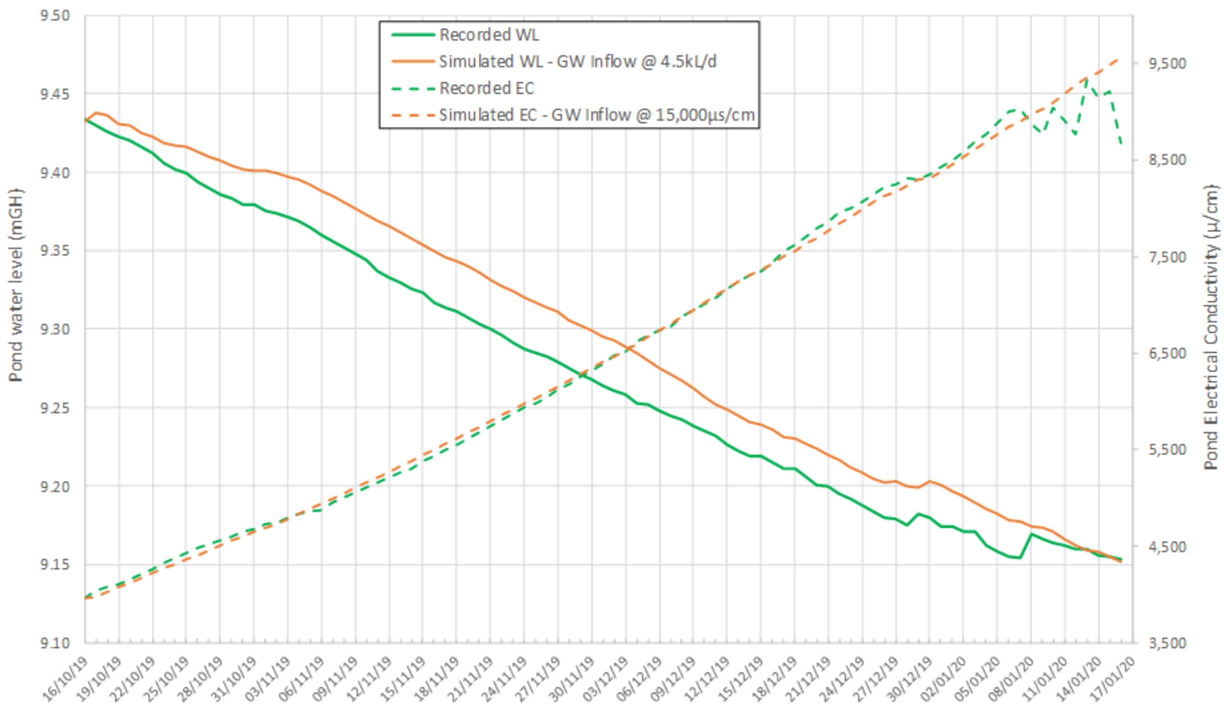

Figure 34: Simulated vs. recorded water level and salinity in Tooloombah Creek pool, with an inflow source of 4.5 kL/day and EC = 15,000 µS/cm (sourced from WRM, 2020)

Monitored data have been plotted in Figure 35 and Figure 36 below and modelled curves presented that indicate scenarios that include: i) potential groundwater ingress to the pools and ii) only result from evaporation of the initial pool water. The results suggest the following and are consistent with the findings from WRM (2020):

- The Tooloombah Creek pool (To2) requires an addition of brackish water to account for the temporal change in salinity. Ingress of 2.0 kL/day (~1 ML/year) of groundwater with a salinity of 4,000 ppm can provide sufficient input to result in the observed profile.
    - Evaporation alone is insufficient to increase the salinity in the time-frame from an indicative pool start volume of 2.6 ML.
    - The To2 pool at Tooloombah Creek is therefore considered to be groundwater supported. The increased salinities observed at the pool may be driven by dissolved salts produced and collected through bank storage draining towards the creek. Alternatively, seasonal rise in underlying (Styx aquifer) water tables may periodically bring more saline groundwater into the alluvium that persists in the alluvium aquifer in the vicinity of the pools even when the regional water table recedes.
    - The pool is therefore likely to have some resilience to drying out over the dry months.

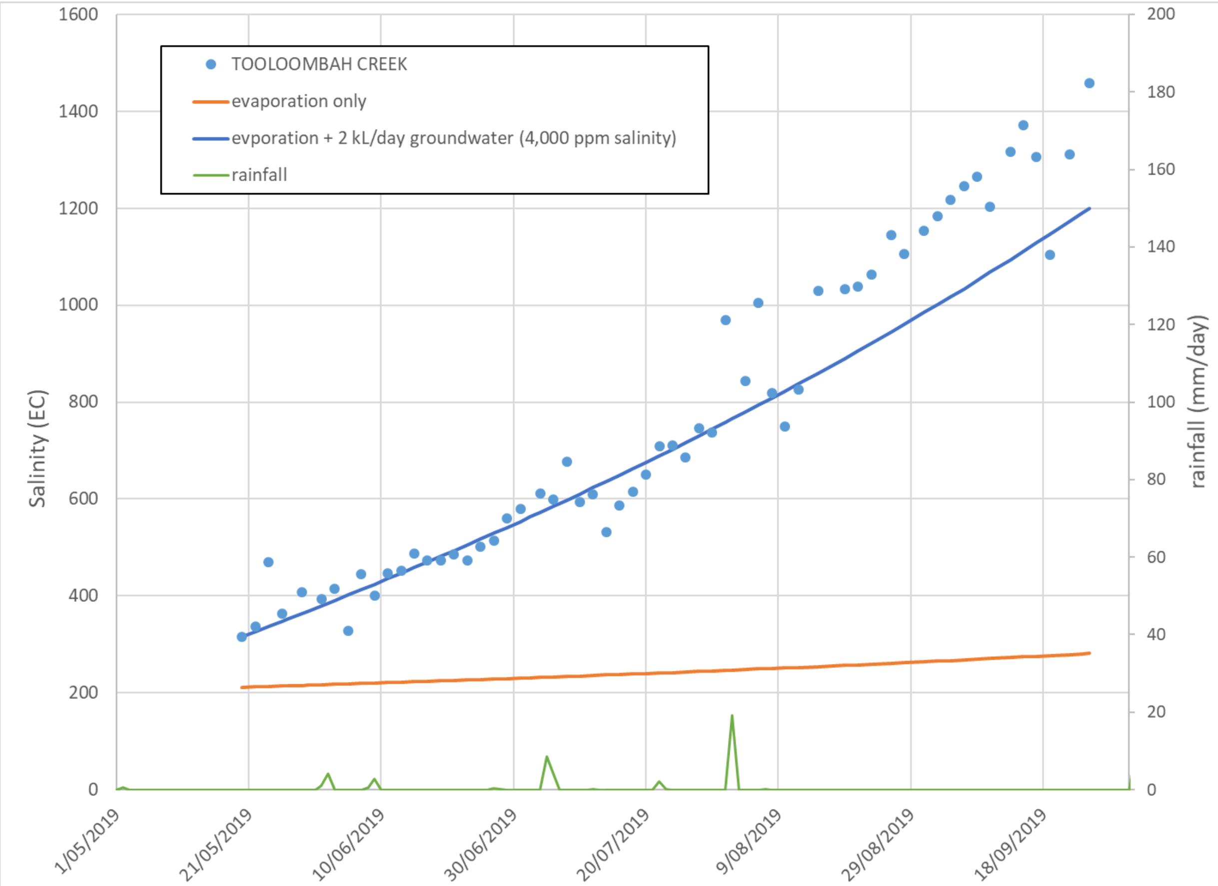

Figure 35: Water source assessment for the Tooloombah Creek (To2) surface water pool (initial salinity 310 µS/cm; groundwater salinity 9,000 µS/cm; ingress at 2.7 kL/day)

- The observed data from Deep Creek can be largely explained purely from evaporative concentration of salts over the observation period. There is, however, the suggestion that groundwater ingress periodically provides support, possibly from multiple sources, but at very low ingress levels.
  - Persistent bank storage is not evident at the gauge location, suggesting rapid loss of any flood water either through runoff or rapid infiltration away from the creek (and sediments).
  - Isolated measurements of elevated salinity may reflect delayed groundwater response. However, this response is short-lived, also suggesting rapid drainage at this site. Alternatively, given that salinity levels are within a small range, the data may instead reflect instrumentation or measurement variation as water remains fresh throughout.
  - The pool was observed to dry up in July 2019 (hence the end of monitored data).
  - The pool is likely to have low resilience to extended dry periods.

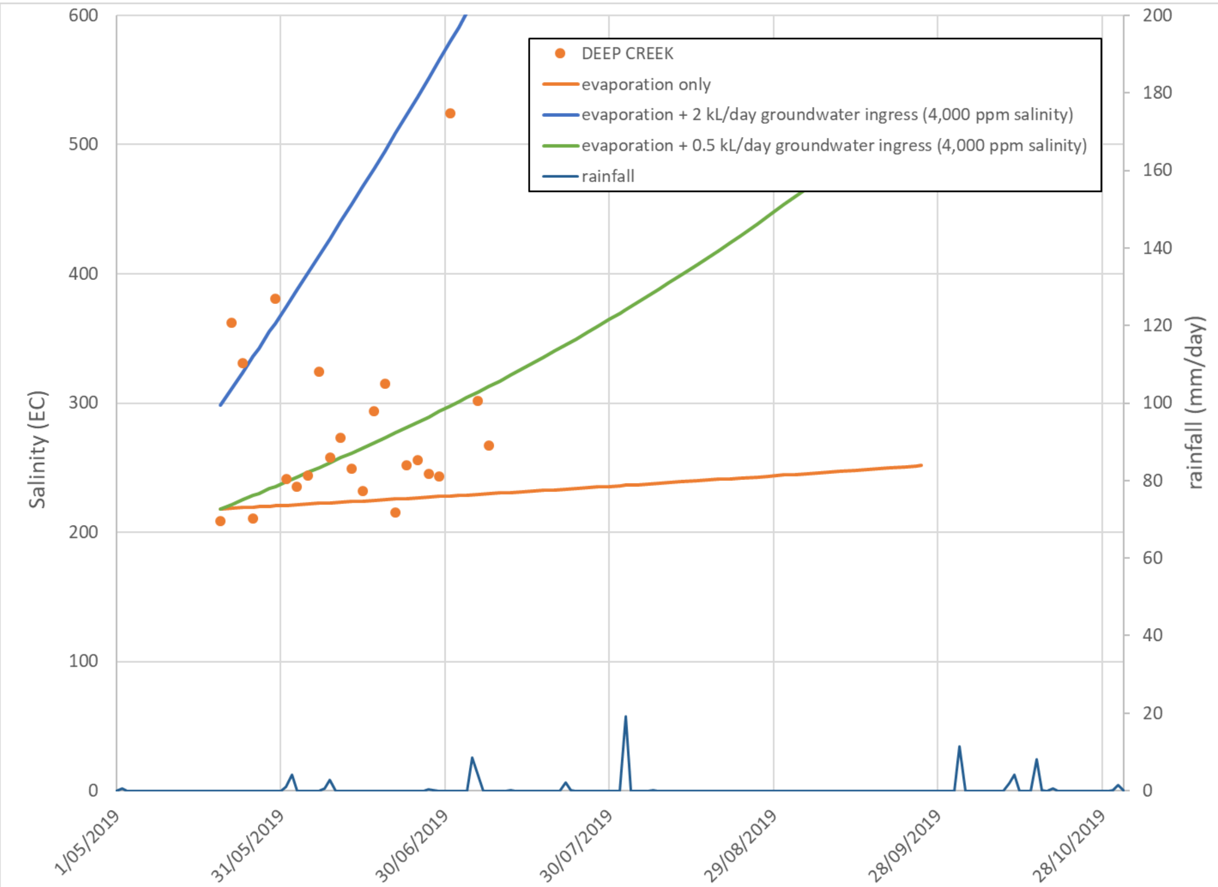

Figure 36: Water source assessment for the Deep Creek (De2) surface water pool (initial pool salinity 220 µS/cm; groundwater salinity 4,500 µS/cm; ingress at 2.7 kL/day and 0.5 kL/day)

Additional spot data since 2017 from pools on Tooloombah Creek display varying characteristics (Figure 37). Spot data from pool To2 verify the 12-hourly measurements (though with some variability), whilst the pools at To1 and To3 display profiles similar to that analysed for Deep Creek (De2). The freshening effect of the rains is also evident, but with a noticeable spike in salinity following the initial flush.

The extended relatively dry period from April 2019 through to January 2020 allows some insight into pool evolution and source contributions during this dry period.

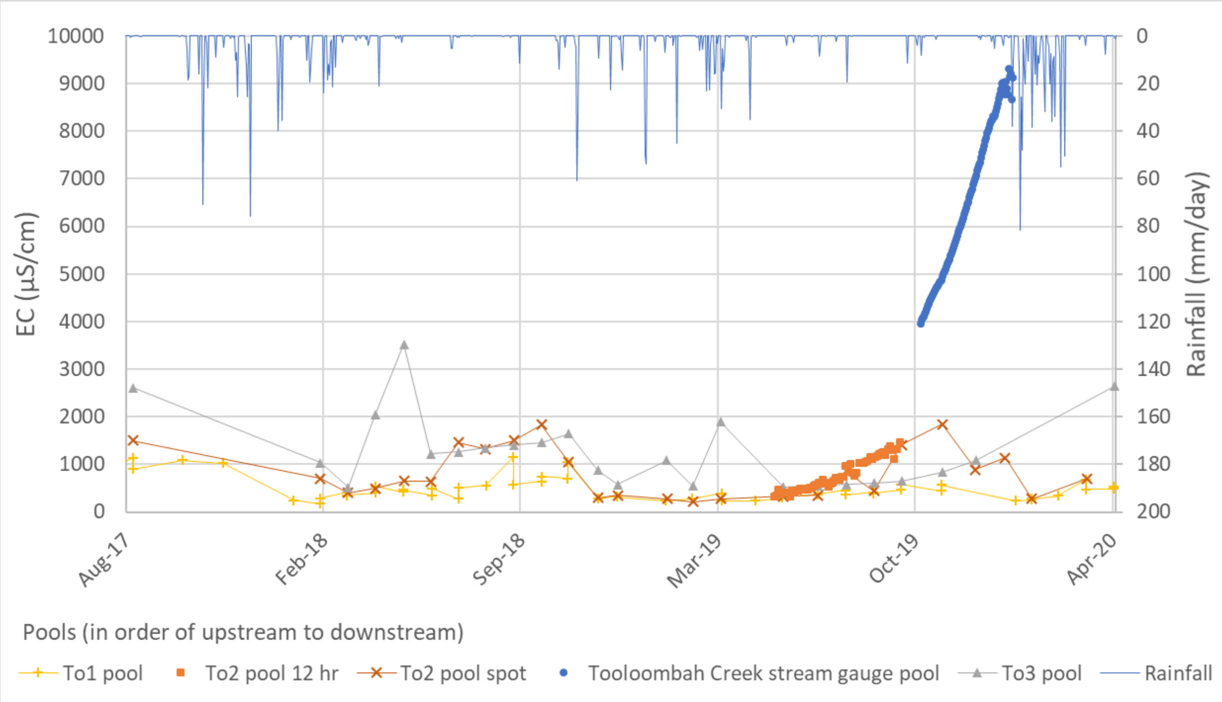

Figure 37: Spot salinity data from Tooloombah Creek pools since 2017

Comparison across the four sites between April 2019 and January 2020, suggests that there is variable interaction between surface water and groundwater along each creek and blanket considerations of surface water – groundwater interaction must be treated with caution. Thus, using the formalism adopted above for To2 and De2, the data from pools at To1 and To3 indicate these pools do not require any groundwater input and can be explained by evaporation alone.

To explain the data trend for the Tooloombah Creek gauge (located in a permanent pool downstream of pool To2; Figure 6), requires local groundwater with a salinity of about 15,000 µS/cm, as reported above (WRM, 2020). The closest shallow bore is WMP04, located 1 km south (upstream) of the gauge pool. Salinity at this bore is recorded as 16,000 EC (i.e. µS/cm), in the basal alluvial sediments, and hence provides a good candidate as a groundwater source at this location.

The pool at To2, however, only requires a salinity of 4,000 ppm (6,000 µS/cm). The closest shallow bore is WMP28, located adjacent to the pool. This recorded a median salinity of 6,085 µS/cm between September and December 2019 and is completed within the sub-cropping Styx sediments.

This supports the above conjecture that seasonal rise in underlying (Styx aquifer) water tables may periodically and locally bring more saline groundwater into the alluvium that persists in the alluvium aquifer in the vicinity of the pools even when the regional water table recedes.

5.2.4 Groundwater discharge

DARCY'S LAW AND FLUX

As previously discussed in Section 5.1 and Section 5.2.1, the Tooloombah Creek profile shows a higher clay content than observed at Deep Creek, and clay underlies the alluvium in places, reducing connection between the alluvium and Styx Coal Measures. Therefore, shallow groundwater is considered to flow laterally, to and from bank storage with minimal vertical connectivity in some areas.

The creek bank profiles and cross-sections that were generated from the alluvial drilling program suggest the alluvial sediments consist of thicknesses up to 10 m for Deep Creek North, 1 m at Deep Creek South and 14 m for Tooloombah Creek. When fully saturated, there is the potential for the alluvium to discharge groundwater volumes to the creek based on these aquifer thicknesses.

The data acquired from the drilling program transects (alluvium base and thickness, distance from the creek and static water levels - SWL), and the calculated hydraulic conductivities (K values) summarised in Table 2, have been used to estimate potential discharge volumes (Q; m^3/day) using Darcy's Law and flow rates (m/s) using the Darcy flux equation, for groundwater to drain from bank storage to the creeks and thus from and to GDE areas. Aquifer transmissivity (T; m^2/day) has also been estimated to provide a further indication of flow within the aquifer and considers the estimated hydraulic gradient between the drilling site and the creek. Return flows to bank storage have also been estimated following streamflow events based on the calculation of these parameters, assuming the creek beds are full during these events. The Darcy's Law and the Darcy flux equation were used to model potential groundwater discharge and flow speeds for each transect under the following two scenarios:

- Scenario 1: saturated thickness is based on the SWL recorded during drilling; and
- Scenario 2: assume the aquifer is fully saturated.

Table 3 and Table 4 present a summary of the results for groundwater flow to the creeks, with Table 5 and Table 6 presenting estimated return flows from bank storage to the creek. It is noted that for Transect 3 (Deep Creek South), K (m/s) is based on literature values as this was unable to be calculated (no PSD values collected). The results suggest the following:

TOOLOOMBAH CREEK (RTK01 TO RTK04)

- The Tooloombah Creek results can be based on RTK01 (40 m from the creek) as groundwater is unlikely to reach the RTK02, RTK03 and RTK04 drill holes due to:
    i. the increased distance from the creek (60 to 180 m);
    ii. the hydraulic gradient (anticipated to direct groundwater flow towards the creek at most times of the year); and
    iii. the low hydraulic conductivities estimated for these sites, suggesting groundwater flow is towards the creek.
- Potential groundwater flows from bank storage at Tooloombah Creek are estimated at 2.5 m^3/day with aquifer transmissivity estimated at 6 m^2/day. Groundwater is estimated to continue flowing towards the creek for approximately 150 days (0.4 years).

- The Tooloombah Creek alluvium presents transmissivities that would be able to provide groundwater flow and moisture to support GDEs within the local area.
- Assuming the same aquifer transmissivity and properties as above, return flow from bank storage to the creek following streamflow events is estimated at 3.7 m^3/day. Groundwater is estimated to continue flowing to bank storage for approximately 100 days (0.28 years).

DEEP CREEK NORTH (WESTERN BANK; RDK07 TO RDK08)

- Loss of groundwater at the Deep Creek North transect is potentially greater than areas to the south and north (downstream) due to the proximity to the north-south trending geological fault to the creek at the transect location.
- The Deep Creek hydraulic conductivities and transmissivities increase from RDK07 towards the west, suggesting groundwater flow is enhanced away from the creek.
- Potential groundwater flows are estimated between 3 m^3/day and 5 m^3/day with aquifer transmissivity between 7 and 10 m^2/day. Based on these results, lateral groundwater movement from the creek may potentially reach RDK08 between 70 and 180 days.
- The indication (from one side of the creek only) is that groundwater flow is favoured towards the creek, but at a rate that is slow enough to ensure persistent pools over several months.

DEEP CREEK NORTH (EASTERN BANK; RDK10 AND RDK11)

- Hydraulic conductivities and transmissivities increase from RDK11 to the west (~60m from the creek bed), suggesting groundwater bank flow can return to the creek.
- Potential groundwater flows from bank storage at Deep Creek are between 0.3 m^3/day and 3 m^3/day with aquifer transmissivity estimated between 1.5 and 6.5 m^2/day. Groundwater is estimated to return to the creek from RDK10 (20 m distance) after approximately 36 days (0.1 years).
- Therefore, the pools located on the far eastern side of Deep Creek are prone to drying during the winter months as bank storage would rapidly return to the creek (from the west) or continue to flow away from the creek (on the east).

DEEP CREEK SOUTH (RDK01)

- The alluvium exists in a pocket at RDK01 and is discontinuous with the other drilling locations along the transect due to outcrop of Styx Coal Measures observed in this area.
- Potential groundwater flow to and from bank storage at RDK01 is estimated at 3 m^3/day with a timeframe of 5 days to travel to and from the creek (10 m distance).

Table 3: Scenario 1 estimated groundwater discharge volumes and rates to creek (based on SWL recorded while drilling)

Location	Site	SWL (mbgl)	Alluv base (mbgl)	b (m)	Distance from creek (m)	K (m/day)	T (m^2/day)	Q (m^3/day)	q (m/s)	Time (years)
Transect 1 – Tooloombah Creek	RTK01	8	8	8	40	0.77	6.16	2.46	1.8×10^{-6}	0.4
	RTK02	8	6	6	60	See Table 4 (SWL is measured below base of alluvium)				
	RTK03	10	14	4	110	0.07	0.28	0.02	3×10^{-8}	71
	RTK04	9	10	1	180	0.31	0.31	0.003	2×10^{-8}	172
Transect 2 – Deep Creek North	RDK07	8	10	2	30	0.77	1.54	0.21	6×10^{-7}	1
	RDK08	6	7	1	55	1.45	1.45	0.05	3×10^{-7}	3.5
	RDK09	3	6.5	3.5	85	0.31	1.085	0.09	1.5×10^{-7}	11
	RDK10	5	4.5	4.5	20	See Table 4 (SWL is measured below base of alluvium)				
	RDK11	8.5	5	5	60	See Table 4 (SWL is measured below base of alluvium)				

Table 4: Scenario 2 estimated groundwater discharge volumes and rates to creek (assuming the aquifer is fully saturated)

Location	Site	SWL (mbgl)	Alluv base (mbgl)	b (m)	Distance from creek (m)	K (m/s)	T (m2/day)	Q (m3/day)	q (m/s)	Time (years)
Transect 1 – Tooloombah Creek	RTK01	8	8	8	40	0.77	6.16	2.46	1.8×10^{-6}	0.4
	RTK02	8	6	6	60	0.01	0.06	0.012	1.2×10^{-8}	99
	RTK03	10	14	14	110	0.07	0.98	0.249	1×10^{-7}	20
	RTK04	9	10	10	180	0.31	3.1	0.344	2×10^{-7}	17
Transect 2 – Deep Creek North	RDK07	8	10	10	30	0.77	7.7	5.13	3×10^{-6}	0.2
	RDK08	6	7	7	55	1.45	10.15	2.58	2×10^{-6}	0.5
	RDK09	3	6.5	6.5	85	0.31	2.015	0.31	2.7×10^{-7}	6
	RDK10	5	4.5	4.5	20	1.45	6.525	2.94	3.8×10^{-6}	0.1
	RDK11	8.5	5	5	60	0.31	1.55	0.26	3×10^{-7}	4
Transect 3 - Deep Creek South	RDK01	4	1.2	1.2	10	10	12	2.88	1.4×10^{-5}	0.01

Table 5: Scenario 1 estimated groundwater discharge volumes and rates from creek to bank storage (based on SWL recorded while drilling)

Location	Site	SWL (mbgl)	Alluv base (mbgl)	b (m)	Distance from creek (m)	K (m/day)	T (m2/day)	Q (m3/day)	q (m/s)	Time (years)
Transect 3 – Tooloombah Creek	RTK01	8	8	8	40	0.77	6.16	3.7	2.7×10^{-6}	0.28
	RTK02	8	6	6	60	See Table 6 (SWL is measured below base of alluvium)				
	RTK03	10	14	4	110	0.07	0.28	0.03	3.7×10^{-8}	57
	RTK04	9	10	1	180	0.31	0.31	0.01	8×10^{-8}	43
Transect 2 – Deep Creek North	RDK07	8	10	2	30	0.77	1.54	0.8	2.4×10^{-6}	0.24
	RDK08	6	7	1	55	1.45	1.45	0.3	1.8×10^{-6}	0.6
	RDK09	3	6.5	3.5	85	0.31	1.085	0.1	1.3×10^{-7}	13
	RDK10	5	4.5	4.5	20	See Table 6 (SWL is measured below base of alluvium)				
	RDK11	8.5	5	5	60	See Table 6 (SWL is measured below base of alluvium)				

Table 6: Scenario 2 estimated groundwater discharge volumes and rates from creek to bank storage (assuming the aquifer is fully saturated)

Location	Site	SWL (mbgl)	Alluv base	b (m)	Distance from	K (m/s)	T (m2/day)	Q (m3/day)	q (m/s)	Time (years)
Transect 3 – Tooloombah Creek	RTK01	8	8	8	40	0.77	6.16	3.7	2.7×10^{-6}	0.28
	RTK02	8	6	6	60	0.01	0.06	0.02	1.7×10^{-8}	66
	RTK03	10	14	14	110	0.07	0.98	0.2	7×10^{-8}	32
	RTK04	9	10	10	180	0.31	3.1	0.2	1×10^{-7}	34
Transect 2 – Deep Creek North	RDK07	8	10	10	30	0.77	7.7	5	3×10^{-6}	0.2
	RDK08	6	7	7	55	1.45	10.15	2.5	2×10^{-6}	0.5
	RDK09	3	6.5	6.5	85	0.31	2.015	0.3	2.7×10^{-7}	6
	RDK10	5	4.5	4.5	20	1.45	6.525	3	4×10^{-6}	0.1
	RDK11	8.5	5	5	60	0.31	1.55	0.3	3×10^{-7}	3.8
Transect 1 - Deep Creek	RDK01	4	1.2	1.2	10	10	12	2.88	1.4×10^{-5}	0.01 (5 days)

5.2.5 Baseflow assessment

Two streamflow gauges are available adjacent to the Project area: "Deep Creek downstream of Central Queensland Coal" (gauge 330452) and "Tooloombah Creek downstream of Central Queensland Coal" (gauge 330451). The Tooloombah Creek gauge is situated in a permanent pool with a downstream rock-bar that controls the pool water levels, whilst the Deep Creek gauge is within an open (ephemeral) channel. The Tooloombah Creek gauge 'cease-to-flow' height was identified as 9.72 mAHD by comparing the pool level with the rock-bar level using LIDAR data. WRM (2020) indicate that there is no easily identifiable hydraulic control for the Deep Creek gauge.

Measured data was available from 17/01/2020 9AM to 19/05/2020 11PM for Deep Creek and 15/10/2019 3PM to 19/05/2020 11PM for Tooloombah Creek and is presented in Figure 38. While the data record only comprises a few months of flow, the data confirms the influence of baseflow on streamflow.

Applying a digital filter (Chapman filter with 3 passes and k = 0.925) to the complete flow time series results in total flow and modelled baseflow separations shown in Figure 39. This was undertaken to provide some quantification of the baseflow influence for the two creeks. The results indicate that baseflow influence is ephemeral and in conjunction with rainfall events. The following can be inferred:

- Protracted 'tails' provide confirmation that there is a baseflow element present, however the limited data makes quantification difficult.
- Figure 38 and Figure 39 suggest there is interflow (flow through the soil profile, represented as 'long tails' in the hydrographs) into the streams through the banks of the creek lines. This is as opposed to direct surface runoff from the catchment (the peaks in the hydrographs).
- It should be noted that the tail after the last rainfall event in mid-March 2020 could either indicate that water is still seeping out of the soils, or the location of the gauges within the pools in the creek lines are causing the gauge to read a non-existent flow and this would need to be confirmed by additional measurements.
- Comparing the two flow gauges shows that the Tooloombah Creek flows are often less than Deep Creek, possibly reflecting the influence of catchment size and additional tributaries.
- Low flows on Tooloombah Creek generally show a more rapid recession into baseflow. However, when similar magnitude flows occur in both creeks, the recession into baseflow follows very similar trajectories, suggesting that similar processes are occurring to provide baseflow to both creeks. The efficacy of the lower flow observations should be verified, however, before being used to draw more definitive conclusions from the data.

It should be noted, however, these results should only be used as an indication of baseflow, as changing the filter type, or parametrisation, can result in a very different baseflow pattern. Specifically, the filter provides a total and baseflow rate that will mis-represent baseflow during periods that constitute entirely baseflow, such as for April and May 2020. This is a function of the filter used, and not the actual separation. It is recommended that once the veracity of the gauges and their readings are confirmed and longer timeseries acquired, that the digital filtering is revisited to be compared to water table information from the groundwater bores in the region. The incorporation of defined dry period flows, when baseflow is considered the only water source needs to be included in the analysis.

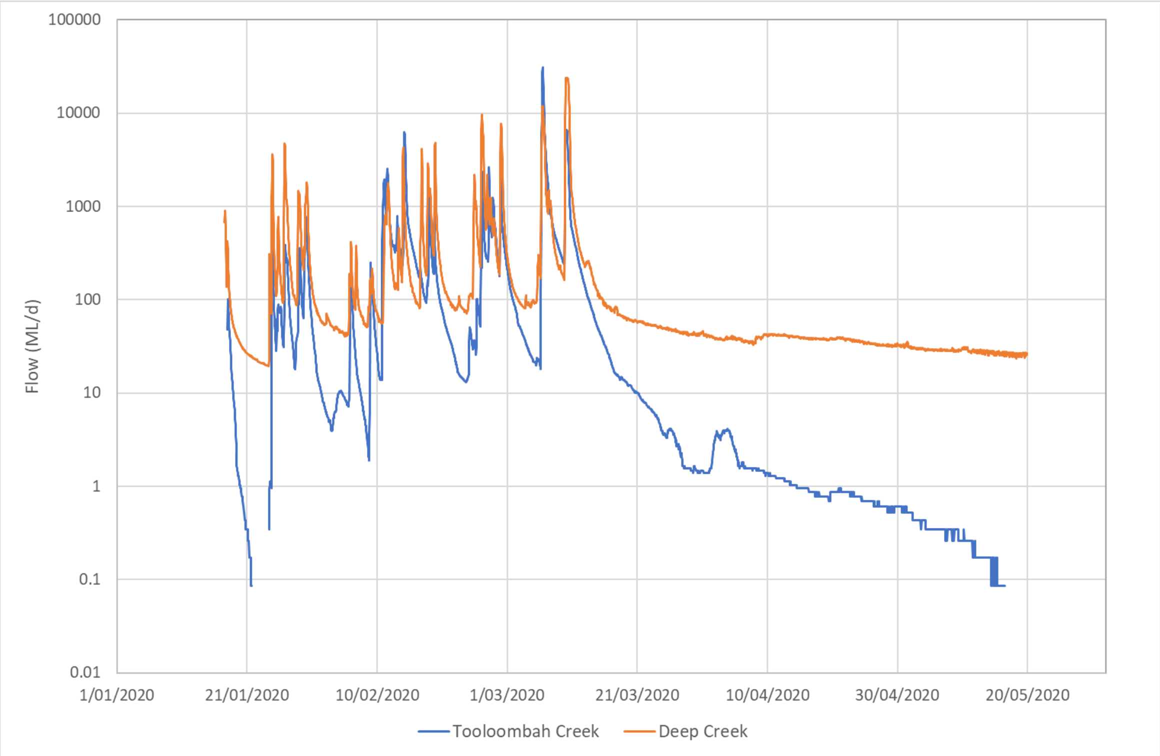

Figure 38: Deep Creek (330452) and Tooloombah Creek (330451) total flow hydrographs

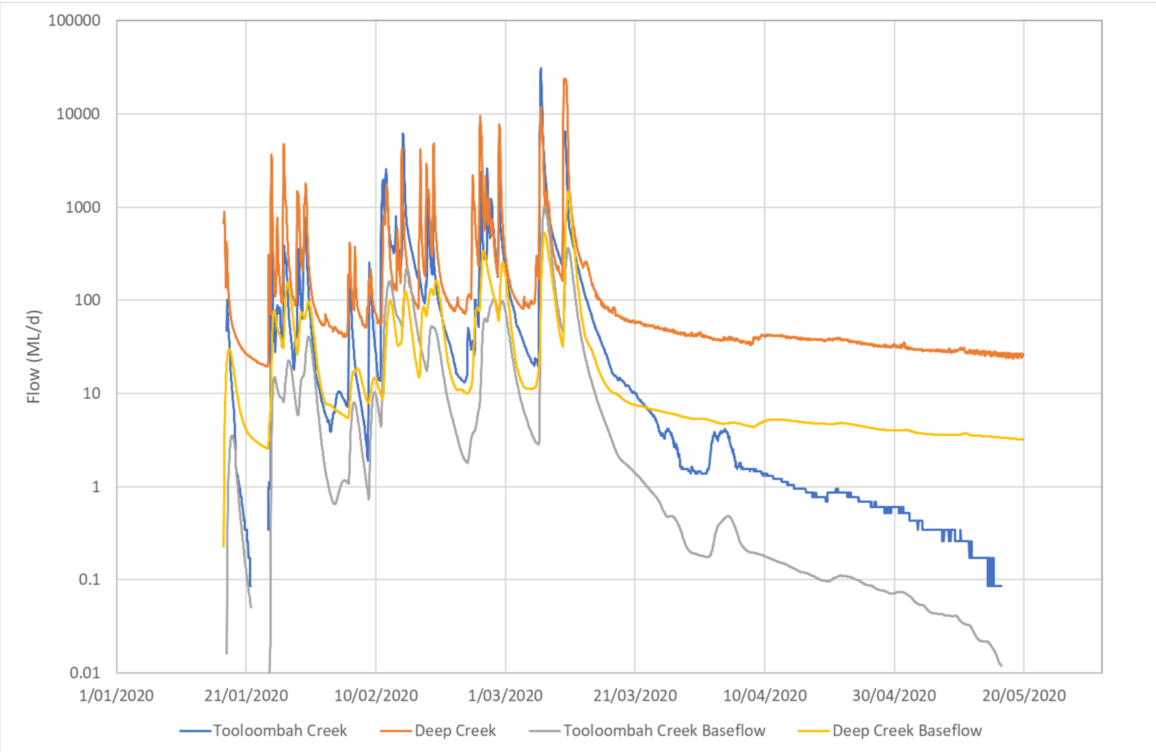

Figure 39: Deep Creek (330452) and Tooloombah Creek (330451) total flow and baseflow hydrographs

5.2.6 Groundwater recharge

Rainfall recharge occurs across the Styx River Catchment at a range of rates, with higher recharge expected in areas where the Cenozoic sediments (Quaternary alluvium) is present. Flood recharge events are expected to result in the highest recharge rates and occur during the large streamflow events (volumes and duration). This is demonstrated by data collected from three separate flood recharge events that have been recorded during 2010-2011, 2013 and 2017, which produced approximately 65 – 75% of annual average rainfall within one month during that year (HydroAlgorithmics, 2020).

CDM Smith (2018f) presented the steady state recharge rate to be in the order of 5.4 GL/year (equivalent to 14.7 ML/day), which is approximately 5.7% when considering the conservative predicted cumulative abstraction volume over the mine life (18 years). The recharge value modelled by HydroAlgorithmics (2020) in the CQC Project numerical groundwater model was 1.3% of annual rainfall applied to the alluvium units, before increasing to 1.51% in the calibrated steady state model for use in the transient calibration. The enhanced recharge rate for spoil materials was applied at 5%.

A review of the available groundwater chloride and isotope data was undertaken to verify and refine the groundwater recharge parameters for the site and to inform future groundwater – surface water numerical modelling. Groundwater recharge was estimated using the chloride mass balance method, based on the chloride data obtained from regional rainfall, groundwater quality data from four monitoring bores (WMP02 and WMP04 at Tooloombah Creek and WMP05 and WMP09 at Deep Creek) and chloride concentrations estimated from soil salinity samples that were collected at various depths throughout each bore profile during the alluvial drilling program at Tooloombah Creek and Deep Creek.

Table 7 presents the recharge rates and volumes estimated for the Tooloombah Creek and Deep Creek catchment areas. Figure 40 and Figure 41 present bar charts of the Table 7 results, for each sample depth within the bore profiles, and indicate that recharge is higher at Deep Creek, likely due to the sandy creek bed in comparison to Tooloombah Creek.

The average recharge rate was calculated at:

- 5.5 mm/year for Tooloombah Creek catchment area (2 ML/year or 0.7% of the annual average rainfall for the region); and
- 17.4 mm/year for the Deep Creek catchment (5.2 ML/year or 2.2% of the annual average rainfall).

An average recharge rate of 9.8 mm/year was estimated for both catchments; i.e. the entire CQC Project area (6.5 ML/year and 1.2% of the annual average rainfall for the region). This recharge rate is consistent with the recharge value implemented in the CQC Project numerical groundwater model by HydroAlgorithmics (2020).

Table 7: Estimated groundwater recharge to Tooloombah Creek and Deep Creek catchments

Location	Site	Sample	RL	EC (mg/L)	Cl (mg/L)	Estimated recharge			
						mm/year	m^3/year	ML/year	% annual rainfall
Tooloombah	RTK01	100204	20	172.16	103.9	19.9	7,379,368	7.4	2.5
		100205	18	199.04	120.1	17.3	6,382,797	6.4	2.2
		100206	15.5	1477.12	891.4	2.3	860,074	0.9	0.3
	RTK02	100150	19.5	154.9	93.5	22.2	8,202,686	8.2	2.8
		100201	16.5	5040	3041.4	0.7	252,070	0.3	0.1
	RTK03	147701	26	4121.6	2487.2	0.8	308,238	0.3	0.1
		147702	23.5	4901.8	2958	0.7	259,179	0.3	0.1
		147703	20	789.1	476.2	4.4	1,609,935	1.6	0.5
		147705	18	2208.6	1332.8	1.6	575,210	0.6	0.2
	RTK04	100301	25	295.7	178.4	11.6	4,296,645	4.3	1.5
		100302	23	1863.7	1124.6	1.8	681,679	0.7	0.2
		100303	22	1801.6	1087.2	1.9	705,169	0.7	0.2
		100304	19	2013.4	1215	1.7	630,976	0.6	0.2
		100305	16	3571.8	2155.4	0.96	355,680	0.4	0.1
	WMP02	--	--	--	5830	0.36	131,499	0.13	0.04
	WMP04	--	--	--	5370	0.4	142,763	0.14	0.1
Deep Creek	RDK09	100413	26.251	78.7	47.5	43.6	12,998,130	13	5.5
		100414	22.701	1077.8	650.4	3.2	949,388	0.95	0.4
	RDK08	100410	27.145	123.5	74.5	27.8	8,283,782	8.3	3.5
	RDK07	100403	26.931	106.2	64.1	32.3	9,631,145	9.6	4
		100404	21.611	181.1	109.3	18.9	5,649,364	5.6	2.4
	RDK10	147721	22.39	150.4	90.8	22.8	6,803,277	6.8	2.9
	RDK11	147716	24.88	1961	1183	1.8	521,792	0.5	0.2
	WMP05	--	--	--	359	5.7	1,719,933	1.7	0.7
	WMP09	--	--	--	7050	0.3	87,582	0.1	0.04

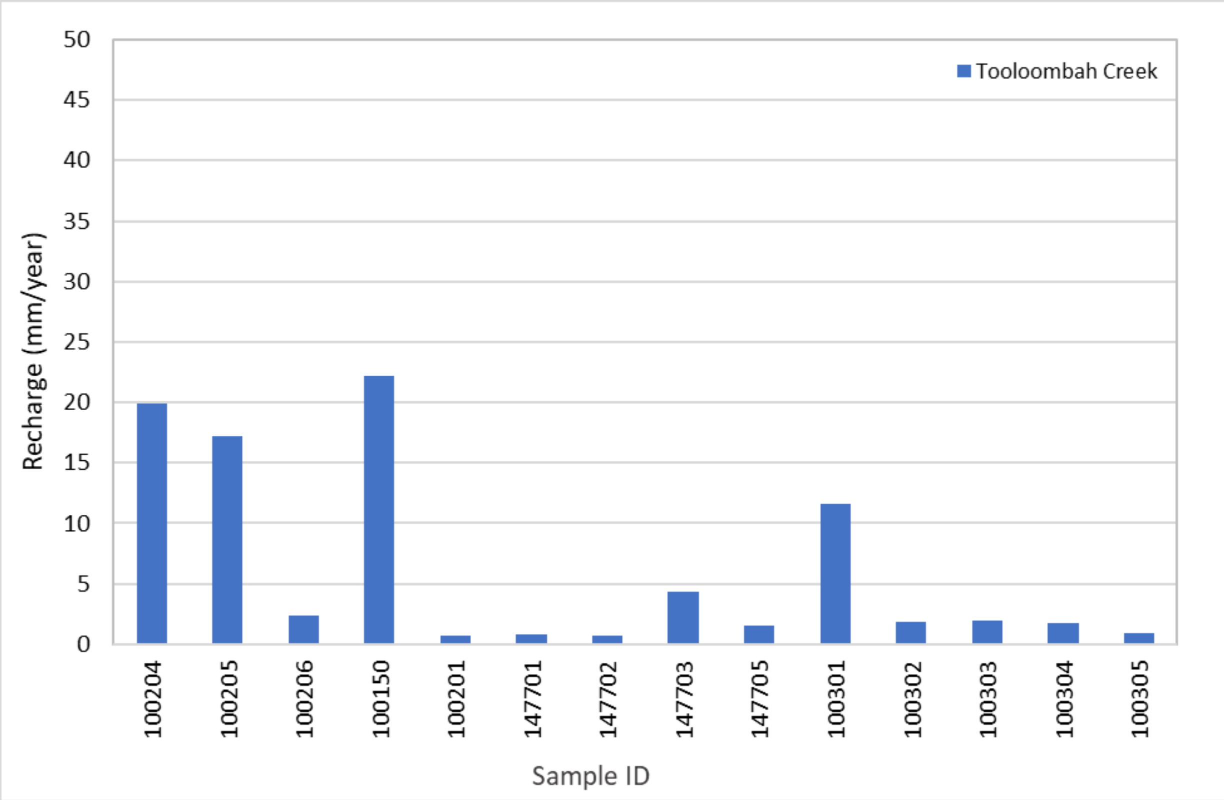

Figure 40: Estimated groundwater recharge for Tooloombah Creek drilling samples (refer to Table 7)

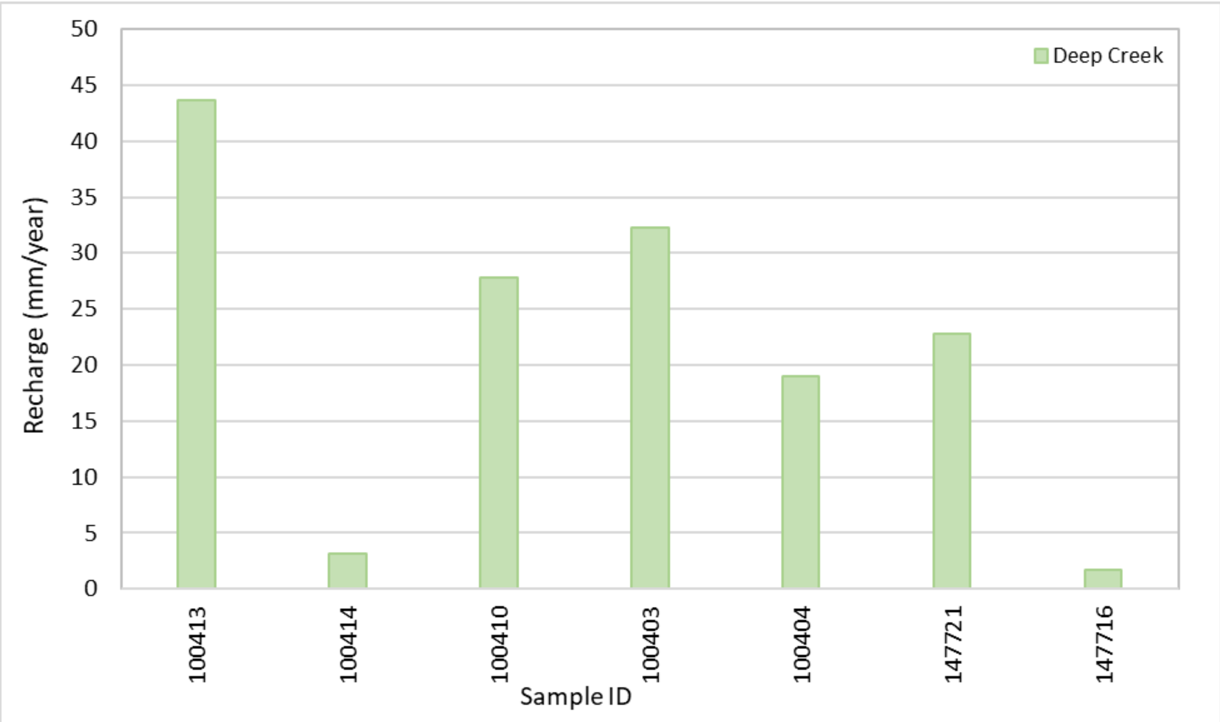

Figure 41: Estimated groundwater recharge for Deep Creek drilling samples (refer to Table 7)

6. Updated conceptualisation

Based on the findings of the technical studies detailed in Section 5 and 3D Environmental (2020), the following conceptualisation has been developed for Tooloombah Creek and Deep Creek. It is noted that the conceptualisations are based on the drilling data acquired from three transects only, and the available data is patchy across the study area and cannot be used as a comprehensive assessment. It is recommended that further studies are undertaken to map these areas further and increase confidence in the conceptualisation, to form the basis of the integrated numerical model.

6.1 Tooloombah Creek

The Tooloombah Creek conceptualisation, in terms of groundwater – surface water interactions in relation to GDEs relevant to the Project, is summarised below. The conceptualisation is best represented by Figure 10 by 3D Environmental (2020; i.e. losing stream conditions dominating in dry periods with regional groundwater levels mostly below the creek bed) and reverting to Figure 9 during high rainfall and streamflow events and the wet season, which provides recharge to in-bank storage along some reaches of the creeks that can then flow back towards the creeks during the dry period.

- Tooloombah Creek consists of a deeply incised channel with a rocky creek bed, up to 15 m deep within the study area.
- The alluvium consists of pockets within the creek bank profile, rather than a continuous formation, and unconformably overlies the Styx Coal Measures and weathered Styx formation (impermeable to some extent). There is a poor hydraulic connection between the two formations due to the presence of the weathered clays typically underlying the alluvium.
- Bank storage is feasible due to the transmissive alluvial sediments present (T = 6 m^2/day) and potentially critical for Tooloombah Creek. Groundwater flow from bank storage is determined to be towards Tooloombah Creek.
- The Tooloombah Creek 'pinch point' is located to the west of the CQC Project, downstream of the Tooloombah Creek and Mamelon Creek confluence and between Mt Brunswick and Mt Mamelon at approximately 25 mAHD elevation (HydroAlgorithmics, 2020). This feature is considered to have formed where the creek incises through the sandstone ridge and acts to typically restrict / concentrate flow within Tooloombah Creek and the shallow alluvial aquifer at this location. This potentially causes local groundwater levels to be elevated compared to the surrounding areas.
- The hydraulic conductivities estimated for the Tooloombah Creek alluvial sediments are suitable to allow groundwater uptake by terrestrial vegetation (K = 10^{-5} to 10^{-7} m/s). Similarly, salinities measured from the alluvial groundwater and surface water pools are suitable to support GDEs (< 10,000 EC units).
- Bank storage within the alluvium is recharged through lateral flow of surface water during the wet season, when creek water levels rise above the potentiometric surface. This causes mounding of the groundwater within the alluvial aquifer.

- Return flow of groundwater to the creek occurs during the dry season and/or dry periods, as baseflow, to recharge surface water within the creek and sustain surface water pools and soil moisture for GDE uptake.
- Potential groundwater flows from bank storage are estimated at 2.5 m^3/day and are anticipated to continue to reach the creek for approximately 150 days (0.4 years).
- Return flow to bank storage following streamflow events is estimated at 3.7 m^3/day. Groundwater is estimated to potentially continue flowing to bank storage for approximately 100 days (0.28 years) until the region becomes dry and flow reverses to recharge surface water.
- The increase in salinity observed within some surface water pools along Tooloombah Creek is likely driven by dissolved salts produced and collected through bank storage draining towards the creek. Alternatively, seasonal rise in underlying (Styx Formation) water tables may periodically bring more saline groundwater into the alluvium that persists in the alluvium aquifer in the vicinity of the pools even when the regional water table recedes.
- Tooloombah Creek is groundwater fed (primarily bank flow), hence surface water pools in this region may be sustained and persist during the dry season.
- Groundwater recharge is estimated at 5.5 mm/year for Tooloombah Creek catchment area (2 ML/year or 0.7% of the annual average rainfall for the region).

6.2 Deep Creek

The following presents a summary of the Deep Creek conceptualisation and is best represented by Figure 13 (i.e. losing stream conditions with groundwater level mostly below the creek bed) and then reverting to Figure 12 during high rainfall and streamflow events and the wet season.

- Deep Creek consists of a sandy / silty creek bed and reaches approximately 10 m depth and ranges in width from 2 to 3 m upstream to 5 to 10 m downstream of the Project.
- The alluvium consists of pockets within the creek bank profile, rather than a continuous formation, and unconformably overlies the Styx Coal Measures and weathered Styx formation (impermeable to some extent). A poor hydraulic connection exists between the two formations due to the weathered sequence.
- Lower clay content is present within the alluvium compared to Tooloombah Creek.
- Bank storage is feasible. Groundwater flow from bank storage is estimated to flow away from the creek, however, and is not considered the critical mechanism to sustain GDEs within the region.
- The hydraulic conductivities estimated for the alluvial sediments are suitable to allow groundwater uptake by terrestrial vegetation ($K = 10^{-5}$ to 10^{-7} m/s).
- Salinities measured from the alluvial groundwater and surface water pools are also suitable to support GDEs (<10,000 EC units).
- Bank storage within the alluvium is recharged through lateral flow of surface water during the wet season, when creek water levels rise above the potentiometric surface. This causes

mounding of the groundwater within the alluvial aquifer and water moves laterally away from the creek.

- Return flow of groundwater back towards the creek occurs during the dry season and/or dry periods, however may not reach the creek.
- Potential groundwater flows from bank storage are estimated up to 5 m^3/day for the western creek bank and between 0.3 m^3/day and 3 m^3/day for the eastern bank. Transmissivity of the alluvial sediments is estimated between 7 and 10 m^2/day for the western bank and 1.5 and 6.5 m^2/day for the eastern bank.
- Deep Creek at the Transect B and C locations (adjacent to the Project) does not appear to be fed by the regional water table groundwater, hence soil moisture and surface water pools in this region are likely to dry out during the dry season.
- The assessed locations on Deep Creek are situated adjacent to the south-north trending geological fault that runs along the eastern boundary of ML 80187 and groundwater losses may occur here due to both increased transmissivity due to the fault and the juxtaposition of more transmissive Permian sediments against the alluvium and Styx Coal Measures.
- The increase in salinity observed within surface water pools at Deep Creek can be largely explained by the effects of evaporation only. Minor groundwater ingress may occur periodically but does not contribute significantly to salinity nor to water levels.
- Areas to the south and north of the Deep Creek transects B and C may experience lower groundwater losses due to increased distance from the geological fault line mapped within the Project area and hence greater likelihood of less transmissive sediments in the adjacent sequence that would inhibit the vertical leakage of groundwater. Therefore, surface water pools downstream (north) towards the confluence may be supported by the ingress of groundwater.
- Groundwater recharge has been estimated at 17.4 mm/year for the Deep Creek catchment (5.2 ML/year or 2.2% of the annual average rainfall). This is comparable to recharge values used in the numerical groundwater modelling (HydroAlgorithmics, 2020).

7. Numerical groundwater – surface water model

The findings of the analytical modelling studies detailed in this report, and the consequent recognition of the heterogeneity and discontinuity of the alluvium within the region as well as the variations in groundwater – surface water interactions that have been identified along Tooloombah Creek and Deep Creek, indicate that a regional 3D model alone is not feasible, nor adequate, to assess and manage potential local-scale, Project-related impacts to GDEs. The use of local scale 2D cross-section models, however, that represent individual sites of significant ecological value to the Project, is a suitable method to provide a refined, site-specific assessment for the identified areas and to support the implementation of an adaptive management approach as outlined in the GDEMMP. This approach also overcomes the current lack of adequate spatial and temporal data required to develop a fine-scale regional 3D model for GDE processes.

The local scale 2D cross-section models would be further developed based on the analytical modelling results from this report, in addition to the proposed analysis of the July 2020 alluvial drilling program data (undertaken subsequent to this report preparation), and any further studies undertaken in key targeted areas.

Further relevant studies might include:

1. Undertaking additional drilling, sampling and field data collection at transects downstream of the Project area to confirm potential downstream impacts due to the CQC Project, as well as to as to refine the conceptualisation of the Wetland 1 GDE assessment area.
2. Collection of a longer temporal series of water table depths and vegetation response to confirm the implications of a single year's data.
3. Additional site-specific geochemistry and isotope assessments, as have been carried out at the five GDE assessment areas, should be undertaken at other vegetated areas in similar landscape and groundwater positions, as described in the GDEMMP.
4. Further data collection and analysis is recommended at the Tooloombah Creek streamflow gauge (ToGS1) for comparison to other sites, to better define the groundwater – surface water interactions and flows and potential implications to GDEs and to investigate the potential mounding of groundwater in this area.
5. Longer-term, higher temporal resolution collection of additional pool level and salinity data from multiple pools. Collection of isotope data would also aid in quantification of volumes and water sources.

The development of 2D cross-section models would then be undertaken using an appropriate numerical code, such as MODFLOW or FEFLOW. The models would specifically extend to the mine pit, which would be represented using a drain boundary condition that declines in elevation from the pre-mining water table to the bottom of the alluvium. The model would allow processes such as baseflow depletion and episodic recharge via bank storage and/or floodplain recharge to be simulated, to further understand the nature of the water balance that supports key GDEs.

8. Summary and recommendations

The technical studies detailed in this report have been undertaken to provide an increased understanding of the groundwater – surface water interactions regarding GDEs in the vicinity of Tooloombah Creek and Deep Creek and verify the conceptual models developed by 3D Environmental (2020). The results aim to form a basis for further review and update of the numerical modelling to better include assessment of potential impacts to GDEs and to be implemented as part of an adaptive management approach through the GDEMMP.

The key findings of this report are summarised below:

- The assessment undertaken on surface water – groundwater interactions along the Tooloombah Creek and Deep Creek in the vicinity of the Project generally support the conceptual models developed for the three GDE assessment areas by 3D Environmental (2020).
- Analysis of shallow bore transects across the alluvial aquifers of Tooloombah Creek and Deep Creek indicate that aquifer materials exist in discontinuous pockets and generally presents with a poor hydraulic connection with the underlying Styx Coal Measures.
- The regional water table may rise to levels that coincide with the base of the alluvial sequence towards the end of the wet season and may provide limited baseflow for some reaches. The limited temporal data suggests these elevated levels are unlikely to continue through the dry season.
- Bank storage is a feasible recharge mechanism for both Tooloombah Creek and Deep Creek and is critical for Tooloombah Creek to sustain the soil moisture and GDEs in this region. The reach between the To2 permanent surface water pool and the stream gauge downstream on Tooloombah Creek has been determined to be groundwater fed from bank storage, potentially supplied by high water tables during the wet months.
- Bank storage does not appear to be a critical process at Deep Creek in the areas studied, where the creek aligns with the north-south trending geological fault line present on the eastern side of the creek and Project area (as seen in the Deep Creek North transect). In this area groundwater flow in bank storage is enhanced away from the creek towards the east. Groundwater losses from bank storage are potentially greater in this location compared to areas south and north (downstream towards the confluence), which may behave more similarly to Tooloombah Creek. Consequently, soil moisture and surface water pools in the areas where the creek follows the geological fault line are unlikely to be sustained through the winter months. However, surface water pools located downstream towards the confluence may be supported by the ingress of groundwater from bank storage.
- The estimated hydraulic conductivities and measured soil moisture and salinity levels from samples taken during the drilling program indicate groundwater from bank storage is of suitable quality and availability for uptake by GDEs identified in the vicinity of Tooloombah Creek and Deep Creek.

- Bank storage may be facilitated either through overbank flooding infiltrating the shallow sediments or through saturation of these sediments from rising regional water tables in the wet season. The former appears to be the dominant process (i.e. with the most sustained input to alluvial sediments) maintaining GDEs.
- Chloride mass balance estimates of groundwater recharge are 5.5 mm/year for Tooloombah Creek catchment area (2 ML/year or 0.7% of the annual average rainfall for the region and 17.4 mm/year for the Deep Creek catchment (5.2 ML/year or 2.2% of the annual average rainfall).

The heterogeneity within the alluvial sediments and discontinuous pockets of alluvium identified in the three transects indicate that the analytical modelling results detailed in this report cannot reasonably be extrapolated across the whole region and hence the regional numerical groundwater model cannot capture the local-scale variability that defines GDE locations. For this reason, the use of local 2D numerical models are required to further understand processes specifically relevant to GDEs and this approach is preferred to a regional 3D model.

Further on-ground studies should be carried out across the CQC Project area, as well as upstream and downstream, to confirm the results and conceptualisations presented here and to better inform the development of local-scale, 2D cross-section models to support the groundwater impact assessment and adaptive management process.

9. References

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Appendix A | Transect 1 to 4 plots

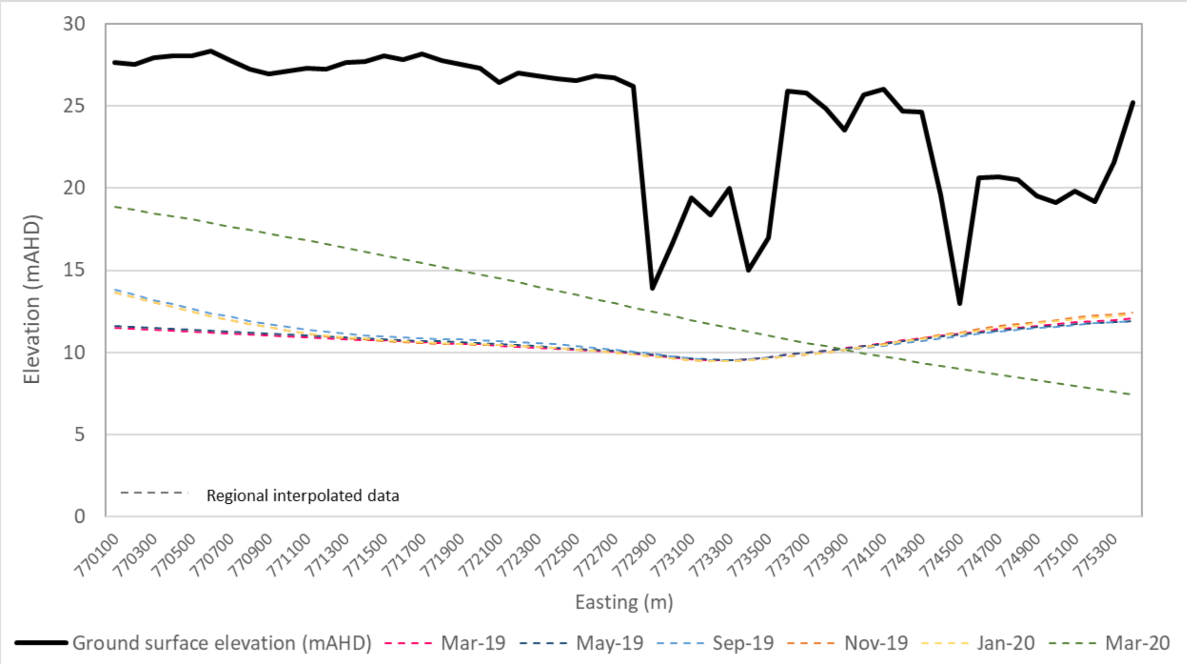


Figure A-1: Transect 1 groundwater level vs. creek elevation

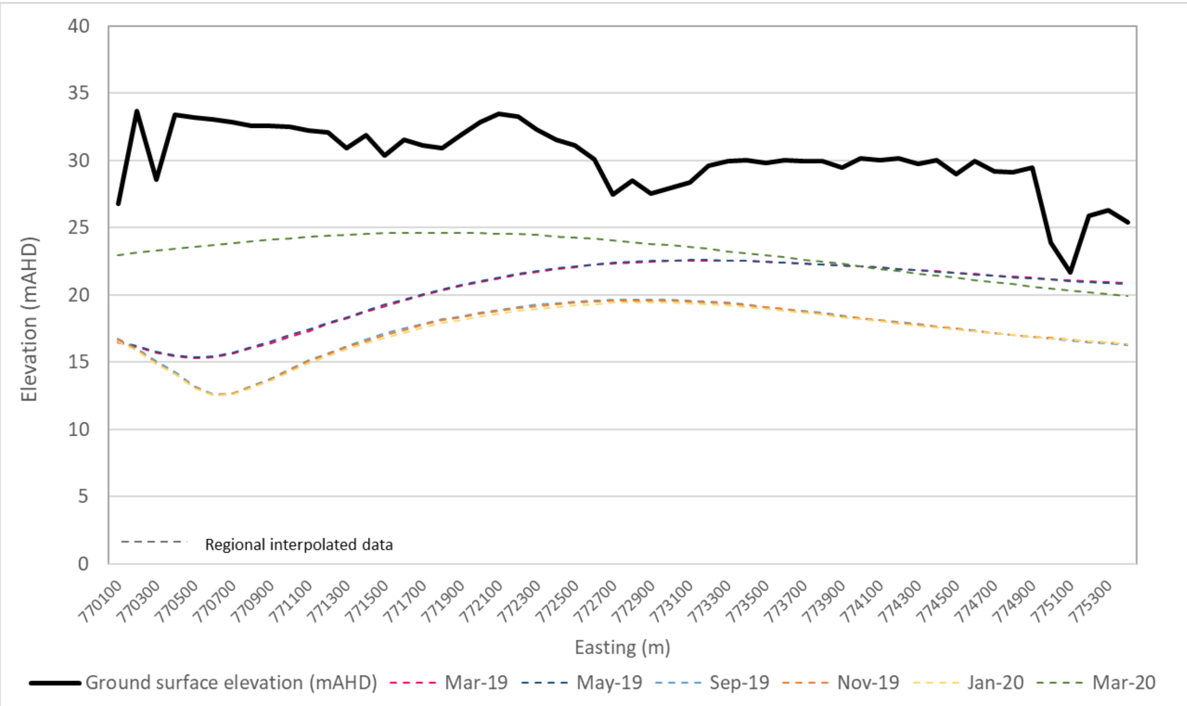


Figure A-2: Transect 2 groundwater level vs. creek elevation

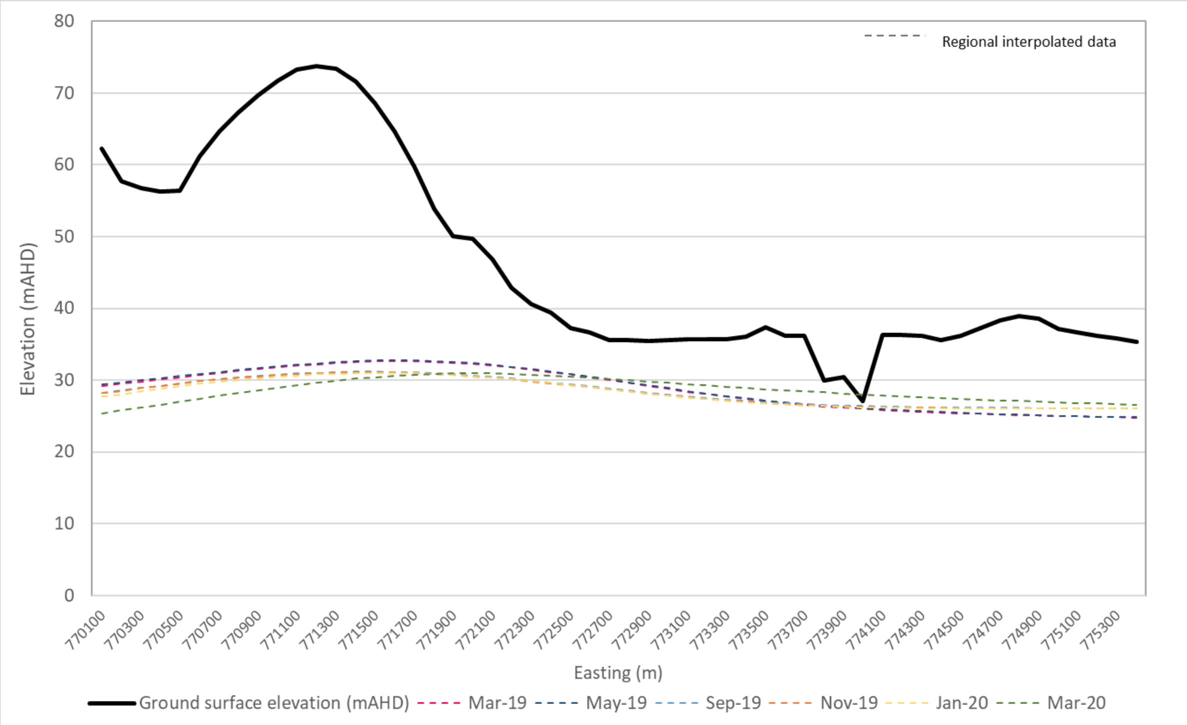


Figure A-3: Transect 3 groundwater level vs. creek elevation

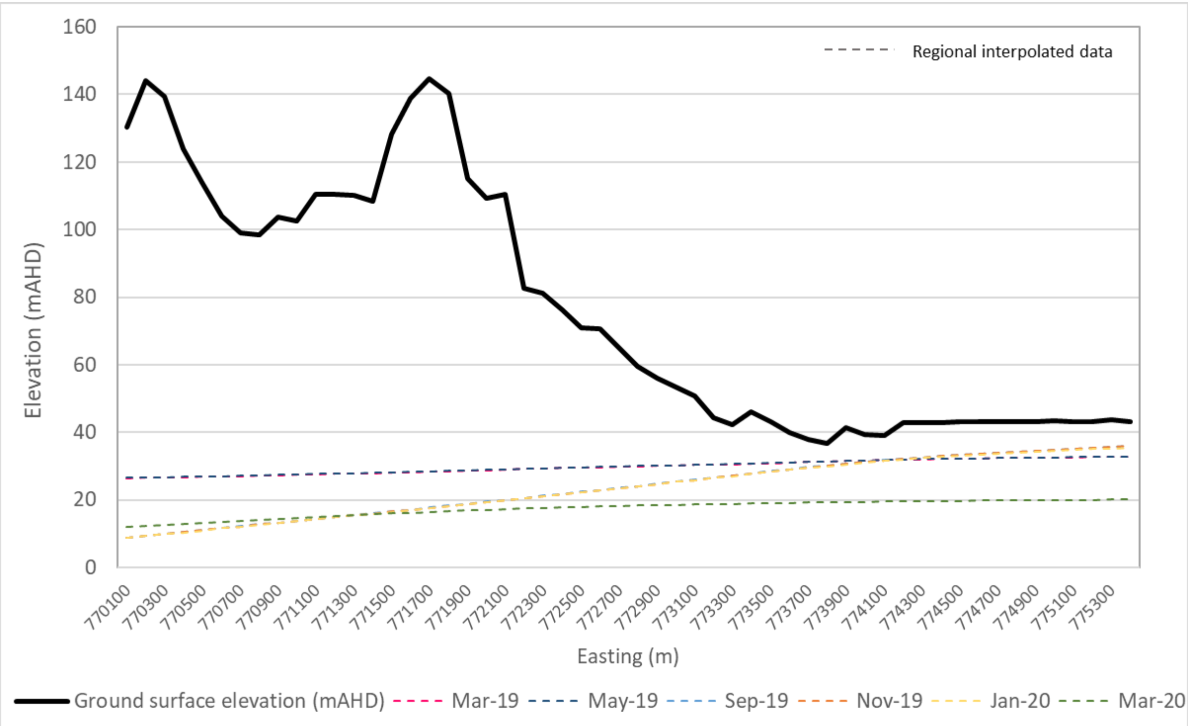
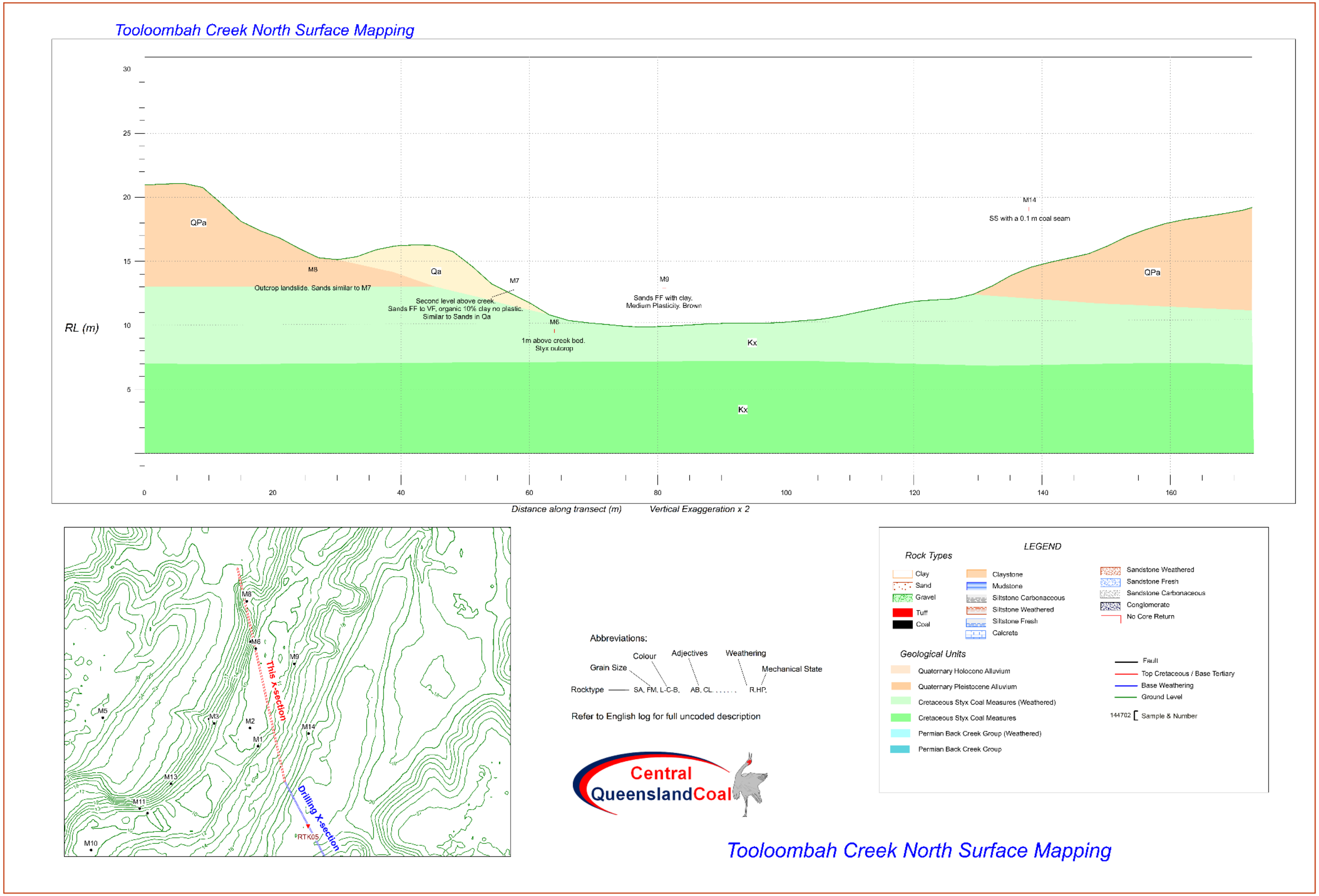
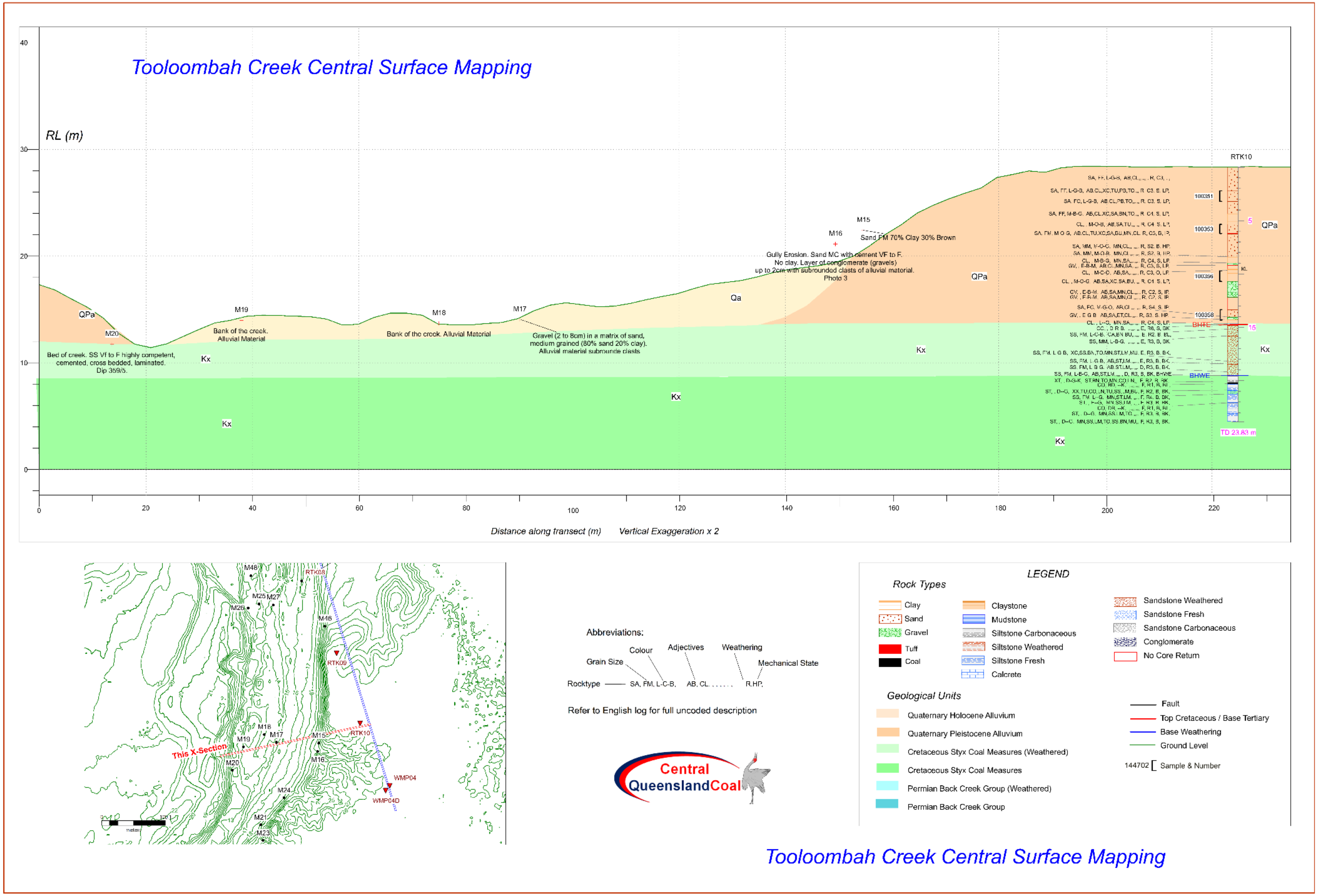
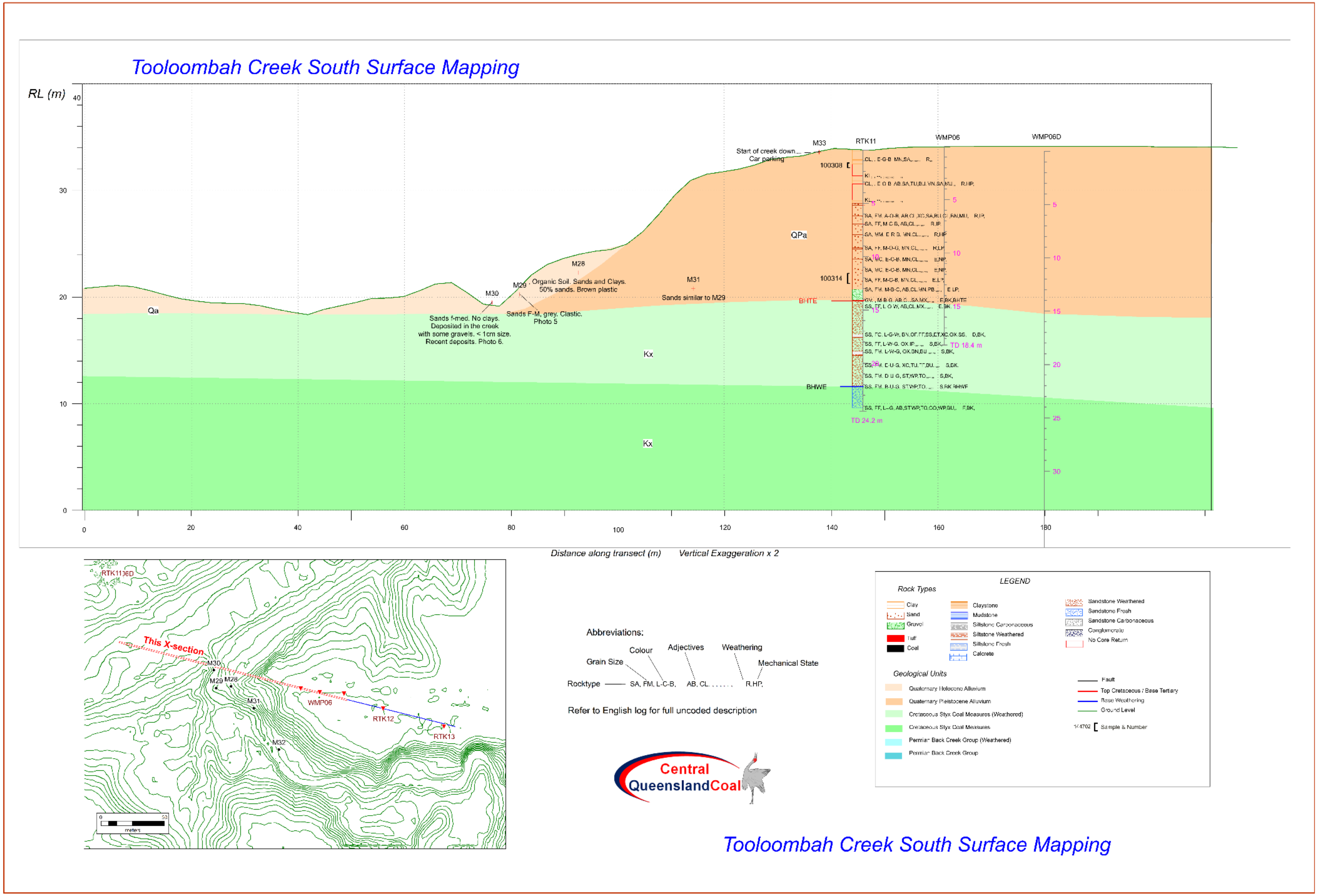


Figure A-4: Transect 4 groundwater level vs. creek elevation

Appendix B | July 2020 cross-sections (provided by CQC 2020)


Tooloombah Creek North Surface Mapping
RL (m)
Distance along transect (m)
Vertical Exaggeration x 2
QPa
Qa
Kx
M8
Outcrop landslide. Sands similar to M7
M7
Second level above creek.
Sands FF to VF, organic 10% clay no plastic.
Similar to Sands in Qa
M6
1m above creek bed.
Styx outcrop
M9
Sands FF with clay,
Medium Plasticity, Brown
M14
SS with a 0.1 m coal seam
This X-section
Drilling X-section
RTK05
Abbreviations:
Rocktype
Grain Size
Colour
Adjectives
Weathering
Mechanical State
SA, FM, L-C-B, AB, CL, R.HP.
Refer to English log for full uncoded description
LEGEND
Rock Types
Clay
Sand
Gravel
Tuff
Coal
Claystone
Mudstone
Siltstone Carbonaceous
Siltstone Weathered
Siltstone Fresh
Calcrete
Sandstone Weathered
Sandstone Fresh
Sandstone Carbonaceous
Conglomerate
No Core Return
Geological Units
Quaternary Holocene Alluvium
Quaternary Pleistocene Alluvium
Cretaceous Styx Coal Measures (Weathered)
Cretaceous Styx Coal Measures
Permian Back Creek Group (Weathered)
Permian Back Creek Group
Fault
Top Cretaceous / Base Tertiary
Base Weathering
Ground Level
144702 Sample & Number
Central QueenslandCoal
Tooloombah Creek North Surface Mapping


Tooloombah Creek Central Surface Mapping
RL (m)
RTK10
QPa
Qa
Kx
M15
M16
M17
M18
M19
M20
Sand FM 70% Clay 30% Brown
Gully Erosion. Sand MC with cement VF to F. No clay. Layer of conglomerate (gravels) up to 2cm with subrounded clasts of alluvial material. Photo 3
Bank of the creek. Alluvial Material
Bank of the creek. Alluvial Material
Gravel (2 to 8cm) in a matrix of sand, medium grained (80% sand 20% clay). Alluvial material subrounde clasts
Bed of creek. SS VF to F highly competent, cemented, cross bedded, laminated. Dip 359/5.
BHTE
BHWE
TD 23.83 m
Distance along transect (m)
Vertical Exaggeration x 2
This X-Section
RTK08
RTK09
RTK10
WMP04
WMP04D
Abbreviations:
Rocktype
Grain Size
Colour
Adjectives
Weathering
Mechanical State
SA, FM, L-C-B, AB, CL, R,HP,
Refer to English log for full uncoded description
Central QueenslandCoal
LEGEND
Rock Types
Clay
Sand
Gravel
Tuff
Coal
Claystone
Mudstone
Siltstone Carbonaceous
Siltstone Weathered
Siltstone Fresh
Calcrete
Sandstone Weathered
Sandstone Fresh
Sandstone Carbonaceous
Conglomerate
No Core Return
Geological Units
Quaternary Holocene Alluvium
Quaternary Pleistocene Alluvium
Cretaceous Styx Coal Measures (Weathered)
Cretaceous Styx Coal Measures
Permian Back Creek Group (Weathered)
Permian Back Creek Group
Fault
Top Cretaceous / Base Tertiary
Base Weathering
Ground Level
144702 [Sample & Number
Tooloombah Creek Central Surface Mapping



Tooloombah Creek South Surface Mapping
RL (m)
Distance along transect (m)
Vertical Exaggeration x 2
Start of creek down
Car parking
M33
RTK11
WMP06
WMP06D
QPa
Qa
Kx
M28
M29
M30
M31
Organic Soil. Sands and Clays. 50% sands. Brown plastic
Sands similar to M29
Sands F-M, grey. Clastic. Photo 5
Sands f-med. No clays. Deposited in the creek with some gravels. < 1cm size. Recent deposits. Photo 6.
BHTE
BHWE
TD 18.4 m
TD 24.2 m
This X-section
RTK12
RTK13
M32
Abbreviations:
Rocktype
Grain Size
Colour
Adjectives
Weathering
Mechanical State
Refer to English log for full uncoded description
LEGEND
Rock Types
Geological Units
Central QueenslandCoal

Appendix C | Laboratory analysis results

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

ALS Environmental

Brisbane QLD

CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-001 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100204

Particle Size Distribution

Particle Size (mm)	% Passing
1.18	100%
0.600	99%
0.425	97%
0.300	93%
0.150	72%
0.075	47%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.084

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

NATA Accreditation: 825 Site: Brisbane
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Satish Trivedi
Soil Senior Chemist
Authorised Signatory

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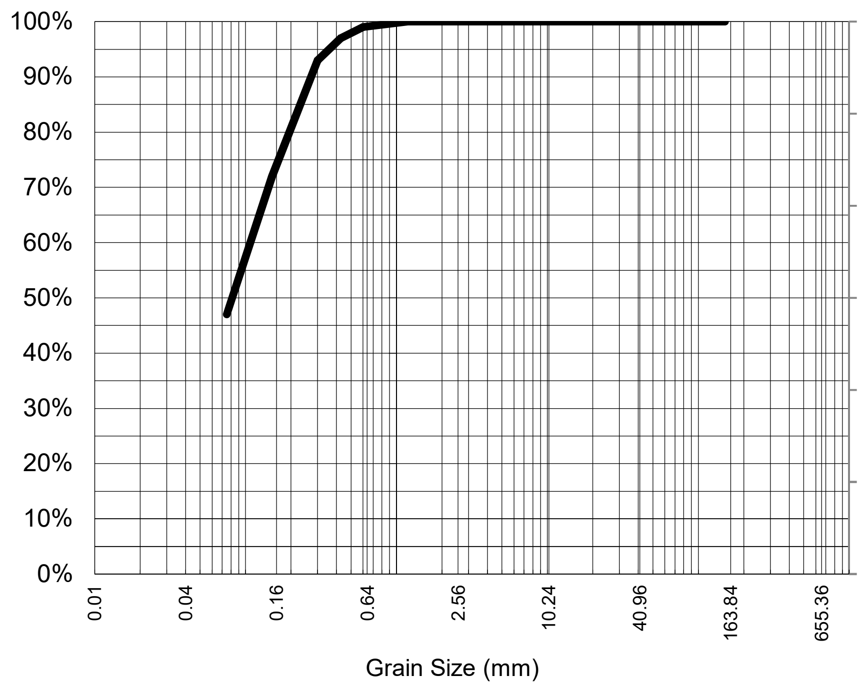
Brisbane QLD

CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-001DUP / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100204

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	99%
0.425	97%
0.300	93%
0.150	72%
0.075	47%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.084

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

NATA Accreditation: 825 Site: Brisbane
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samples.brisbane@alsenviro.com

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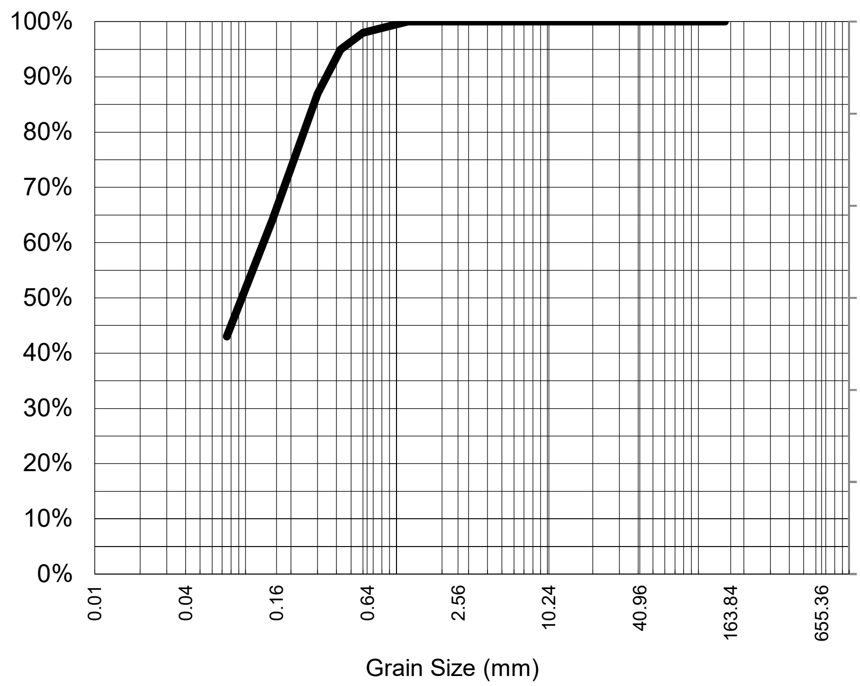
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-002 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100205

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	98%
0.425	95%
0.300	87%
0.150	64%
0.075	43%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.100

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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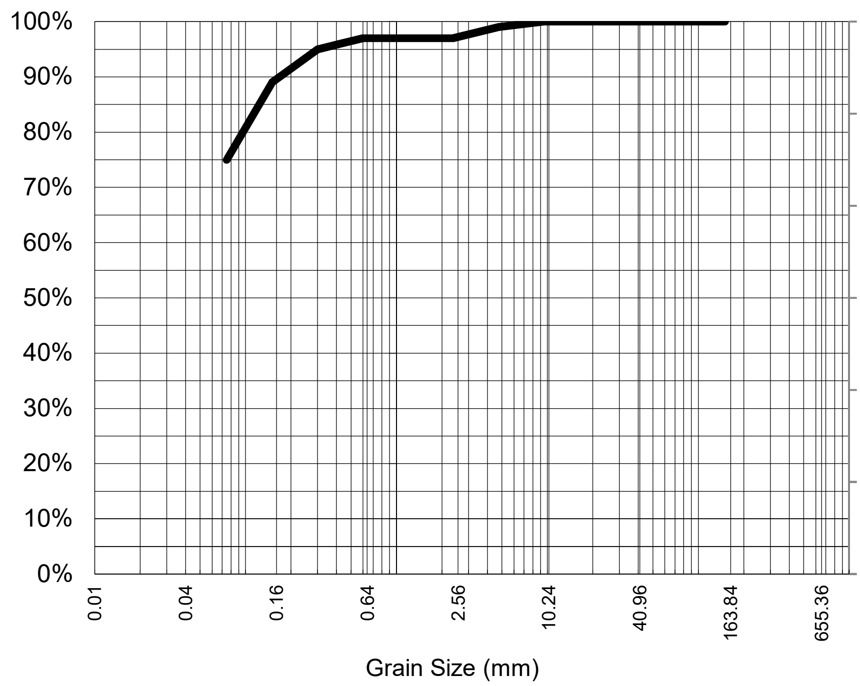
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-003 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100206

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	97%
1.18	97%
0.600	97%
0.425	96%
0.300	95%
0.150	89%
0.075	75%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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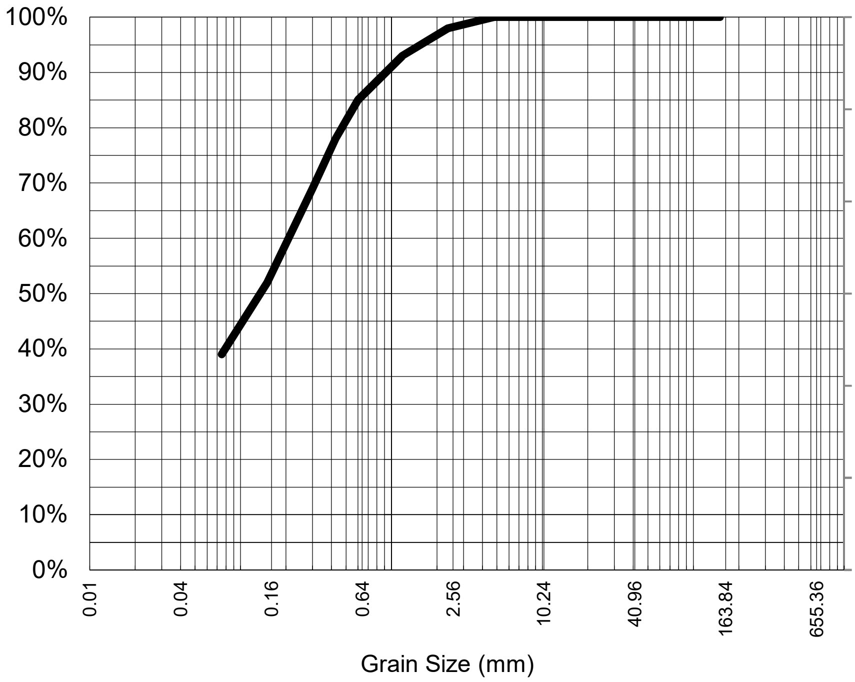
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-004 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100208

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	98%
1.18	93%
0.600	85%
0.425	78%
0.300	69%
0.150	52%
0.075	39%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.138

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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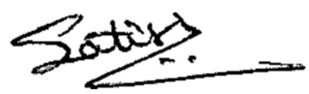

Satish Trivedi
Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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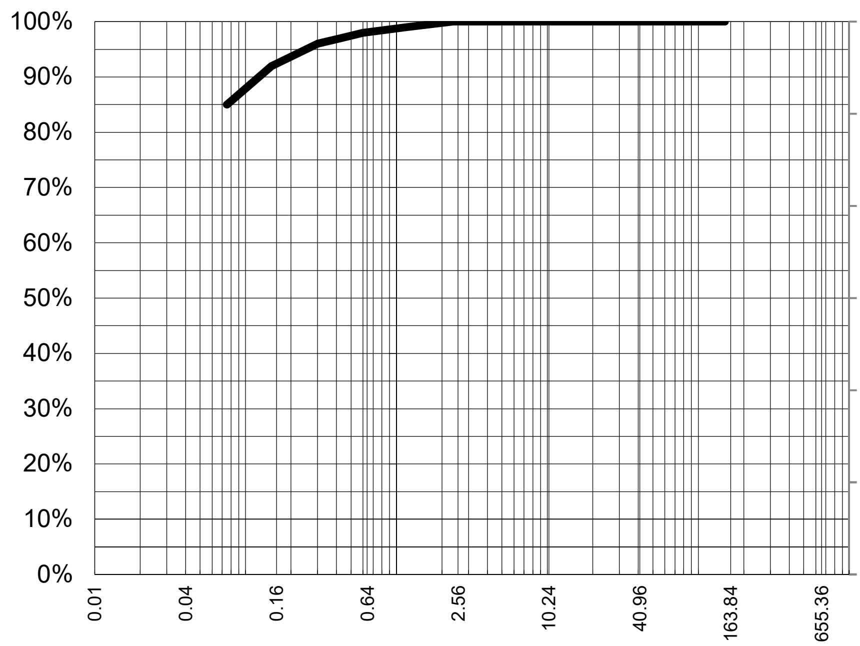
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-005 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100150

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	98%
0.425	97%
0.300	96%
0.150	92%
0.075	85%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-006 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100201

Particle Size Distribution

Particle Size (mm)	% Passing
19.0	100%
9.50	93%
4.75	66%
2.36	47%
1.18	38%
0.600	34%
0.425	33%
0.300	31%
0.150	30%
0.075	29%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	2.737

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

Satish Trivedi
Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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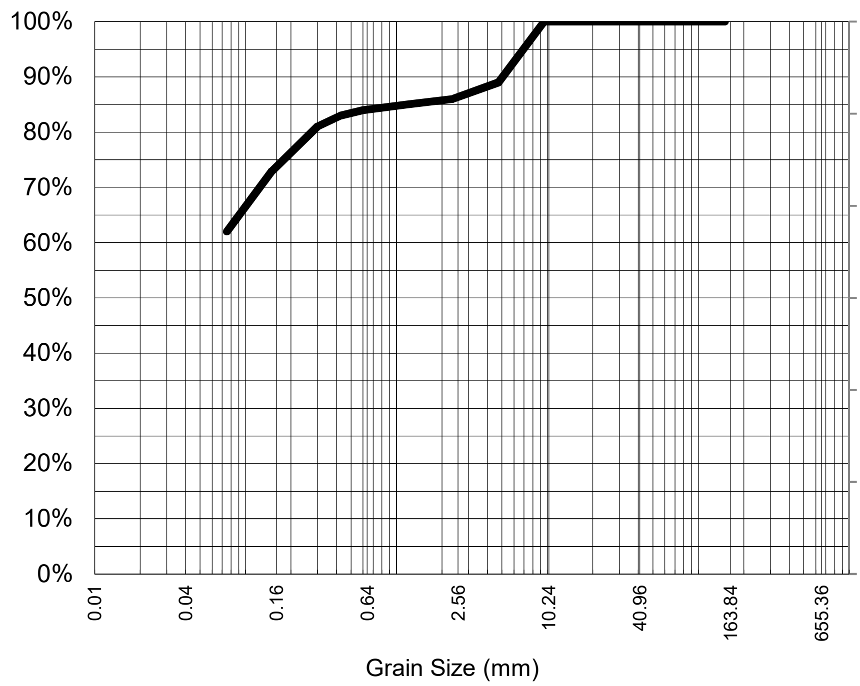
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-007 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100202

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	89%
2.36	86%
1.18	85%
0.600	84%
0.425	83%
0.300	81%
0.150	73%
0.075	62%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
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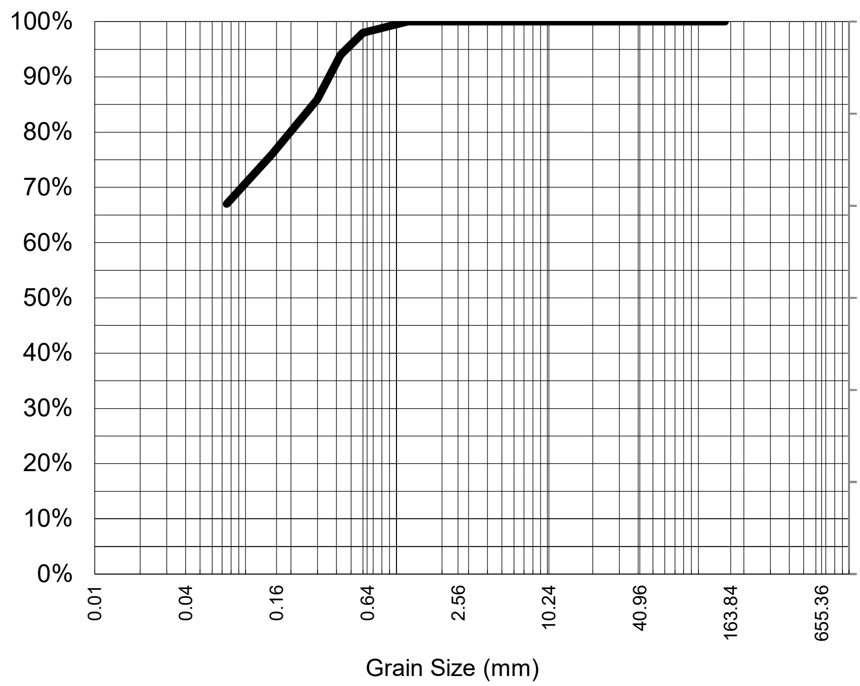
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-008 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147701

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	98%
0.425	94%
0.300	86%
0.150	76%
0.075	67%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
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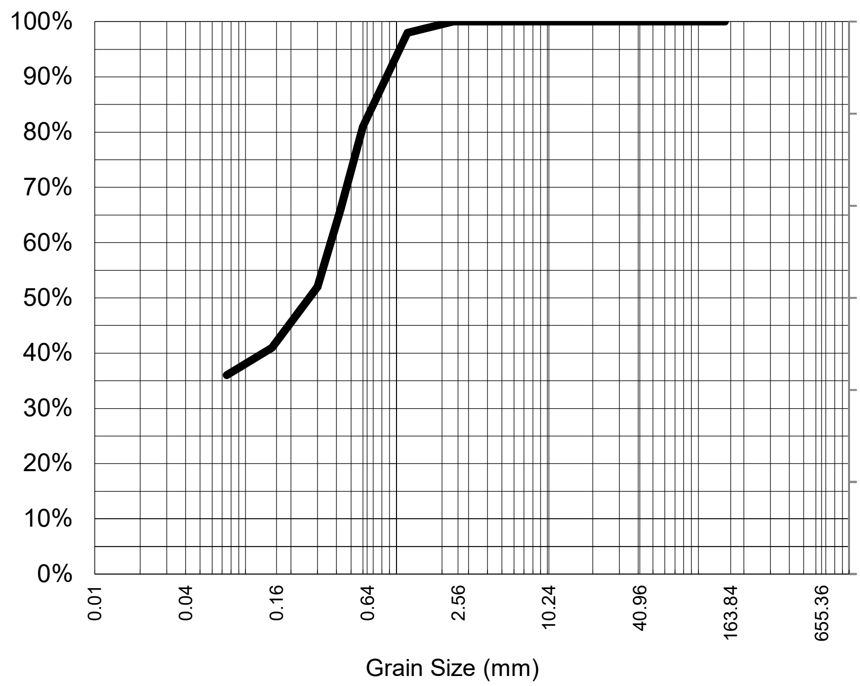
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-009 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147702

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	81%
0.425	66%
0.300	52%
0.150	41%
0.075	36%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.273

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
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pH 07 3243 7222
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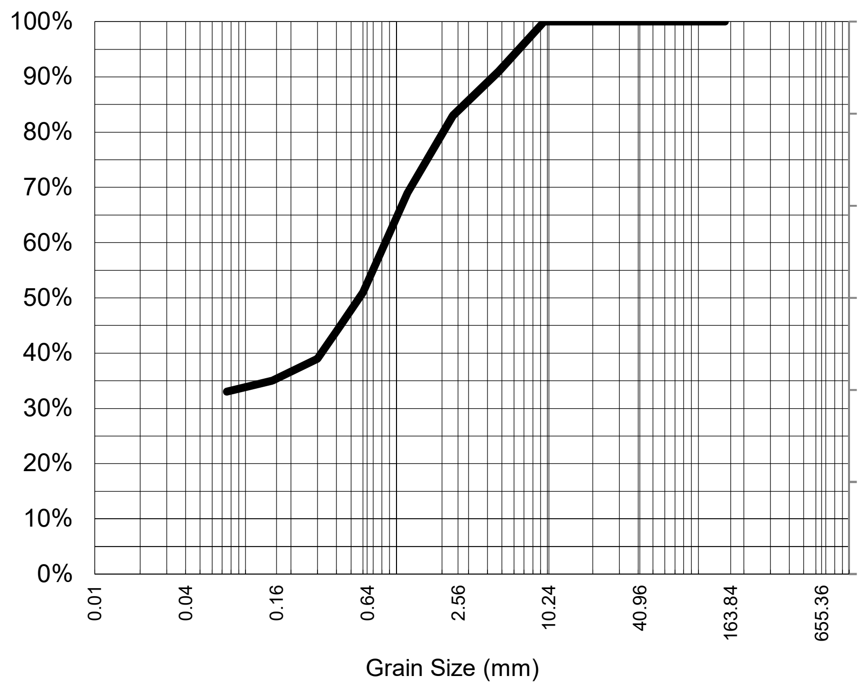
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-010 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147703

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	91%
2.36	83%
1.18	69%
0.600	51%
0.425	45%
0.300	39%
0.150	35%
0.075	33%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.571

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Stafford, QLD 4053
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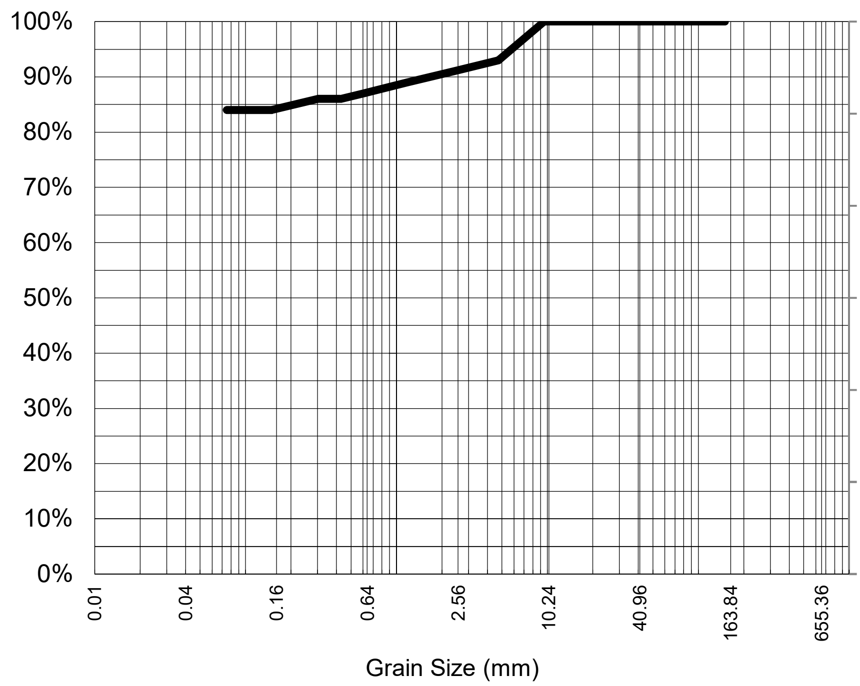
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-011 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147705

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	93%
2.36	91%
1.18	89%
0.600	87%
0.425	86%
0.300	86%
0.150	84%
0.075	84%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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samples.brisbane@alsenviro.com

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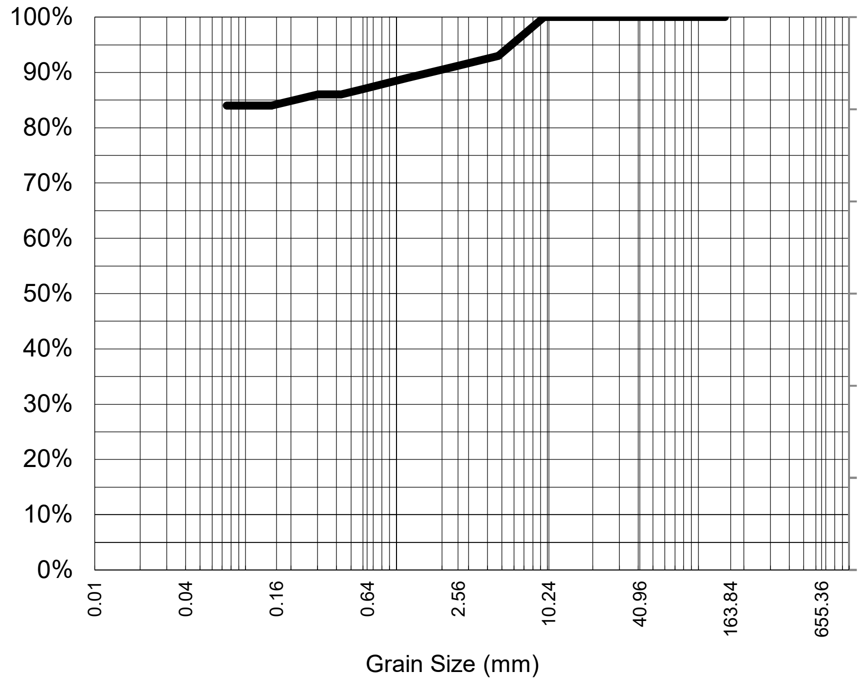
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-011DUP / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147705

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	93%
2.36	91%
1.18	89%
0.600	87%
0.425	86%
0.300	86%
0.150	84%
0.075	84%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Stafford, QLD 4053
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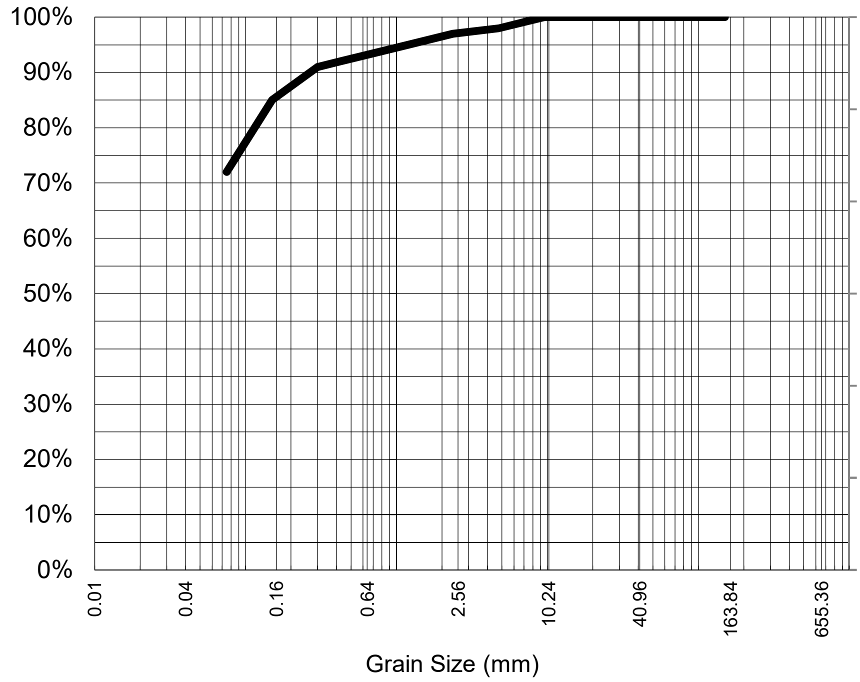
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-012 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147707

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	97%
1.18	95%
0.600	93%
0.425	92%
0.300	91%
0.150	85%
0.075	72%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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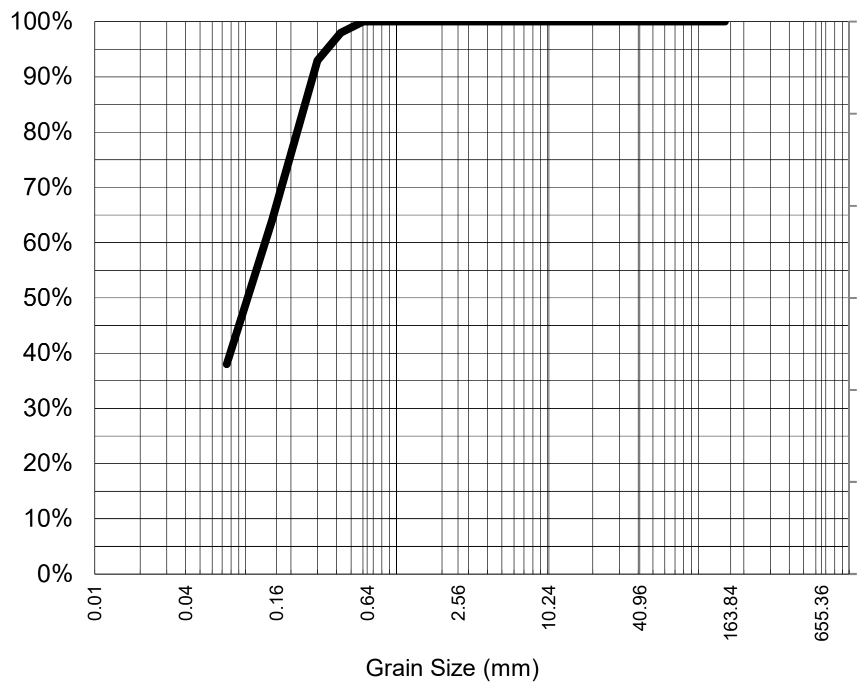
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-016 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100403

Particle Size Distribution



Particle Size (mm)	% Passing
0.600	100%
0.425	98%
0.300	93%
0.150	64%
0.075	38%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.110

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
Authorised Signatory

Template Version PKV8.0 180919

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Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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Brisbane QLD

CLIENT: JOHNBERNAL

DATE REPORTED: 11-Jun-2020

COMPANY: WARATAH COAL

DATE RECEIVED: 27-May-2020

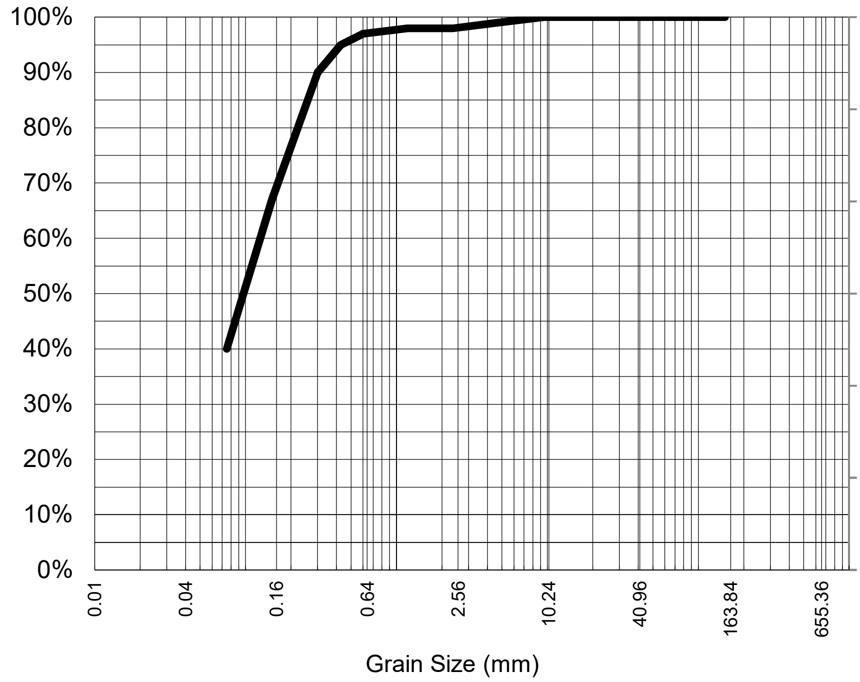
ADDRESS: C/- Als Emerald
9 Foundry Rd
Emerald

REPORT NO: EB2014000-017 / PSD

PROJECT: Central Queensland Coal Project

SAMPLE ID: 100404

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	98%
0.600	97%
0.425	95%
0.300	90%
0.150	67%
0.075	40%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.103

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Satish Trivedi
Soil Senior Chemist
Authorised Signatory

Certificate of Analysis

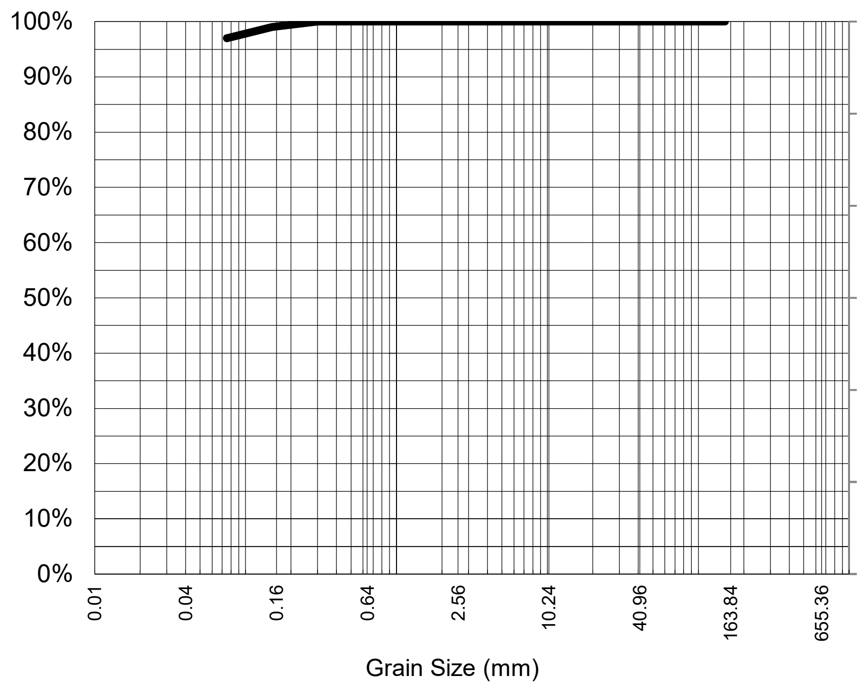
ALS Laboratory Group Pty Ltd
2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

ALS Environmental

Brisbane QLD

CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-018 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100406

Particle Size Distribution



Particle Size (mm)	% Passing
0.300	100%
0.150	99%
0.075	97%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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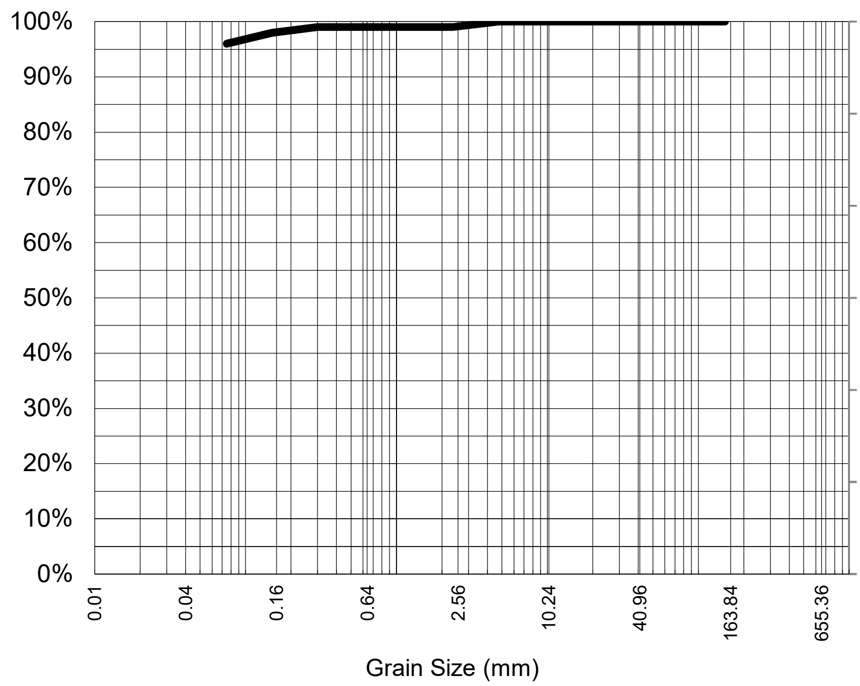
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-019 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100409

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	99%
0.425	99%
0.300	99%
0.150	98%
0.075	96%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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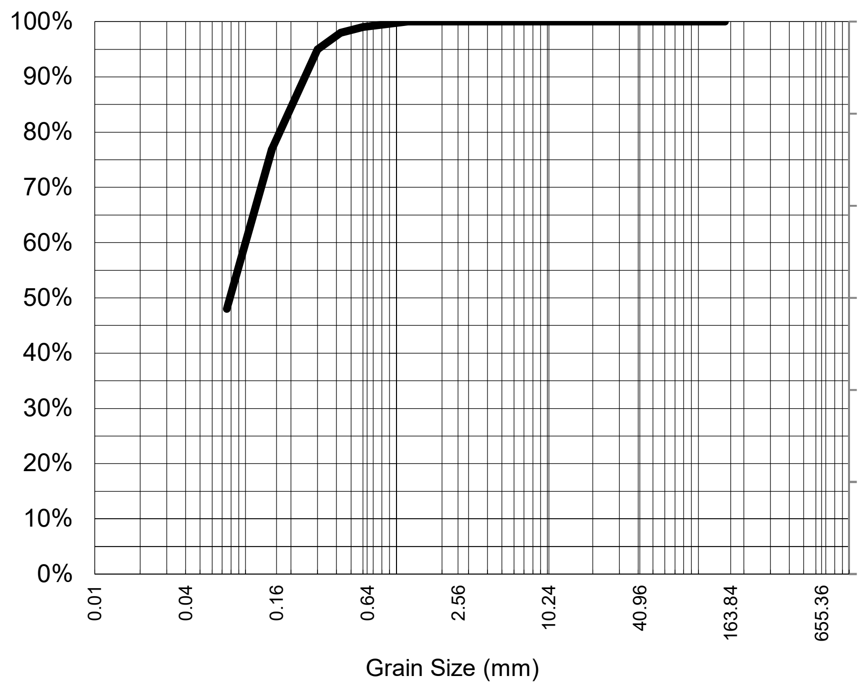
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-020 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100410

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	99%
0.425	98%
0.300	95%
0.150	77%
0.075	48%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.080

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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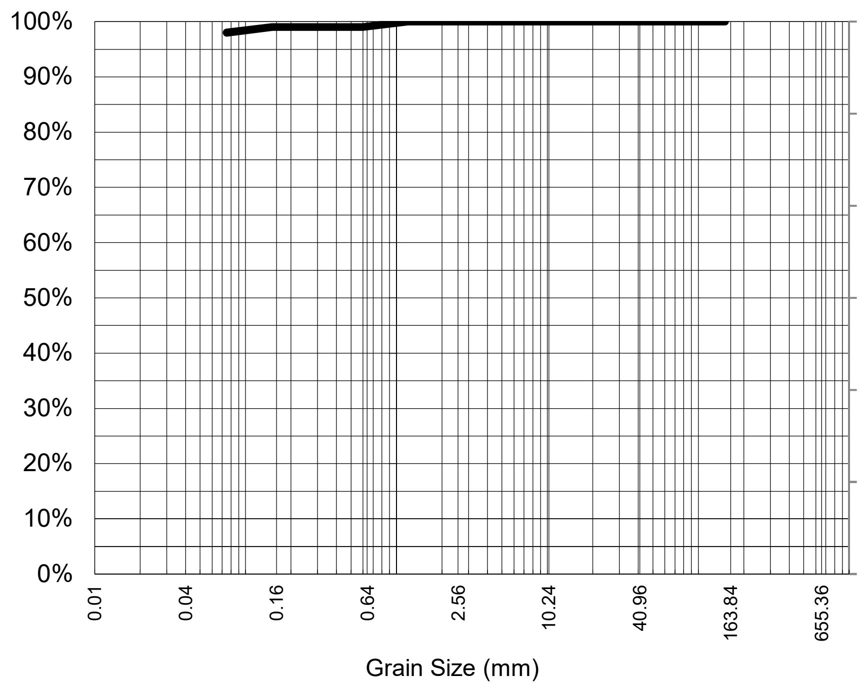
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-021 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100412

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	99%
0.425	99%
0.300	99%
0.150	99%
0.075	98%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-022 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100413

Particle Size Distribution

Particle Size (mm)	% Passing
0.600	100%
0.425	99%
0.300	98%
0.150	89%
0.075	63%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
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Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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CLIENT: JOHNBERNAL

DATE REPORTED: 11-Jun-2020

COMPANY: WARATAH COAL

DATE RECEIVED: 27-May-2020

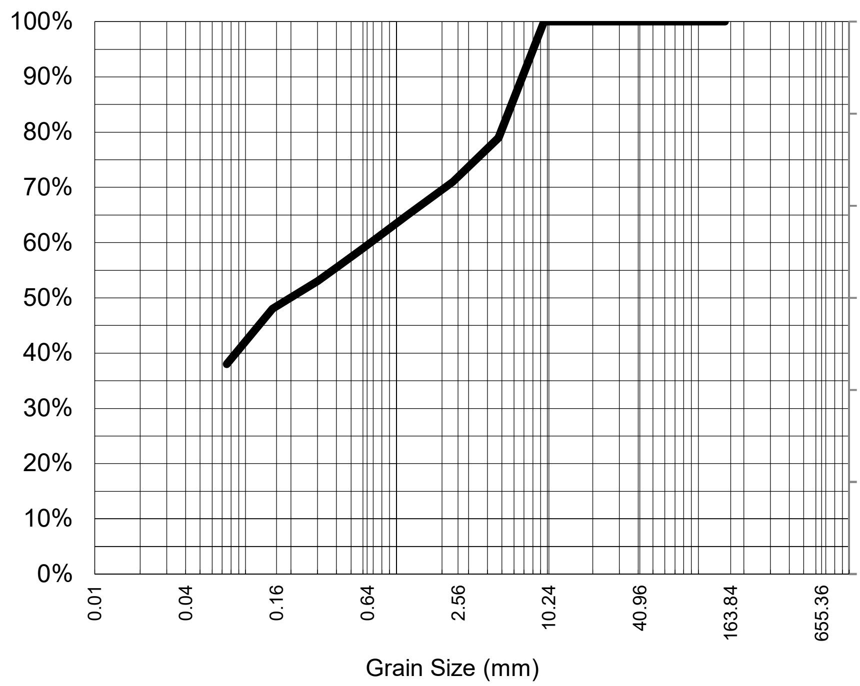
ADDRESS: C/- Als Emerald
9 Foundry Rd
Emerald

REPORT NO: EB2014000-023 / PSD

PROJECT: Central Queensland Coal Project

SAMPLE ID: 100414

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	79%
2.36	71%
1.18	65%
0.600	59%
0.425	56%
0.300	53%
0.150	48%
0.075	38%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.210

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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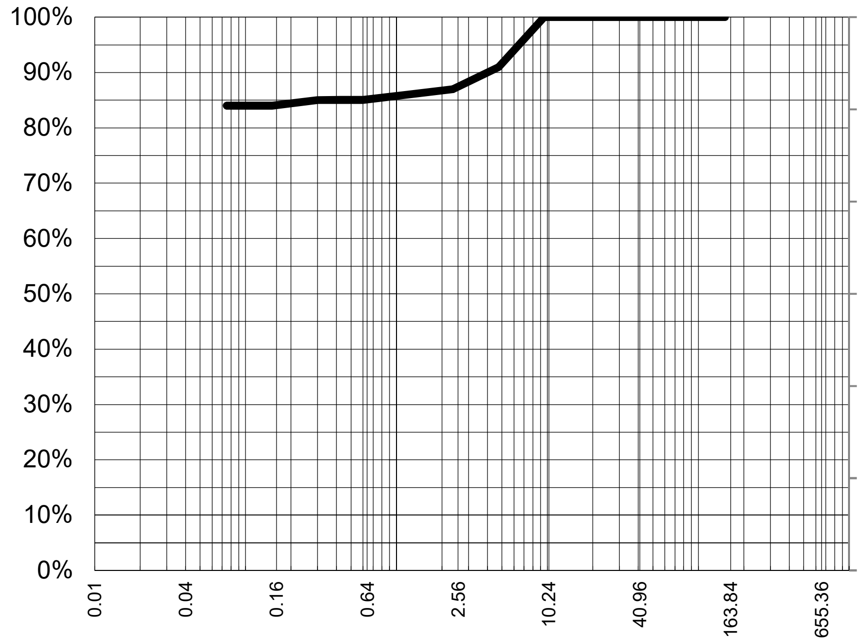
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-024 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100415

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	91%
2.36	87%
1.18	86%
0.600	85%
0.425	85%
0.300	85%
0.150	84%
0.075	84%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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pH 07 3243 7222
samples.brisbane@alsenviro.com

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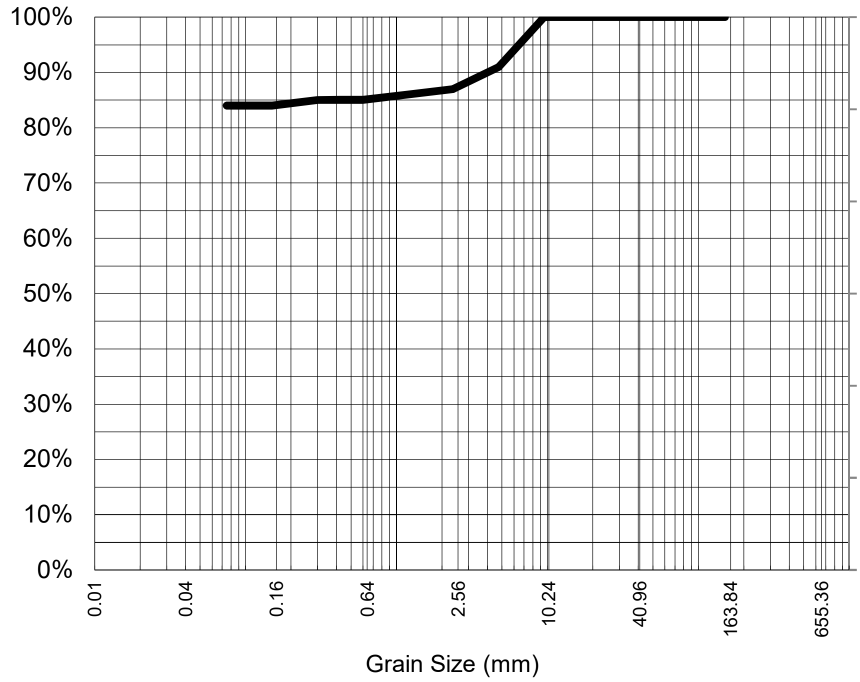
CLIENT: JOHNBERNAL
DATE REPORTED: 11-Jun-2020

COMPANY: WARATAH COAL
DATE RECEIVED: 27-May-2020

ADDRESS: C/- Als Emerald
9 Foundry Rd
Emerald
REPORT NO: EB2014000-024DUP / PSD

PROJECT: Central Queensland Coal Project
SAMPLE ID: 100415

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	91%
2.36	87%
1.18	86%
0.600	85%
0.425	85%
0.300	85%
0.150	84%
0.075	84%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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pH 07 3243 7222
samples.brisbane@alsenviro.com

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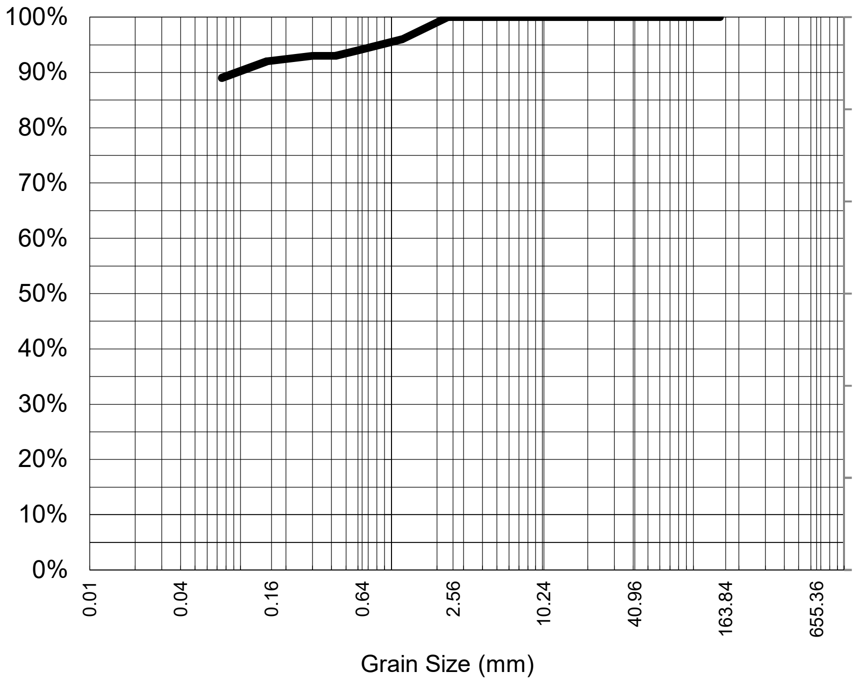
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-025 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100417

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	96%
0.600	94%
0.425	93%
0.300	93%
0.150	92%
0.075	89%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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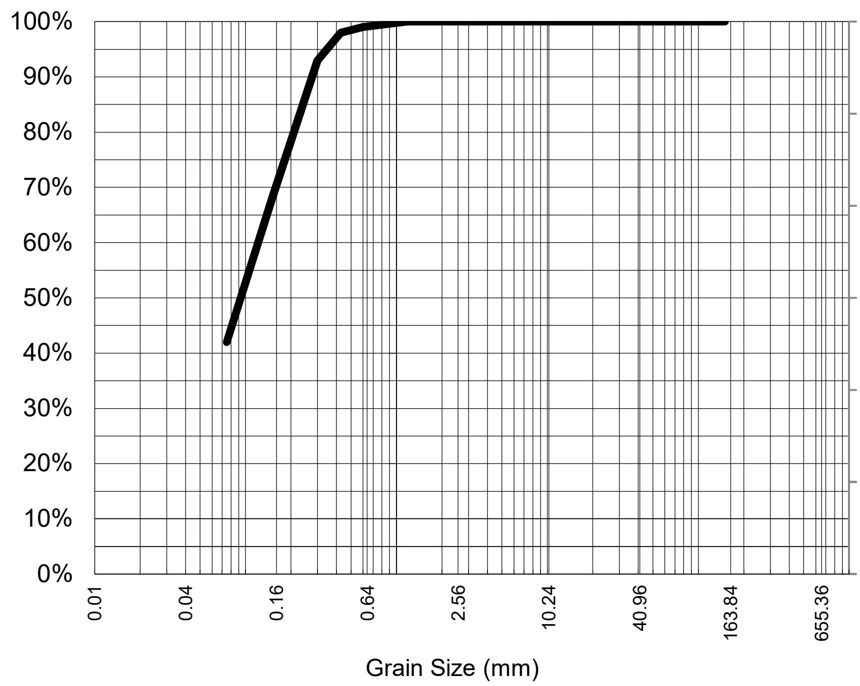
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-026 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147721

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	99%
0.425	98%
0.300	93%
0.150	68%
0.075	42%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.098

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-029 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147725

Particle Size Distribution

Particle Size (mm)	% Passing
19.0	100%
9.50	92%
4.75	75%
2.36	70%
1.18	67%
0.600	66%
0.425	65%
0.300	64%
0.150	62%
0.075	57%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Authorised Signatory

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Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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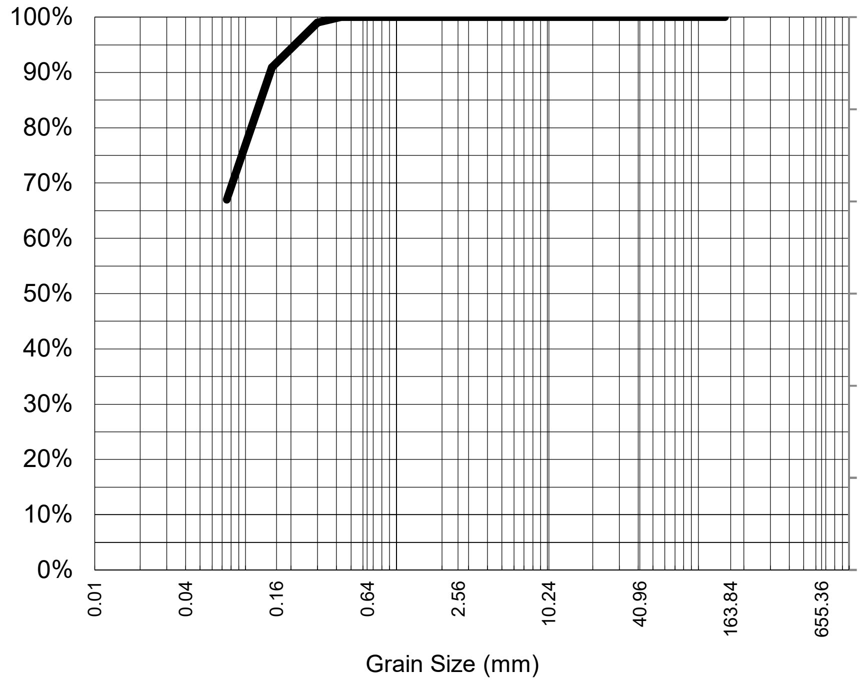
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-030 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147716

Particle Size Distribution



Particle Size (mm)	% Passing
0.425	100%
0.300	99%
0.150	91%
0.075	67%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Soil Senior Chemist
Authorised Signatory

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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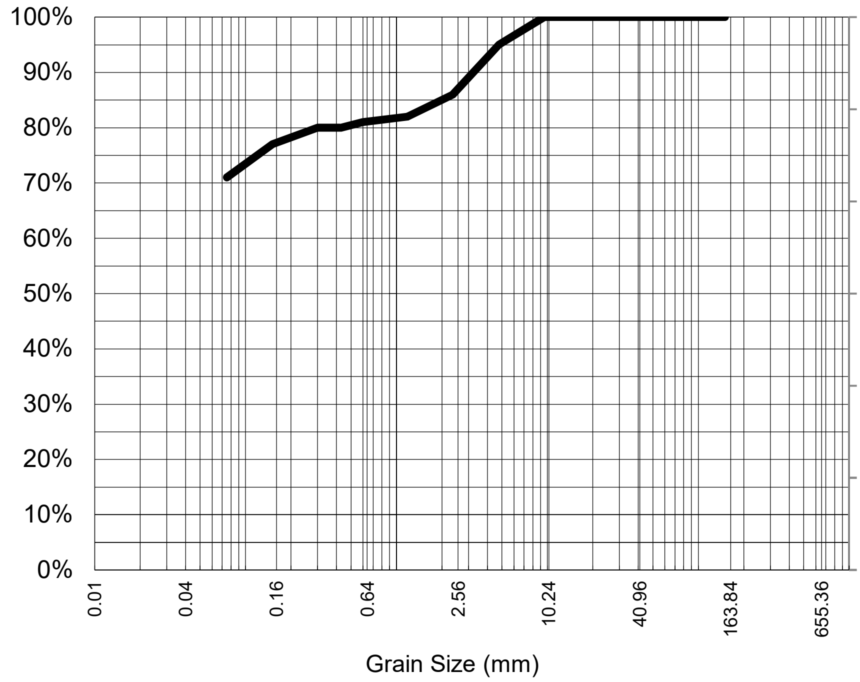
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-037 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	147737

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	95%
2.36	86%
1.18	82%
0.600	81%
0.425	80%
0.300	80%
0.150	77%
0.075	71%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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pH 07 3243 7222
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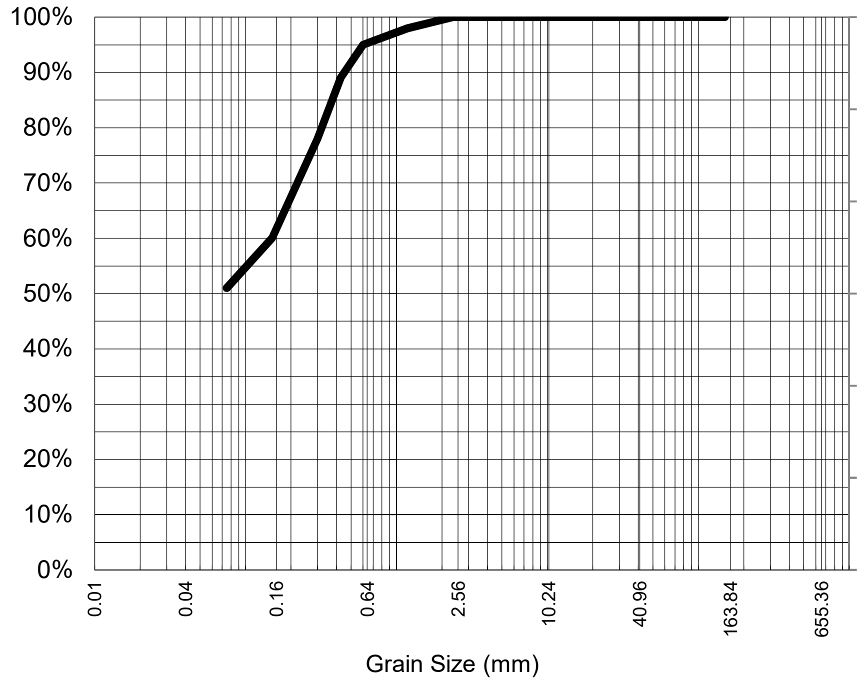
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-038 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100301

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	95%
0.425	89%
0.300	78%
0.150	60%
0.075	51%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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pH 07 3243 7222
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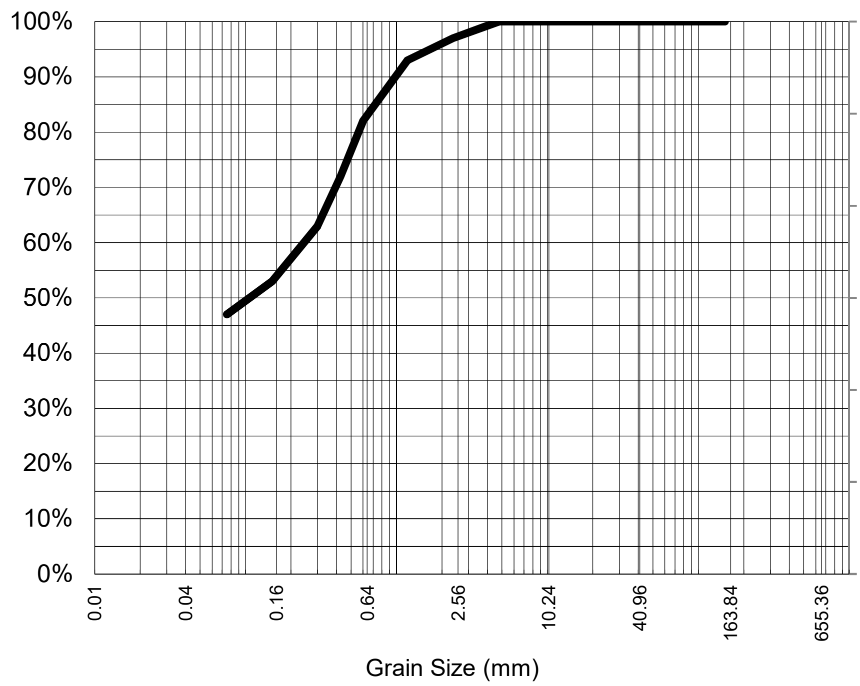
CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-039 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100302

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	97%
1.18	93%
0.600	82%
0.425	72%
0.300	63%
0.150	53%
0.075	47%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.113

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

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CLIENT: JOHNBERNAL

DATE REPORTED: 11-Jun-2020

COMPANY: WARATAH COAL

DATE RECEIVED: 27-May-2020

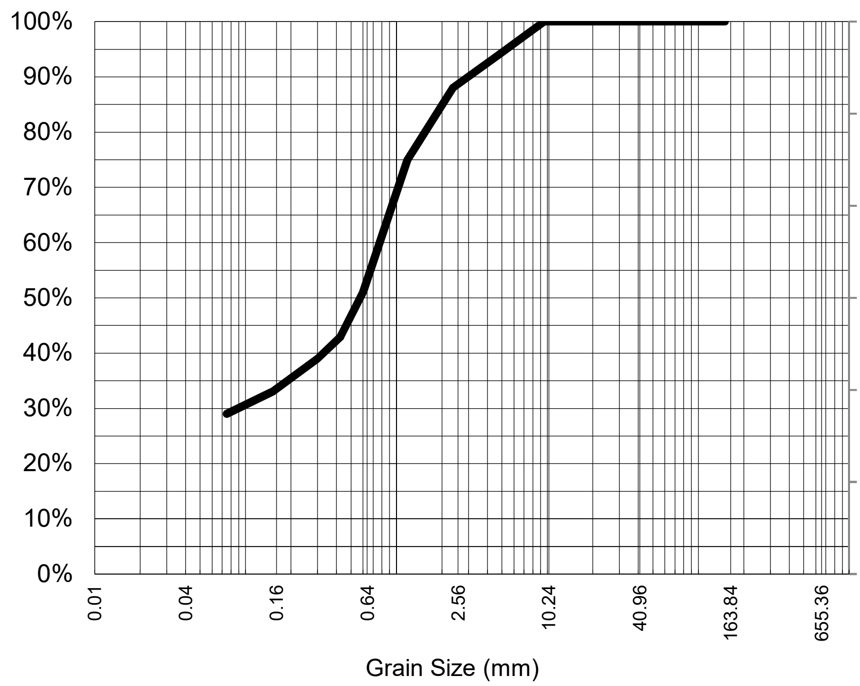
ADDRESS: C/- Als Emerald
9 Foundry Rd
Emerald

REPORT NO: EB2014000-040 / PSD

PROJECT: Central Queensland Coal Project

SAMPLE ID: 100303

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	94%
2.36	88%
1.18	75%
0.600	51%
0.425	43%
0.300	39%
0.150	33%
0.075	29%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.578

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Satish Trivedi
Soil Senior Chemist
Authorised Signatory

Template Version PKV8.0 180919

Certificate of Analysis

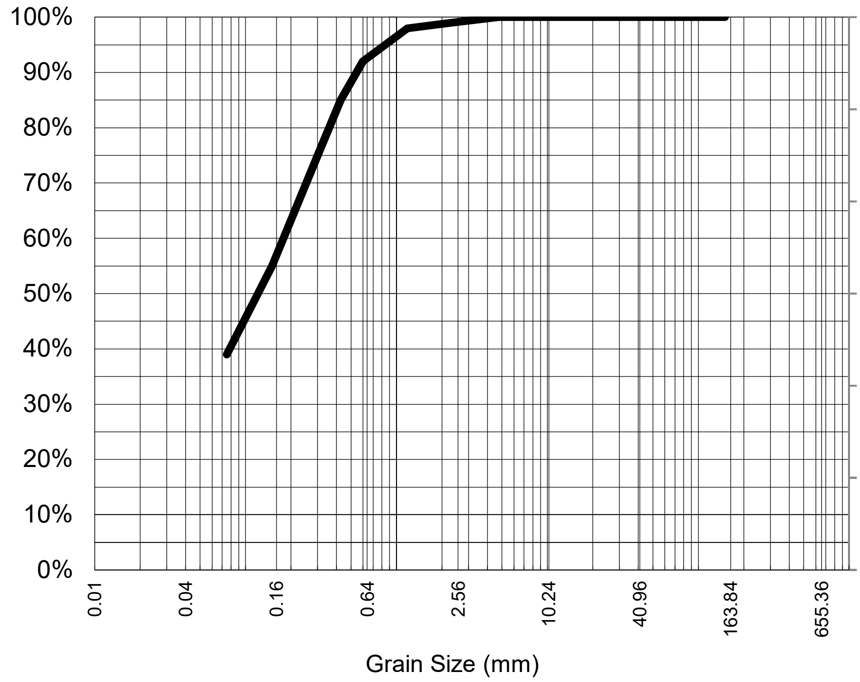
ALS Laboratory Group Pty Ltd
2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

ALS Environmental

Brisbane QLD

CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-041 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100304

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	92%
0.425	85%
0.300	75%
0.150	55%
0.075	39%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	0.127

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Satish Trivedi
Soil Senior Chemist
Authorised Signatory

Certificate of Analysis

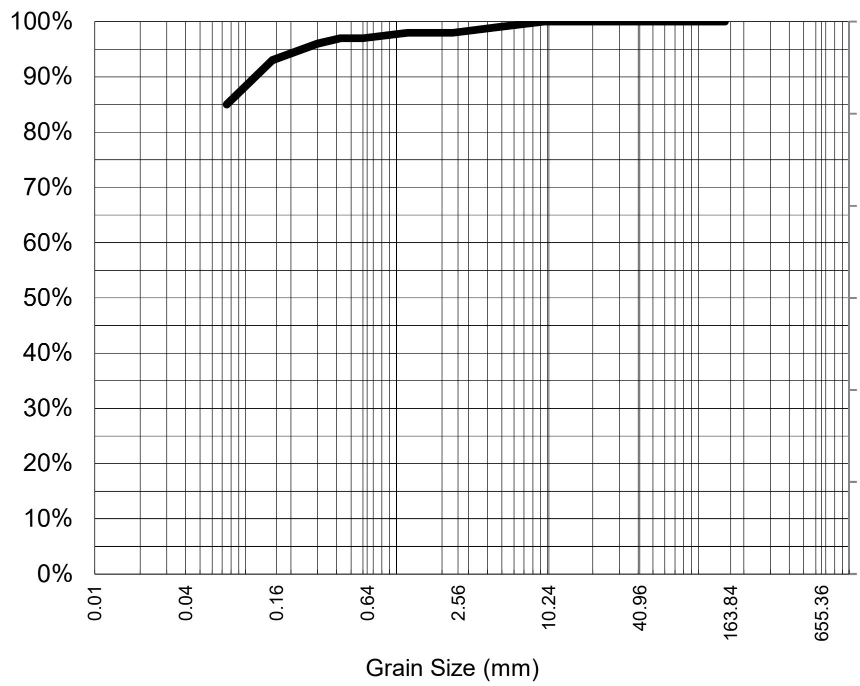
ALS Laboratory Group Pty Ltd
2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

ALS Environmental

Brisbane QLD

CLIENT:	JOHNBERNAL	**DATE REPORTED:**	11-Jun-2020
COMPANY:	WARATAH COAL	**DATE RECEIVED:**	27-May-2020
ADDRESS:	C/- Als Emerald 9 Foundry Rd Emerald	**REPORT NO:**	EB2014000-042 / PSD
PROJECT:	Central Queensland Coal Project	**SAMPLE ID:**	100305

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	98%
0.600	97%
0.425	97%
0.300	96%
0.150	93%
0.075	85%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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Satish Trivedi
Soil Senior Chemist
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street
Stafford, QLD 4053
pH 07 3243 7222
samples.brisbane@alsenviro.com

ALS Environmental

Brisbane QLD

CLIENT: JOHNBERNAL

DATE REPORTED: 11-Jun-2020

COMPANY: WARATAH COAL

DATE RECEIVED: 27-May-2020

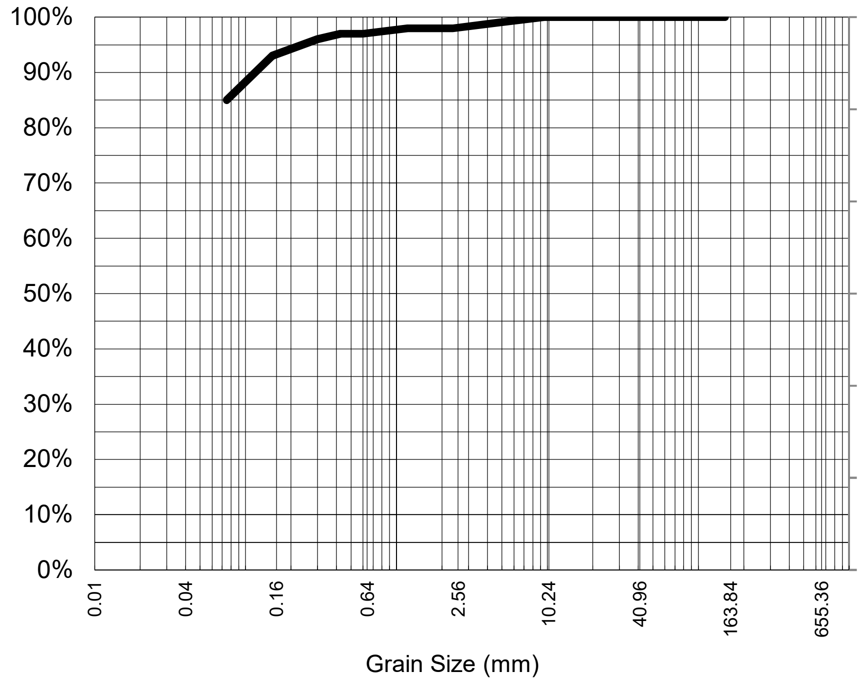
ADDRESS: C/- Als Emerald
9 Foundry Rd
Emerald

REPORT NO: EB2014000-042DUP / PSD

PROJECT: Central Queensland Coal Project

SAMPLE ID: 100305

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	98%
0.600	97%
0.425	97%
0.300	96%
0.150	93%
0.075	85%

Analysis Notes

Samples analysed as received.

Median Particle Size (mm)*	<0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 2-Jun-20

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description:

Test Method: AS1289.3.6.2/AS1289.3.6.3

#N/A

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NATA
WORLD RECOGNISED ACCREDITATION

Satish Trivedi
Soil Senior Chemist
Authorised Signatory

A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au